THE COAL RESOURCES OF THE WORLD

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THE COAL RESOURCES OF THE WORLD

AN INQUIRY MADE UPON THE INITIATIVE OF THE EXECUTIVE COMMITTEE OF THE XII INTERNATIONAL GEOLOGICAL CONGRESS, CANADA, 1913

WITH THE ASSISTANCE OF

GEOLOGICAL SURVEYS AND MINING GEOLOGISTS OF DIFFERENT COUNTRIES

EDITED BY

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OF THE GEOLOGICAL SURVEY OF CANADA

With Plates and Illustrations in the Text and Accompanied by an Atlas of Maps

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CORRIGENDA

Page 102, Netherlands-India.—The figures for the Ombilin River coal-field should be corrected as indicated on page xlviii of the Summary of the Reports.

Page 441, Canada.—First line of table, 4,891,817,000 should be 4,871,817,000.

Page 581, Chili.—The author's name, Miguel R. Michado, should be Miguel R. Machado.

Page 808, Belgium.—Table C, sixth column, bottom line, 120 m. should be 170 m.

PREFACE

The Executive Committee of the Eleventh International Congress, desirous of making that session of greater permanent value to the public at large, chose as the main topic of discussion a subject of great economic as well as scientific importance—The Iron Ore Resources of the World. The splendid monograph issued by them on this topic was so successful from every standpoint that the Executive Committee of the Twelfth Congress decided to make the Coal Resources of the World the chief topic for the Twelfth Session, publishing as a basis for the discussions a similar monograph on this subject.

A special committee, appointed by the Executive, after some correspondence with representative coal specialists of different countries, selected a classification to which the returns of the coal resources, for uniformity and comparableness, should conform, and provided a circular to be sent to the various countries, asking for reports on their coal resources. The preparation of the monograph was entrusted to the Geological Survey of Canada, and Mr. McInnes was appointed editor. Later, when the pressure of work became heavy, he was joined by Messrs. D. B. Dowling and W. W. Leach.

The following circular and covering letter were sent to the Directors of Geological Surveys or Mining Bureaus, or in cases where no official sources of information existed, to the most competent authority available.

"INTERNATIONAL GEOLOGICAL CONGRESS

12th Session, Canada, 1913

COAL RESOURCES OF THE WORLD

Ottawa, *May, 1911.*

"For some years the attention not only of geologists and mine owners, but also of the general public, has been directed to the question of the coal reserves of the world. The very large increase in the consumption of coal in recent years makes this question of the world's supply of great importance to almost every country. The Eleventh Congress dealt with the iron ore reserves of the world, calling attention to the fact that, along with coal, the iron ore supply is one of the most important factors in industrial development, and to the radical importance of the relation between supply and demand in these materials to the industry of the future.

"The Executive Committee of the Twelfth Session of the International Geological Congress, to be held in Toronto, in 1913, has, therefore, decided to make coal the chief subject for discussion at that session. In order to obtain a sure basis for the discussion and to secure a profitable result, the committee would like to have the co-operation of colleagues in every country, so that they may publish statistics of the amount and distribution of the world's supply of coal. With this end in view, we have decided to address to the proper authority in each country, a respectful request that there be sent us for publication a concise report on the geological occurrence, extent of the coal-areas, and amount of the reserves in that country.

"The statement should include:

"(I). Coal of economic value contained in seams of workable thickness, situated within a mineable distance of the surface.

"(II). Coal of economic value contained in seams of workable thickness, situated beyond present mineable distance of the surface, but possibly of future availability.

"In Group I should be given coal in seams containing less than 1 foot of merchantable coal occurring not more than 4,000 feet below the surface, including workable submarine areas.

"In Group II should be given coal in seams containing not less than 2 feet of merchantable coal occurring not less than 4,000 feet and not more than 6,000 feet below the surface and submarine areas not included in Group I.

"Since estimates of quantity may differ in exactitude, both groups should be subdivided into: (1) Actual Reserves, including cases in which the calculation of the amount is based on a knowledge of the actual thickness and extent of the seams; (2) Probable Reserves, including cases in which an approximate estimate only can be arrived at; and (3) Possible Reserves including cases in which an estimate in figures cannot be given.

"Thus:

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserve (Approximate estimate)			Possible Reserve
	No. of	Thickness	Area	Class	Metric Tons	Area	Class	Metric Tons	
Napanee...	1	3 ft. 2 in. to 3 ft. 6 in..........	2 sq. m....	A_2	7,841,118				
	3	1 ft., 3 ft., and 4 ft.........	....	......	....	Same area	A_1	18,214,560	
Essex......	5	Aggregate 25 ft.	50 sq. m...	B_2	1,312,337,500				
	4	Aggregate 15 ft.	....	......	....	Same area	B_1	786,750,000	
Mackinnon	2	4 ft. and 5 ft...	....	......	....	200 sq. m.	B_2	1,888,000,000	Large
Olliver.....	15	Aggregate 60 ft.	$1\frac{1}{2}$ sq. m...	B_1	21,189,580				
				B_2	81,267,320				

GROUP II

Including Seams 2 feet and over at Depths Between 4,000 and 6,000 feet

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserve (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class	Metric Tons	Area	Class of Coal	Metric Tons	
Mackinnon	1	3 ft.	...	...	...	200 sq. m.	B_1	600,000,000	Moderate
Olliver.....	2	2 ft. and 3 ft...	1½ sq. m...	A_2	8,538,075				
Ballantyne	...	...	...	...	...	150 sq. m.	...	...	B_1 large. A_2 moderate

"In columns 1 and 2 returns should be expressed in figures. In 3 a general statement should be made, e.g., 'Large,' 'Moderate,' 'Small.' All quantities in columns 1 and 2 should be given in metric tons.

"In order to have the various reports uniform and easily comparable, a standard classification has been adopted, to which, it is respectfully requested, the matter of each report should be made to conform. A chapter summarizing the chief results will be prepared by the committee, but each report received will appear separately.

"This classification is adopted as a simple basis on which the desired information can be received and correlated. The committee recommend a discussion by the Congress, looking to the adoption of a universal standard classification.

"The reserves of coal of each of the following classes or subdivisions of classes should be given in conformity with the above schedule. It is hoped that the characteristics mentioned under each class and subdivision of class will enable authors to place in its proper class, not only a well-known coal, but even a coal that may not have been closely studied.

Class A

"1. Burns with short, blue flame; gives off 3 to 5% of volatile combustible matter.

Fixed carbon

$$\text{Fuel ratio } \frac{\text{Fixed carbon}}{\text{Volatile matter}} = 12 \text{ and over.}$$

Calorific value, 8,000 to 8,330 calories, or, 14,500 to 15,000 British Thermal Units.

Mean composition,

Carbon	93 to 95%
Hydrogen	2 to 4
Oxygen and nitrogen	3 to 5

"2. Burns with slightly luminous, short flame and little smoke; does not coke and yields from 7 to 12% of volatile matter.

Fuel ratio, 7 to 12.

Calorific value generally 8,330 to 8,600 calories, or, 15,000 to 15,500 B.T.U.

Mean composition.

Carbon	90—93
Hydrogen	4—4.5
O and N	3—5.5

CLASS B

"1. Burns with short, luminous flame and yields 12 to 15% volatile matter; does not readily coke. Fuel ratio 4 to 7.

Calorific value generally 8,400 to 8,900 calories, 15,200 to 16,000 B.T.U.

Mean composition,

Carbon	8 to 90%
Hydrogen	4.5 to 5
O and N	5.5 to 12

"2. Burns with luminous flame and yields from 12 to 26% volatile matter; generally cokes.

Fuel ratio 1.2 to 7.

Calorific value 7,700 to 8,800 calories, 14,000 to 16,000 B.T.U.

Mean composition,

Carbon	75 to 90%
Hydrogen	4.5 to 5.5
O and N	6 to 15

"3. Burns freely with long flame; withstands weathering but fractures readily and occasionally has moisture content up to 6%; volatile matter up to 35%; makes porous, tender coke.

$$\frac{\text{Fixed carbon} + \frac{1}{2}\text{ volatile}}{\text{Hygroscopic moisture} + \frac{1}{2}\text{ volatile}} = 2.5 \text{ to } 3.3.$$

Calorific value 6,600 to 7,800 calories, 12,000 to 14,000 B.T.U.

Mean composition,

Carbon	70 to 80%
Hydrogen	4.5 to 6
O and N	18 to 20

CLASS C

"Burns with long, smoky flame; yields from 30 to 40% volatile matter on distillation, leaving very porous coke. Fracture generally resinous.

Calorific value 6,600 to 8,800 calories, 12,000 to 16,000 B.T.U.

CLASS D

"Contains generally over 6% of moisture; disintegrates on drying; streak brown or yellow; cleavage indistinct.

"1. Moisture in fresh-mined, commercial output up to 20%. Fracture generally conchoidal.

Drying-cracks irregular, curved lines.

Colour generally lustrous black, occasionally brown.

$$\frac{\text{Fixed carbon} + \frac{1}{2}\text{ volatile}}{\text{Hygroscopic moisture} + \frac{1}{2}\text{ volatile}} = 1.8 \text{ to } 2.5.$$

Calorific value 5,500 to 7,200 calories, or, 10,000 to 13,000 B.T.U.

Average composition,

Carbon	60 to 75%
Hydrogen	6 to 6.5
O and N	20 to 30

"2. Moisture in commercial output over 20%. Fracture generally earthy and dull.

"Drying-cracks generally separate along bedding planes and often show fibrous (woody) structure.

Colour generally brown, sometimes black.

Calorific value 4,000 to 6,000 calories, or, 7,000 to 11,000 B.T.U.

Average composition,

Carbon	45 to 65
Hydrogen	6 to 6.8
O and N	30 to 45

"The reports should include not only a statement of the location and distribution of the various deposits (if possible, illustrated by means of maps and sections), but should deal with such chemical and physical qualities as are determinative of their technical utilization.

"For the rest, every writer is free to act as he thinks fit, though it is very desirable that his statement should not exceed the dimension of . . . . . quarto pages of print.

"The choice of language is limited to French, German and English.

"It is the intention that these reports, together with the chapter prepared by the committee, shall be published before the end of 1912, so that every one interested may make use of them for all purposes, and particularly for the discussion at the meeting of Congress. Under these circumstances it is specially desirable that the separate reports reach us before January 1st, 1912.

"We, therefore, address ourselves to you, in the hope that you will contribute to the investigations referred to, by drawing up a comprehensive survey of the occurrences of coal in . . . .

"We feel sure that the plan we have presented will gain your interest, and that you will not refuse us the benefit of your valued co-operation, and we beg you to rest assured of our gratitude for the assistance that we feel confident you will give us.

"All communication on this subject should be addressed to the General Secretary of the Twelfth Congress, R. W. Brock, Director of the Geological Survey, Ottawa, Canada,

G. G. S. Lindsey, *Convener.*
F. D. Adams,
R. W. Brock,
D. B. Dowling,
Chas. Fergie,
Jas. McEvoy,
J. B. Porter,

"Committee on Coal Resources of the World, appointed by the Executive Committee of the International Geological Congress Twelfth Session."

OTTAWA, *June 16th, 1911.*

"Dear Sir,—

"The Twelfth International Geological Congress has decided to make The Coal Resources of the World the chief subject for discussion at its meeting in Toronto, Canada, in 1913. For the volume on Coal, which will form the basis of the discussion, it is necessary to have the latest and most reliable information on the subject. I have therefore been requested by the Executive Committee of the Congress, and by the Honourable Minister of Mines of Canada, who is taking a keen interest in the matter, to respectfully request you to co-operate in this important undertaking, and to become responsible for supplying this information concerning . . . . , . . If you cannot undertake the task personally please put it in the hands of the most competent authority available.

"Thanks to the interest taken in the matter by those who were asked to contribute information, the similar work done on The Iron Resources of the World by the Eleventh Congress has been so successful from every standpoint, including the economic, that we are confident of your enthusiastic and hearty co-operation in the present undertaking, which in itself has such an important bearing on the progress of civilization and which will supplement in such a useful way the monumental work on the iron resources.

"Please inform me of the disposition you are making of this request, and the date at which we may expect to receive the report on your section, which must not be later than January 1st, 1912. It has been found necessary to extend the time for the reception of some of the reports to July 1st, 1912.

"Thanking you for your interest and co-operation, I am,

Yours very respectfully,

(Sgd.) R. W. BROCK,

Secretary-Treasurer, Twelfth International Congress."

As will be seen from the reports contained in these volumes, the response has been general and generous. In three instances only, Greenland, Peru and Brazil, has it been necessary for the editors to compile from published literature. Consequently, the reports here presented may be accepted as the latest and most authoritative pronouncements upon the coal resources of the individual countries; in many cases they represent the first complete statement yet made, and in other cases much new field work has been undertaken for these special reports.

The Executive Committee is deeply grateful to the contributors, one and all, to whose whole-hearted assistance the success of the undertaking is due. In most cases the extent of this indebtedness is apparent from the text. Special mention, however, must be made of colliery companies that have furnished private information unattainable from other sources; of Japan for its reports on China, Manchuria and Korea; of the British Consular Service for most courteously securing information concerning countries that could not be reached through any other source; of the Imperial Institute for information concerning some of the British Colonies; of the Pan-American Union for information concerning Central and South America; of the United States Geological Survey for placing its good offices at the disposal of the committee, when, at the last moment, Mexico was unable to furnish a report; also of the following private individuals who generously contributed articles:—Dr. Noah Drake, on China; R. T. Hill, late of the United States Geological Survey, on Mexico; Leon Dominian, M.E., on Turkey; Dr. T. W. Edgeworth David, University of Sydney, on the Antarctic; and Bertil Högbom, Upsala University, on Spitzbergen.

In order to secure the publication of the monograph in time for the Congress, it was asked that reports be sent in by January 1st, 1912. The approximate length of the report from each country, to make a well-balanced work, was also indicated. Many countries were unable to comply with the former request and reports have been received as late as the middle of May, 1913. This has made it impossible for the editors to do justice to their work, but on the other hand, it has enabled much new material to be secured and presented, thus adding greatly to the value of the monograph. But publication had to be contracted for, necessitating the fixing of an arbitrary limit to the size of the work and the number of the illustrations, and printing started while many important reports were still outstanding. Thus it was that the latest reports received, being longer than anticipated, had to be hurriedly condensed by the editors and many illustrations and maps, not adapted for direct reproduction in the form in which they were received, had to be omitted. It is hoped, however, that nothing essential has been left out. The late date at which the last reports have come to hand, has made it a difficult task to adequately summarize The Coal Resources of the World in the introductory chapter.

The Executive Committee of the Twelfth Geological Congress extends its heartiest thanks to the various collaborators who have given so freely of time and information toward the production of this monograph. Their reward lies in knowing they have applied their knowledge for the general good.

The result of their work in taking stock of this most important natural resource will be of lasting benefit, not alone to geologists and miners who have a technical interest in the subject, but also and in a larger measure, to the industrial world and the public at large, who have a vital interest in the undeveloped fields and the probable life of the world's supply of coal, a commodity which has become to such a surprising extent, fundamental to our present-day civilization.

For the Executive Committee of the Twelfth International Geological Congress.

R. W. BROCK,

General Secretary.

OTTAWA, *June 14th, 1913.*

INTRODUCTION

BY

D. B. DOWLING

SUMMARY STATEMENT

THE general distribution of the coal-fields of the world is shown on the maps of the Eastern and Western Hemispheres in the Atlas. An estimate of the coal reserves in tabular form is given at the end of this summary.

The greater part of the known coal reserves of the world is found in the northern hemisphere. This is partly due to the larger land areas found there and partly to the fact that the earlier, coal-bearing portions of the Carboniferous are not represented in the southern hemisphere.

GEOLOGICAL DISTRIBUTION

In the Palæozoic, important coal-deposits are found in Lower Carboniferous rocks in central Russia (including the Ural basin), in Scotland and in the Arctic islands north of Canada and Europe. The great coal-basins of western Europe and eastern North America, which contain a large part of the coal reserves of the world, are of Upper Carboniferous age. The Palæozoic coal-measures of China, India, South Africa, Australia and eastern South America are mainly Permo-Carboniferous in age. These measures have a great areal extent in China and are remarkable for their rich coal-bearing character in Australia. In Africa and South America, although large areas are found, they are not coal-bearing to the same extent as those in Australia.

Mesozoic deposits contain important coal reserves in small scattered basins in central Europe and in western North America, central Asia and Indo-China, they equal in richness the coal deposits in many basins of the Carboniferous measures.

Tertiary deposits containing coal and brown-coal form fields of importance in central and southern Europe. In north-eastern Asia they form the important fields in Japan and on the north-eastern coast of Siberia. The principal coal-measures of New Zealand and the other islands of the Pacific are also of Tertiary age. On the American continents the Tertiary is rich in coal; deposits of that age are found on the western and northern parts of South America, in central America and the West Indies and in North America, on the great plains and the Pacific slope.

The Reserve

In the compilation of the following tables the figures given for Actual Reserve include only those so given in the reports received from the various countries. Owing to the incomplete classification of the reserves in many of the reports the figures for Probable Reserve, in many cases include Actual and Probable and in other cases Probable and Possible Reserves.

The reports deal with a very large variety of coals but in the following table they are grouped in only three divisions, anthracitic, bituminous and the less-altered coals.

In considering the amount of the reserve relative to the duration of the supply it should be borne in mind that in this estimate no deduction is made for coal not at present mineable nor for loss of coal in mining. A large part of the coal included in the estimate will be very difficult to mine and generally the loss in mining will be great.

Estimate of the Coal Reserves of the World

IN MILLION TONS

	Class A	Classes B & C	Class D	Totals
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignites	
Oceania	*659*	*133,481*	*36,270*	170,410
Asia	*407,637*	*760,098*	*111,851*	1,279,586
Africa	*11,662*	*45,123*	*1,054*	57,839
America	*22,542*	*2,271,080*	*2,811,906*	5,105,528
Europe	*54,346*	*693,162*	*36,682*	784,190
	496,846	3,902,944	2,997,763	7,397,553

For the purpose of comparison with the total estimated coal supply indicated in the above table, a statement of the annual production of the principal countries of the world, compiled from statistics published in *Mineral Industry*, New York, is given in the following table.

TABLE OF THE ANNUAL COAL PRODUCTION OF PRINCIPAL COUNTRIES OF THE WORLD

IN MILLION TONS

	1865	1870	1875	1880	1885	1890	1895	1900	1905	1910
Australia	.....	.....	.....	.....	.....	.....	4.01	6.48	6.83	10.00
New Zealand	.....	.....	.....	.....	.....	.....	0.76	1.11	1.41	2.23
China	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.59
India	.....	.....	.....	.....	.....	.....	2.65	6.22	7.92	12.09
Japan	.....	.....	.....	.....	.....	.....	4.84	7.43	11.89	14.79
South Africa	.....	.....	.....	.....	.....	.....	1.40	0.76	3.22	5.50
Canada	....	.....	.....	.....	.....	.....	3.19	5.09	7.96	13.01
United States	24.79	29.95	48.20	66.83	102.18	141.62	177.59	243.41	351.12	445.81
Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.45
Great Britain	99.76	112.24	135.49	149.38	161.96	184.59	194.35	228.77	239.89	264.50
Spain	0.45	0.66	0.61	0.85	0.94	1.18	1.77	2.58	3.20	3.55
France	11.84	13.30	16.95	19.36	19.51	26.08	28.24	33.40	36.05	38.57
Belgium	11.84	13.69	15.01	16.88	17.44	20.37	20.41	23.46	21.84	23.13
Germany	28.33	34.88	48.53	59.12	73.67	89.29	103.96	149.79	173.66	221.98
Austro-Hungary	2.03	8.36	13.06	14.80	20.43	26.10	27.25	39.03	40.72	38.00
Italy	.....	.....	.....	.....	.....	.....	0.25	0.48	0.31	0.40
Sweden	.....	.....	.....	.....	.....	.....	0.20	0.25	0.33	0.21
Russia	0.33	0.69	1.17	3.27	4.24	7.00	9.10	14.76	17.12	24.57
Other countries	2.71	4.04	6.26	9.28	12.45	16.89	1.75	2.90	4.55	8.00
Total	182.08	217.81	285.30	339.37	412.82	513.12	581.72	765.92	928.02	1,143.38

OCEANIA

THE East Indian archipelago and the islands of the Australian group have an estimated potential reserve of coal of about 170,000 million metric tons, the greater part of which is composed of the several varieties of bituminous coal. The better grade coals are found in deposits of Palæozoic and Mesozoic age, and those with lower percentages of carbon, in Tertiary rocks.

PALÆOZOIC COALS

The oldest coals which are Permo-Carboniferous in age, are found in Australia and Tasmania, they have their greatest development in New South Wales where the coal-bearing series is considered to extend down into the Carboniferous.

Mesozoic Coals

In Tasmania and New South Wales thin seams of coal occur in the Lower Triassic and, in Queensland and New South Wales, important deposits are found in the Upper Triassic. Jurassic rocks containing coal-seams are found on South Island, New Zealand, in Victoria, in South Australia and in Tasmania, where they constitute the principal Coal-Measures. Brown-coal in thin seams is found in Lower Cretaceous rocks in South Australia and in mineable seams in a large, partly prospected area of Upper Cretaceous rocks in Queensland.

Tertiary Coals

Tertiary deposits with important coal-bearing strata have a wide distribution in Oceania and are found in South Australia and Victoria and on many of the islands of the East Indies where they form the principal coal-fields. The Eocene rocks of Tasmania contain a large unestimated reserve of brown-coal while in New Zealand they form the principal coal-bearing series. The coal mined in Borneo, Java and Sumatra is of Eocene age. Deposits of Miocene age contain lignites in New Zealand, and Borneo, and probably on other islands of the group; in the Philippine islands these deposits contain a valuable reserve of both lignite and sub-bituminous coal. Lignite deposits of Pliocene and Pleistocene age are found in New Zealand and Borneo.

Estimate of the Coal Reserves of Oceania

IN MILLION TONS

	Class A	Classes B & C	Class D	Totals
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignites	
Australia	*659*	*132,250*	*32,663*	165,572
New Zealand	...	*911*	*2,475*	3,386
British North Borneo	...	*75*	.....	75
Netherlands India	...	*240*	*1,071*	1,311
Philippines	...	*5*	*61*	66
Total	659	133,481	36,270	170,410

Actual Reserve	4,073 million tons
Probable Reserve	166,337 "
Total estimated reserve	170,410 million tons

ASIA

THE reserve of coal in Asia is probably underestimated as many of the Siberian and Chinese coal-fields have not been sufficiently explored to admit of an estimate of their reserves being made.

The coal-fields of importance in India and China are underlain by Permo-Carboniferous measures. In Japan the important coal-bearing deposits are of Miocene age and in Siberia coal is found in formations varying in age from Lower Carboniferous to recent.

PALÆOZOIC COALS

Lower Carboniferous coals are found in the disturbed zone east of the Urals and also in Turkestan. Coal-bearing beds equivalent to the Coal-Measures of Europe occur above the marine beds of the Carboniferous, in the region south of the Black Sea; the beds found in the Kirghiz steppes and near Tomsk are of about the same age as the Permo-Carboniferous coal-bearing series of China, Manchuria and India. Small amounts of coal are found in the Permian rocks of Yenisei.

MESOZOIC COALS

Coal is found in small amounts in the Triassic rocks of Japan. Extensive coal deposits of Rhætic or Lower Jurassic age occur in Persia, Turkestan, Irkutsk, Trans-Baikal, southern China and Indo-China, minor occurrences being found in Japan and the east slope of the Urals.

Jurassic measures containing coal of economic importance are found in large areas in eastern Siberian and a few areas of smaller extent occur in Manchuria, Corea, Japan and northern India.

Coal is found in the Cretaceous deposits of south-western Japan and of Sakhalien island. The Lower Cretaceous measures of the northern Urals contain a few seams of coal.

TERTIARY COALS

Tertiary coals are widely distributed and although not of high grade, are of importance especially in Japan and north-eastern Siberia where Miocene beds contain a large reserve. Other localities where Tertiary coals are found include the Malay States, Burma, Kashmir, Jammu, Arabia and Turkey in Asia.

In China and Japan and possibly in northern Siberia, Pliocene lignites are found.

A noticeable feature of the reserve for Asia is the large amount of anthracitic coal, most of which is found in China.

Estimate of the Coal Reserves of Asia

IN MILLION TONS

	Class A	Classes B & C	Class D	Totals
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignites	
Corea	*40*	*14*	*27*	81
China	*387,464*	*607,523*	*600*	995,587
Japan	*62*	*7,130*	*778*	7,970
Manchuria	*68*	*1,140*	......	1,208
Siberia	*1*	*66,034*	*107,844*	173,879
Indo-China	*20,002*	......	......	20,002
India	......	*76,399*	*2,602*	79,001
Persia	......	*1,858*	......	1,858
Total	407,637	760,098	111,851	1,279,586

Actual Reserve	20,502	million tons
Probable Reserve	1,259,084	"
Total estimated Reserve	1,279,586	million tons

AFRICA

The most important coal reserves of Africa are confined to the southern portion of the continent; the northern portion is practically without coal, with the possible exception of some small streaks of lignite in Tertiary rocks. In the central part, small deposits of lignite of Tertiary age have been found in Abyssinia and important ones in Southern Nigeria, where coal is also found in beds of Upper Cretaceous age.

Palæozoic Coals

The coal-bearing formations of the southern portion of Africa are all included in the Karroo system which is made up of a succession of deposits ranging in age from Carboniferous to Jurassic. The coal-beds of the Karroo cover extensive tracts and contain the major portion of the reserve of the continent. The lowest formation (Ecca series) in which coal is found is Permo-Carboniferous in age; it contains most of the coal found in Rhodesia and Nyasaland, and an important reserve in Belgian Congo. The coal-bearing rocks of the

Transvaal and Madagascar (Beaufort series) are probably Permian in age. In the Belgian Congo, rocks at approximately this horizon are thought to be Permo-Triassic.

Mesozoic Coals

In the Cape of Good Hope and Natal the coal-bearing beds are confined to the Stormberg series which is of Rhætic age.

Estimate of the Coal Reserves of Africa

IN MILLION TONS

	Class A	Classes B & C	Class D	
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignltes	Totals
Belgian Congo	.....	*90*	*900*	990
Southern Nigeria	.....	.....	*80*	80
Rhodesia	*2*	*493*	*74*	569
Union of South Africa	*11,660*	*44,540*	.....	56,200
Total	11,662	45,123	1,054	57,839

Actual Reserve	499 million tons
Probable Reserve	57,340 "
Total estimated Reserve	57,839 million tons

NORTH AMERICA

This continent is particularly well supplied with fossil fuel, the Carboniferous deposits of the east and the Mesozoic and Tertiary deposits of the west containing about two thirds of the estimated coal reserve of the world.

Palæozoic Coals

In the far north a large possible reserve is contained in beds supposed to lie below the marine limestone of the Carboniferous in that respect resembling the deposits of the Urals and the Moscow basin. Small deposits were also found in the Lower Carboniferous on the Alaska coast and in Nova Scotia. The Carboniferous coal-bearing formations of Europe are represented by the Pennsylvanian formation which underlies large areas in the eastern and central United States and smaller areas in New Brunswick, Nova Scotia and Newfoundland.

Mesozoic Coals

Triassic deposits containing coal-seams are found in western and southern Mexico and in North Carolina and Virginia. Jurassic deposits containing coal are reported on the east coast of Greenland and on the Arctic coast of Alaska. In western Canada the deposits that immediately succeed the marine Jurassic are specially rich in coal beds and form important coal-fields in British Columbia, the Yukon Territory and the Rocky Mountain region of Alberta. They are referred to the Lower Cretaceous and are succeeded by marine and fresh-water deposits of Cretaceous age which, over great areas of the interior plains and in the Rocky mountains south of the Canadian line, are coal-bearing at several horizons. The coal found on the islands off the coast of British Columbia belongs to the Middle and Upper Cretaceous. The Cretaceous-Tertiary transition beds of the interior are especially rich in coal deposits in the northern plains of the United States and in Alberta. Deposits of similar age are found in northern Mexico, in the Yukon and Colville River basins and on the west coast of Greenland.

Tertiary Coals

Tertiary deposits in which coal is found (generally in the form of lignite) have a wide distribution. Most of the coal-fields of central America and the Gulf region of Mexico and the United States, large areas in the northern plains of the United States and Canada, isolated areas in the Pacific coast States and in British Columbia, a large area in Alaska and areas on the Arctic coast and islands, belong to the Eocene. Miocene beds occasionally contain coal in the Rocky mountains and Mexico. Recent deposits approaching lignite are found in northern Ontario and southern British Columbia.

Estimate of the Coal Reserves of North America

IN MILLION TONS

	Class A	Classes B & C	Class D	Totals
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignites	
Newfoundland	.....	*500*	....	500
Canada	*2,158*	*283,661*	*948,450*	1,234,269
United States	*19,684*	*1,955,521*	*1,863,452*	3,838,657
Central America	......	*1*	*4*	5
Total	21,842	2,239,683	2,811,906	5,073,431

SOUTH AMERICA

The fields from which the best grades of coal are obtained appear to be those along the Pacific and the Gulf of Mexico, and are generally of Tertiary age.

Palæozoic Coals

Permo-Carboniferous coal-bearing deposits occur east of the Andes; they outcrop in southern and eastern Brazil and underlie part of Uruguay (where the coal may be mineable) and possibly a large part of Argentina. The most westerly outcrops of the Permo-Carboniferous are probably those in Bolivia and in isolated localities east of the Andes in Argentina, but it is doubtful if the formation there contains many valuable coal-seams. This series has been correlated with the Karroo system of South Africa.

Tertiary Coals

Tertiary coals are found in the coastal zone in southern Argentina and Chili, and in the mountainous regions of Peru, Ecudor, Colombia and northern Venezuela.

Coal-seams supposed to be of bituminous origin are found in western Argentina and Venezuela.

Estimate of the Coal Reserves of South America

IN MILLION TONS

	Class A	Classes B & C	Class D	
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignites	Totals
Colombia	....	*27,000*	....	27,000
Venezuela	....	*5*	....	5
Peru	*700*	*1,339*	....	2,039
Argentina	....	*5*	....	5
Chili	....	*3,048*	....	3,048
Total	700	31,397	....	32,097

Actual Reserve	2,087 million tons
Probable Reserve	32,010 "
Total estimated Reserve	32,097 million tons

EUROPE

Coal is found in commercial quantity in practically all the independent political divisions of Europe. In some the reserve is nearly exhausted, as in Switzerland; in others the large production is rapidly depleting the reserves; and in Europe as a whole, the duration of the coal supply, in view of the present output, is a matter for serious consideration.

The principal anthracite fields are the Donetz basin in Russia and the Welsh fields of Breat Britain. The largest reserves of bituminous coal are in the Belgian-German basins, although the British fields may be more easily exploited and a larger percentage of the reserves extracted. Germany and Austria have about equal amounts of the less altered varieties of coal which constitute a large part of their present output.

Coal occurs in many of the post-Devonian deposits but the principal reserve is found in the Upper Carboniferous, although Lower Carboniferous and Tertiary beds contain valuable coal-seams.

Palæozoic Coals

The coal deposits of greatest age are those reported in the Upper Devonian of Buren island, north of Norway and the Shungite beds of northern Russia. Lower Carboniferous coals are found in Spitzbergen and, in Russia, in the Moscow and Donetz basins and the Urals. The coals of Scotland and the north coast of Ireland as well as those of small basins in the Armorican *massif* of France are also of Lower Carboniferous age.

The Coal-Measures proper, of Upper Carboniferous age, are the richest in coal.

In the Lower Coal-Measures in England and in the Namurian of France and Belgium a few thin seams are found. The principal Coal-Measures of Ireland and of the Valenciennes and Pas de Calais basins of France are of this age. Two seams of this age in the Bohemian coal-fields of Austria contains a large reserve, and it is probable that the lower measures of the Dombrova basin are of the same age.

The middle division (Westphalian) forms the principal productive measures of Great Britain, northern France and Brittany, Belgium and Germany and the concealed fields of the Netherlands. Other basins such as the coal-fields of Asturias and Leon in Spain and *Étage* C_2 of the Donetz basin may be correlated with the Westphalian measures.

The Upper Coal-Measures (Stephanian) are coal-bearing in central and southern France, in Upper Silesia and the adjacent parts of Austria and Russia and in a small area in Portugal. Small areas grouped as Carboniferous include basins in Sardinia, Hungary, Servia and Bulgaria. Permian coal deposits are rare, but occur in Bohemia, Saxony and central France.

Mesozoic Coals

Coal-seams occur at various horizons from Upper Triassic to Upper Cretaceous. The lower coal horizons lying between the Triassic and Jurassic are coal-bearing in northern Austria and southern Sweden and to a less degree in the Alpine regions of France and Italy and at Ternal in Spain. The coals of Bornholm, Denmark, are of Rhætic or Liassic age.

Lower Jurassic coals occur in Sweden, Servia and Hungary; Middle Jurassic coals in the Kutaiss district of the Caucasus, and Upper Jurassic coals in Suchum (Caucasus), Portugal and Norway (Andö island).

Borings in New Russia and Lithuania have penetrated seams supposed to be of Jurassic age and important Jurassic deposits occur on Spitzbergen island and in the Grestener series in Austria.

Cretaceous coal-measures are found in the southern part of Europe. Coal is being mined in large areas in Servia and in the Balkan basin of Bulgaria, where many seams of friable coal are found. In the Lower Cretaceous of Spain, coal is found in Alva and on the Balearic islands and lignite in Saragossa and Barcelona. Upper Cretaceous measures in the Rhone valley (France) contain an important reserve. Those of Servia contain more coal than the older rocks and in Austria the Gosau layers are mined near Salzburg. In Spain the rocks of this division contain lignite in the province of Alva.

Tertiary Coals

A large proportion of the brown-coal of Europe is found in beds of Tertiary age, the principal fields being those of Germany, Austria and southern Russia.

Eocene beds contain the principal brown-coal reserves of the Saxony-Thurgia districts of Germany as well as the reserves on the Main and near Cassel. In Austria the Eocene coals are found in many localities in Dalmatia and Istria and in Hungary they include the coals of Talabânya and Nitrabânya. In southern Russia the coals of Kiev and Buchak are probably Eocene. Other occurrences of coals at this horizon are found in Italy and Sardinia, and in small areas in Switzerland, in La Counette basin, France and on the Balearic islands, Spain.

Oligocene coal-bearing beds are found in the Austrian Tyrol, and in northern Bohemia, in the Stotzka strata of southern Austria and in Dalmatia. In the Poltava beds of Kiev, Russia, and in many small areas in Hungary coals of possibly Oligocene age accur. To these may also be added the beds of Lerida, Spain and of Kherson, New Russia.

Miocene coals form the principal reserve of Galicia and occur in Bohemia, and in the Mürtz and Mur fields west of Vienna, Austria. They are also the principal coals of Bosnia and Herzegovina and occur in Hungary and southern Russia, Switzerland and France. Many areas in Germany, among which are those near Cologne, Lusatia, Cassel, Westerwalds, Frankfurt on the Oder and Gorlitz, contain important brown-coal deposits. Italy and Sardinia also have Miocene coals and in the centre of Denmark a large unestimated reserve of lignite has been found. The Miocene coals of Spitzbergen are of great importance and are the only ones being mined on the island.

Pliocene lignites occur in Tuscany and Umbria, Italy. In southern Russia and Austria a division into Upper and Lower, i.e. Pontic and Sarmatic is made. The Sarmatic of the Caucasus contains an important reserve in the Olti district and the Pontic is coal-bearing in New Russia and in Austria in the Schall valley.

Other Tertiary basins occur in Servia, Bulgaria, the Rhone valley (France), and Barcelona (Spain).

Recent peaty deposits approaching lignite are found in Lithuania (southern Russia), and lignitic beds of the same age in the Styrian Alps of Austria.

Estimate of the Coal Reserves of Europe

IN MILLION TONS

	Class A	Classes B & C	Class D	
	Anthracitic Coals, including some Dry Coals	Bituminous Coals	Sub-bituminous Coals, Brown-coals and Lignites	Totals
Great Britain and Ireland	*11,357*	*178,176*	....	189,533
Portugal	*20*	....	....	20
Spain	*1,635*	*6,366*	*767*	8,768
France	*3,271*	*12,680*	*1,632*	17,583
Italy	*144*	......	*99*	243
Greece	......	......	*40*	40
Bulgaria	......	*30*	*358*	388
Denmark	......	......	*50*	50
Netherlands	*320*	*4,082*	......	4,402
Belgium	......	*11,000*	......	11,000
Germany	......	*409,975*	*13,381*	423,356
Hungary	......	*113*	*1,604*	1,717
Austria	......	*40,982*	*12,894*	53,876
Bosnia and Herzegovina	......	......	*3,676*	3,676
Servia	......	*45*	*484*	529
Roumania	......	......	*39*	39
Sweden	......	*114*	......	114
Russia in Europe	*37,599*	*20,849*	*1,658*	60,106
Spitzbergen	......	*8,750*	......	8,750
Total	54,346	693,162	36,682	784,190

THE ACTUAL AND PROBABLE COAL RESERVES OF THE WORLD

Oceania

	Actual Reserve (In million tons)			Probable Reserve (In million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Australia:							
New South Wales	....	....	....	....	*B 118,439*		
Victoria	....	*B 40*	....	....	*B 12*	*31,114*	
Queensland	*99*	*B 1,766*	*66*	*560*	*B 11,011*	*800*	
		C 165			*C 751*		
Tasmania	....	....	....	....	*B 65*		
					C 1		
West Australia	....	....	*153*	....	....	*500*	
	99	1,971	219	560	130,279	32,414	165,572
New Zealand	....	B 26	612	....	B 99	1,863	
		C 363			C 423		3,386
British North Borneo	....	C 5	....	....	C 70		75
Netherlands India	....	C 40	734	....	C 200	337	1,311
Philippines	....	....	4	....	B 5	57	66
Total estimate for Oceania	99	2,405	1,569	560	131,076	34,701	170,410

Small reserves of brown-coal not estimated are found in South Australia, Queensland, Tasmania and Netherlands India. A possible reserve of moderate proportions is expected in the Philippines.

A possibly large reserve has also been discovered on the Antarctic continent.

Asia

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Corea	7	1	5	33	B 4	22	
					C 9		81
China:							
Chili	*6,785*	*B 6,201*	....	*3,242*	*B 5,490*		
		C 292	....	....	*C 658*		
Shantung	*1,360*	*B 2,842*	....	*640*	*B 2,241*		
Shansi	*240*	*B 123*	....	*299,760*	*B414,217*		
Shensi	....	....	....	....	*B 1,050*		
Kansu	....	....	....	....	*B 5,129*		
Honan	....	....	....	*6,575*	*B 2,700*		
Kiangsu	....	....	....	*10*			
Anhui	....	....	....	....	*B 187*		
Hupei	....	....	....	....	*B 117*		
Chekiang	....	....	....	*18*	*B 6*		
Chekiang	....	....	....	....	*B *120*		
Kiangsi	....	*B 325*	....	....	*B 3,070*		
Fukien	....	....	....	**80*			
Kuantung	*498*	....	....	*256*	*B 255*		
Kuangsi	....	....	....	....	*B 500*		
Hunan	....	....	....	*48,000*	*B 42,000*		
Szechuan	....	....	....	*20,000*	*B 60,000*	*500*	
Kueichou	....	....	....	....	*B 30,000*		
Yunnan	....	....	....	....	*B 30,000*	*100*	
	8,883	9,783	....	378,581	597,740	600	995,587
Japan:							
Mesozoic coal	*4*	....	....	*37*	*B 5*		
					C 5		
Tertiary:							
Karafuto	....	*C 17*	....	....	*C 1,345*		
Hokkaido	....	*C 336*	....	....	*C 2,106*	*233*	
Honsu	*1*	*C 1*	*67*	*20*	*C 14*	*478*	
Kyushu	....	*C 542*	....	....	*C 2,374*		
Taiwan	....	....	....	....	*C 385*		
	5	C 896	67	57	6,234	711	7,970

* Estimate by Kinosuke Inouye.

Asia—*Continued*

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Manchuria	....	B 31	....	68	B 223		
		C 378	....	....	C 508	....	1,208
Siberia	....	....	....	1	B 66,034*	107,844	173,879
Indo-China	....	....	....	20,002	....	....	20,002
India:							
Bengal, Bihar and Orissa	....	*B 48*	....	....	*B 53,037*		
					C 210		
Central India	....	....	....	....	*B 22,657*		
Central Provinces	....	*B 24*	*222*	....	*B 246*	*2,327*	
		C 30					
Mesozoic and Tertiary	....	*C 119*	*3*	....	*C 28*	*50*	
		221	225	....	76,178	2,377	79,001
Persia	....	....	....	....	B 1,858	....	1,858
Total estimate for Asia	8,895	11,310	297	398,742	748,788	111,554	1,279,586

* Provisional estimate based on statement by S. F. Maliavski that the reserve of 150,000 tons for Irkutsk was largely of coal belonging to Group 1 of Grüner—percentage assumed being a minimum of 66.

Large unestimated reserves are reported in Siberia. Small amounts are reported in the Federated Malay States, Siam and Asia Minor.

Africa

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Belgian Congo...........	....	....	....	....	B 90	900	990
Southern Nigeria.........	....	....	80	....	....	....	80
Rhodesia................	2	B 306	74	....	B 119		
		C 37			C 31		569
South Africa:							
Transvaal.............	....	....	....	....	*B 28,800*		
					C 7,200		
Natal.................	....	....	....	*4,700*	*B 4,600*		
Zululand..............	....	....	....	*6,000*			
Orange Free State, Cape, Basutoland, Swaziland.	....	....	....	*960*	*B 2,880*		
					C 960		
				11,660	44,540	....	56,200
Total estimate for Africa.	2	343	154	11,660	44,780	900	57,839

Large unestimated reserves remain in southern Nigeria, a moderate amount in Nyasaland, and small reserves in Madagascar, East African Protectorate, Sudan and Abyssinia.

North America

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Newfoundland	....	....	....	....	500	....	500
Canada:							
Nova Scotia	....	*B 2,138*	....	....	*B 7,511*		
		C 50			*C 20*		
New Brunswick	....	....	....	....	*B 151*		
Ontario	....	....	....	....	....	*25*	
Manitoba	....	....	....	....	....	*160*	
Saskatchewan	....	....	....	....	....	*57,400*	
Alberta	*668*	*B 3,209*	*384,908*	*100*	*B194,883*	*491,271*	
British Columbia	*7*	*B 23,764*	*60*	*1,343*	*B 43,925*	*5,136*	
					C 1,800		
Yukon	....	....	....	*40*	*B 210*	*4,690*	
North-West Territories	....	....	....	....	....	*4,800*	
Arctic Islands	....	....	....	....	*6,000*		
	675	29,161	384,968	1,483	254,500	563,482	1,234,269
United States:*							
Eastern	....	....	....	*16,906*	*494,454*		
Interior	....	....	....	*363*	*478,232*		
Gulf	....	....	....	....	....	*20,952*	
Northern Plains	....	....	....	....	*41,106*	*1,134,000*	
Rocky Mountains and Coast	....	....	....	*484*	*335,460*	*692,207*	
Coal deeply covered	....	....	....	....	*604,900*		
Alaska	....	....	....	*1,931*	*1,369*	*16,293*	
				19,684	1,955,521	1,863,452	3,838,657
Central America:							
Honduras	....	....	....	....	*1*	*4*	
					1	4	5
Total estimate for North America	675	29,161	384,968	21,167	2,210,532	2,426,938	5,073,431

* In the estimate submitted by the United States, the reserves were not subdivided into Actual and Probable Reserves.

Some lignite has been found in Greenland, Guatemala, Salvador, Costa Rica, Panama, Trinidad and Santo Domingo. A moderate reserve of coal is known in Mexico, but no estimate could be obtained.

South America

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Colombia	....	....	....	....	B 27,000	....	27,000
Venezuela	....	....	....	....	5	....	5
Peru	....	....	....	700	B 1,339	....	2,039
Argentina	....	B 5	....	....	....	....	5
Chili	....	C 2,082	....	....	C 966	....	3,048
Total estimate for South America		2,087		700	29,310		32,097

Small reserves, not estimated, are supposed to occur in Ecuador, Bolivia and Uruguay Brazil is believed to have somewhat larger supplies.

Europe

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Great Britain and Ireland:							
England	....	*B 79,869*	....	....	*B 46,030*		
Wales	*8,672*	*B 31,402*	....	*13*	*B 195*		
Scotland	*2,500*	*B 18,876*	....	....	*B 1,685*		
Ireland	*172*	*B 8*	....	....	*B 111*		
	11,344	130,155	....	13	48,021	....	189,533
Portugal	20	....	....	....	....	....	20
Spain:							
Asturias	*1,008*	*B 2,016*	....	*148*	*B 296*		
		C 2,016			*C 296*		
Other fields	*42*	*B 358*	*394*	*437*	*B 567*	*373*	
		C 386			*C 431*		
	1,050	4,776	394	585	1,590	373	8,768
France:							
N. of Ardennes Massif	*520*	*B 2,600*	....	*1,690*	*B 6,260*		
		C 670			*C 420*		
Eastern	....	*B 3*	....	....	*B 13*		
					C 630		
Armorican massif	....	*B 2*	....	*7*	*B 24*		
Central massif	*59*	*B 233*	....	*890*	*B 1,079*		
		C 114			*C 632*		
Alps	*2*	....	....	*103*			
Lignite areas	....	....	*301*	....	....	*1,331*	
	581	3,622	301	2,690	9,058	1,331	17,583

EUROPE—*Continued*

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Italy:							
Anthracite..............	*1*	....	....	*143*			
Piciform Lignite........	....	....	*1*	....	....	*28*	
Xyloid Lignite..........	....	....	*50*	....	....	*20*	
	1	....	51	143	....	48	243
Greece....................	....	....	10	....	....	30	40
Bulgaria..................	....	....	....	....	C 30	358	388
Denmark							
Färoes..................	....	....	....	....	....	*50*	
						50	50
Netherlands:*							
South Limburg..........	*50*	*159*	....	*145*	*B 1,698*		
					C 320		
South Peel.............	....	....	....	*125*	*B 1,640*		
					C 265		
	50	159	....	270	3,923	....	4,402
Belgium:							
Campine...............							
Limbourg..........	....	....	....	....	*B 7,000*		
D'Anvers..........	....	....	....	....	*B 1,000*		
Namur.................	....	....	....	....	*B 3,000*		
					11,000	....	11,000
Germany:*							
Saar district...........	....	*B,C16,548*	....	....			
Westphalia.............	....	*B,C56,344*	....	....	*B,C157,222*		
L. Silesia..............	....	*B 718*	....	....	*B 2,226*		
U. Silesia..............	....	*B 10,325*	....	....	*B155,662*		
Saxony.................	....	*B 225*	*3,000*				
Left of the Rhine,........	....	*B 10,458*					
Other districts...........	....	*B 247*					
N. German States.......	....	....	*6.069*	....	....	*3,676*	
Bavaria.................	....	....	*75*	....	....	*293*	
Hesse..................	....	....	*169*	....	....	*99*	
		94,865	9,313	....	315,110	4,068	423,356

* A small amount of anthracitic coal is probably included in the Classes B and C given in the table.

EUROPE—*Continued*

	Actual Reserve (in million tons)			Probable Reserve (in million tons)			Total
	Class of Coal			Class of Coal			
	A	B & C	D	A	B & C	D	
Hungary:							
Carboniferous...........	....	....	....	....	*B 3*		
Liassic................	....	*B 4*	*3*	....	*B 106*	*22*	
Cretaceous.............	....	....	....	....	....	*3*	
Tertiary...............	....	....	*343*	....	....	*1,101*	
Neo-Tertiary...........	....	....	*8*	....	....	*124*	
		4	354	....	109	1,250	1,717
Austria:							
Alpine regions..........	....	*B 3*	*353*	....	*B 7*	*107*	
Tertiary lowlands........	....	....	*170*	....	....	*80*	
Bohemia, Silesia and Galicia..................	....	*B 2,967*	*11,707*	....	*B 25,410*	*463*	
Dalmatia...............	....	....	*1*	....	....	*13*	
Deep measures..........	....	....	....	....	*B 12,595*		
		2,970	12,231	....	38,012	663	53,876
Bosnia and Herzegovina:							
Triassic................	....	....	....	....	....	*1*	
Oligocene-Miocene.......	....	....	*850*	....	....	*475*	
Pliocene................	....	....	*850*	....	....	*1,500*	
			1,700	....	....	1,976	3,676
Servia....................	....	B 2	58	....	B 43	426	529
Roumania.................	....	....	3	....	....	36	39
Sweden...................	....	B 106	....	....	B 8	....	114
Russia:							
Dombrova...............	....	....	....	....	*B 2,525*		
Moscow.................	....	....	....	....	....	*1,578*	
Donetz..................	....	....	....	*37,599*	*B 18,014*		
S.W. Russia............	....	....	....	....	....	*43*	
W. Urals...............	....	*B 57*					
Caucasus...............	....	....	*12*	....	*B 253*	*25*	
		57	12	37,599	20,792	1,646	60,106
Spitzbergen..............	....	....	....	....	B 8,750	....	8,750
Total estimate for Europe	13,046	236,716	24,427	41,300	456,446	12,255	784,190

NOTE.—Small reserves of coal are found in Switzerland, Denmark, Iceland, Norway, Montenegro and Turkey. A reserve of brown-coal in eastern Prussia is probably underestimated.

TOTAL RESERVES OF THE WORLD

Actual Reserve

IN MILLION TONS

	Class of Coal			Totals
	A	B & C	D	
Oceania	99	2,405	1,569	4,073
Asia	8,895	11,310	297	20,502
Africa	2	343	154	499
America:				
North	*675*	*29,161*	*384,968*	
Central	....	....	....	
South	....	*2,087*	....	
	675	31,248	384,968	416,891
Europe	13,046	236,716	24,427	274,189
	22,717	282,022	411,415	716,154

Probable and Possible Reserve

	A	B & C	D	Totals
Oceania	560	131,076	34,701	166,337
Asia	398,742	748,788	111,554	1,259,084
Africa	11,660	44,780	900	57,340
America:				
North	*21,167*	*2,210,521*	*2,426,934*	
Central	....	*1*	*4*	
South	*700*	*29,310*	....	
	21,867	2,239,832	2,426,938	4,688,637
Europe	41,300	456,446	12,255	510,001
	474,129	3,620,922	2,586,348	6,681,399

Actual, Probable and Possible Reserves

IN MILLION TONS

	A	B & C	D	Total
Oceania	659	133,481	36,270	170,410
Asia	407,637	760,098	111,851	1,279,586
Africa	11,662	45,123	1,054	57,839
America	22,542	2,271,080	2,811,906	5,105,528
Europe	54,346	693,162	36,682	784,190
Total	496,846	3,902,944	2,997,763	7,397,553

SUMMARY OF THE REPORTS

(With short notes on a number of countries from which no full reports have been received.)

OCEANIA

New South Wales

(*E. F. Pittman*)

The coals of economic importance in New South Wales, occur principally in the Permo-Carboniferous, though seams of lignite and brown-coal are found in the Tertiary and coal of inferior quality, in the Mesozoic. The main coal-bearing area lies in the eastern portion of the State, and covers an area of about 16,550 square miles extending north-westerly from the east coast.

The Permo-Carboniferous system, in New South Wales, has been divided into six series, of which three, with a total thickness of about 3,000 feet, are coal-bearing, namely: The Upper, or Newcastle Coal-Measures, with 12 seams, having an aggregate thickness of 30 to 40 feet; the Middle or Tomago, or East Maitland Coal-Measures, with 3 to 7 seams, having an aggregate thickness of about 18 feet of coal; and the Lower or Greta Coal-Measures, with three seams, aggregating about 20 feet of coal.

The reserve of coal is estimated to be: Probable Reserve (B_3), 118,439,-880,000 tons.

Victoria

(*Department of Mines*)

The Department of Mines of Victoria furnishes the following estimate of the reserve of coal in the State:

Actual Reserve (B_3)..........	40,150,000	metric tons
Probable Reserve (B_3)........	12,000,000	"

The output of coal for the year 1911 was 300,000 tons.

The following brief description of the coal-bearing areas is taken from "The Coal Deposits of Victoria," by James Stirling.*

The coal-bearing deposits of Victoria occur in three well defined areas: the Gippsland district, the Cape Otway district and the Wannon (Merino) district. The coal is of two classes—Jurassic black-coal and Tertiary brown-coal, the latter occurring in deposits of enormous thickness. The Jurassic

* *Min. Jour.*, London, Vol. LXX, 1900, p. 1411.

coals are those principally mined. In the Gippsland area, where coal was first discovered, at Cape Patterson, the coal is mined at a number of places centreing around Korumburra, about 67 miles from Melbourne.

At Korumburra Coal creek three seams are worked: one with a thickness of 3 feet, at a depth of 60 feet from the surface; one 2 feet 6 inches, at a depth of 486 feet, and one 3 feet 5 inches, at a depth of 539 feet. It is estimated that 56,000,000 tons of coal are available in the Gippsland field. An analysis of the coal gave:—moisture 7.9%; volatile matter 28.78%; fixed carbon 57.17%; ash 6.14%.

At Jumbunna colliery, about 6 miles south of Korumburra, the seam worked is 5 feet thick in places and averages 4 feet. At Cape Patterson, the seam has an average thickness of from 2 feet 6 inches to 3 feet. At Kilcunda, on the coast, 12 miles distant, the seam is 2 feet 6 inches thick. Other localities where workable coals occur include Moe, Mirboo and Hazelwood where the seams are from 2 to 4 feet thick.

In the Cape Otway district the coal contains a higher percentage of fixed carbon.

The Victorian Jurassic coal is a good steaming and domestic fuel; it gives off comparatively little smoke and can be used to advantage for naval purposes where the absence of smoke is a desideratum. The average of a great number of proximate analyses gave:—moisture 4.10%; volatile matter 25.36%; fixed carbon 54.61%; ash 3.8%.

Beds of Eocene, Miocene and Pliocene age occur either directly overlying or flanking the areas occupied by the older coal formation. In some of the districts these deposits are separated by flows of basalt, and there is evidence of faulting succeeding the invasion of the basaltic rocks. This extensive faulting, in the Latrobe valley, at the close of the Miocene period, produced enormous depressions and in these large accumulations of vegetable matter were deposited during the Pliocene age. These deposits, now in the form of brown-coal or lignite, have been but little worked; small quantities were mined at Morwell river, Mirboo collieries, Yarragon, etc., during the great Maritime strike of 1890, and sporadic efforts have been made to work the Lal Lal deposits near Ballarat. The thickness of the Gippsland deposits is shown in a bore-hole put down near Morwell which disclosed no fewer than seven beds of brown-coal. Three of these proved to be of phenomenal thickness, without parallel elsewhere. A summary of the seams cut is as follows:

Depth from surface to top of seam	*Thickness of coal*
66 feet 2 inches	29 feet 8 inches
167 " 6 "	25 " 8 "
202 " 2 "	23 " 0 "
251 " 6 "	227 " 10 "
482 " 4 "	265 " 6 "
818 " 4 "	166 " 1 "
995 " 2 "	43 " 8 "
Total coal	781 feet 5 inches

In addition to the Morwell beds, there are other deposits of similar character outcropping on the banks of a number of the southern tributaries of the Latrobe river and on the head waters of the Tarwin river farther south, while at Mirboo and Yarragon, shafts were sunk through beds of brown-coal, varying from 20 to over 100 feet in thickness. To the west of Melbourne, at Newport, Altona bay and other places, deposits from 30 to 70 feet in thickness have been met with above the basalt which forms the consolidated rock surface at these localities. Similar deposits occur at Lal Lal near Ballarat, at Dean's Marsh, in the Cape Otway district and in other parts of the Colony.

It may be roughly estimated that an area 50 miles long, in the Latrobe valley, contains, within a depth of 1,000 feet from the surface, at least 31,144,319,000 tons of brown-coal.

Analyses of the coal mined near Morwell gave an average of: moisture 25.58%; volatile matter 32.14%; fixed carbon 39.06%; ash 2.30%.

Queensland

(*B. Dunstan*)

The coal-bearing series of Queensland are of three geological ages: upper Cretaceous; Trias-Jura, and Permo-Carboniferous. The area of the geologically surveyed coal-measures of the State is estimated to be 73,000 square miles. Of this area 20,000 square miles is made up of recognized coal-fields, the remainder consisting of lands known to contain coal in places; but not proved to be valuable for coal mining purposes. The Cretaceous fields are situated in the central part of the State and the Trias-Jura and Permo-Carboniferous fields in the south-eastern part. The Cretaceous fields are of minor importance, the Trias-Jura measures being those from which most of the coal supplies are now obtained, though it is probable that in the future the Permo-Carboniferous fields will be an important source of supply. In several of the areas very large seams are found, conspicuous among them being the 20-foot "Mammoth" seam, in the Mackenzie area and the 66-foot seam, in the Clermont area. Other noteworthy occurrences are the nine seams of the Burrum area containing 20 feet of good coal, the 20 feet of coal in the Callide area and the 60-foot seam at Waterpark creek.

The reserve of coal, underlying the parts of the coal-bearing areas that are fairly well known, is estimated to be:

Actual Reserve...........	2,097,120,000	metric tons
Probable Reserve.........	13,122,000,000	"

The greater part of the coal is bituminous of a high grade, though it includes a small amount of brown-coal.

South Australia

(*J. Keith Ward*)

Coal is found in three formations in South Australia; the Tertiary, the lower Cretaceous and the Jurassic. Mining has been attempted only in the

Leigh's Creek field where Jurassic coal-measures occupy several connected basins of erosion in the Palæozoic (probably Cambrian) rocks of the Flinders range and are known to continue over an area, the maximum length of which is sixteen miles and the maximum breadth, six miles. A seam, 7 feet thick, was mined for a time; but the venture did not prove a success. The coal does not stand exposure to the atmophere and is little better than brown-coal.

Small seams of brown-coal are found in the lower Cretaceous; and lignites in the Tertiary basins, of the southern portion of the State; but no attempts have been made to exploit them.

Tasmania

(*W. H. Twelvetrees*)

Important beds of coal are found in Tasmania, in deposits of Permo-Carboniferous and Mesozoic ages. The Permo-Carboniferous beds, known as the Lower Coal-Measures, lie chiefly in the north-western part of the island, although there is one field of some importance on the south-east coast. Few of the seams mined are more than 3 feet thick. The coals are generally bituminous and some of them are highly suitable for gas enrichment while others are good steam coals.

The Mesozoic coal-fields, which lie in the eastern part of the island, contain a large coal reserve and have the greatest output The seams are more numerous and thicker than those in the Permo-Carboniferous measures. The coal is generally bituminous; but contains less fixed carbon than that of the lower measures.

The probable reserve is estimated to be:

Permo-Carboniferous Coal (B_2)..	11,000,000 metric tons
Mesozoic Coal (B_3)............	54,800,000 "
Total....................	65,800,000 metric tons

Western Australia

(*Henry P. Woodward*)

Two coal-fields are known, one in the northern portion, at Liveringa station (not developed or mined) and the other in the southern portion, called the Collie field. The beds are believed to be Permo-Carboniferous and form a basin surrounded by granite. The area is estimated to be about 95 square miles. Boring operations have shown a number of seams, but in the four mines now working, the thicker seams only are mined; these vary from 6 to 10 feet. The thickest seams found in borings are 17 feet.

The coal is a non-caking, bituminous coal, high in moisture and burns with a short flame. The following is a representative analysis:

Moisture 21.18%; volatile matter 28.99%; fixed carbon 43.73%; ash 6.10%.

The reserve for the Collie field is estimated to be:

Actual Reserve (D_1)..........	153,331,200 metric tons
Probable Reserve (D_1)........	500,000,000 "

New Zealand

(*P. G. Morgan*)

The chief coal-bearing rocks in New Zealand are of Tertiary age; but coal-seams almost certainly occur in the upper Cretaceous and small seams in the Jurassic, in the southern part of South Island. There are considerable quantities of lignite of Miocene, Pliocene and possibly even Pleistocene age. The seams are marginal or basin deposits of lenticular character, which have been formed, generally, under fresh-water conditions; no seam has been traced more than a few miles. The maximum thickness of some of the lenses is as great as 80 feet, in the lignite seams; 50 to 60 feet, in the brown-coal seams, and about 50 feet, in the bituminous seams.

Owing to local structural conditions the coal has a wide range in character; but the highly altered coals form but a small reserve, the mass being bituminous coal, brown-coal and lignite. The amount of the reserves, arranged under the classification commonly adopted in New Zealand, is estimated to be:

Anthracite	Very little	
Bituminous coal (including semi-anthracite)	851,000,000	metric tons
Glance-coal or Pitch-coal	455,000,000	"
Brown-coal and lignite	2,080,000,000	"
Total	3,386,000,000	metric tons

British North Borneo

(*J. W. Evans*)

Coal of Tertiary age is widely distributed in British North Borneo. The coals mined are of Eocene age; but other deposits are known to occur, of Oligocene, Miocene, Pleistocene and Recent ages. The principal areas in which mining is being done are: (1) The Sadong River field, where 45 square miles have been prospected, with 2 seams, having 2 feet 6 inches and 3 feet of coal. (2) The Brooketon field, on the south-west side of Brunei bay, where very thick seams are found; the operating mines work two seams, 28 and 26 feet in thickness. The coal-measures probably extend under the sea as far as the north end of the island of Labuan, where coal outcrops in the hills. The extent of the area underlain by coal-seams has not been ascertained; but it is large. The coal is a brown-coal of good quality. (3) The Silimpopon coal-field, near Cowie harbour, one of the most important fields in North Borneo. A 5-foot, 10 inch seam is being mined, underlying a shallow synclinal basin. The reserve of coal in the Silimpopon has been estimated to be:

Actual Reserve	5,600,000	metric tons
Probable Reserve	70,000,000	"

The coals show, occasionally, patches of resin; they may be classed among the lower grades of bituminous coal or the higher grades of lignite.

Netherlands India

(*E. A. Douglas*)

The coal deposits of the Indian Archipelago contain a large reserve of coal; but, on account of the extent of the unexplored areas, it is impossible to estimate the amount. The coal-bearing measures are all of Tertiary age or younger. Among the best explored coal deposits are those of the Lower Tertiary formations of Sumatra, Java and Borneo, and of the younger coal formations of the north-western part of Borneo.

The Eocene coals are glistening black in colour, are hard, have a conchoidal fracture and yield practically no dust. They are good steam coals, burning with a long flame. The Borneo Eocene coals are rather high in ash, averaging 8%.

The younger, Miocene coal exhibits woody and earthy textures; it flakes on drying and falls to pieces.

The moisture in the coals is, for the Eocene, 3% to 6%; Miocene, 9%-20%; and Pliocene, more than 20%.

In Sumatra the main fields are the Lampong, in southern Sumatra and the Ombilin, the principal Eocene deposit, in the central part of the island. Lower Miocene coals are found in Benkoelen residency. Later Miocene and Pliocene coal-bearing beds are widely distributed, the principal areas being on the eastern part of the island, in Palembang.

In Java, Eocene coals are found at the west end of the island in several areas, the most important of which is the Bajah field. Miocene coal is also found in the same district. Oligocene and younger deposits occur to the east of the centre of the island.

In Borneo, Eocene coals occur in the western part of the island; but the region is too little known to permit of an estimate being made of the available amount of reserve. The eastern and south-eastern parts are better known. Actual mining operations are being carried on in the district east of Barito river, where several seams have been traced for a distance of 45 km. Other areas on the south-east coast and islands form parts of one basin.

Miocene coals are found on the east coast and one important deposit lies between the Segah and Kaleh rivers. Upper Miocene deposits, containing important lignite seams, lie between the last named locality and the sea, while farther to the north, near Saint Lucia bay, there are 21 seams, with about 31 metres of workable lignite.

Eocene and Miocene coals are known to occur also at several places on the island of Celebes and occurrences of coal in New Guinea are reported.

The reserve of coal in Netherlands India is estimated to be:

Sumatra—Actual Reserve (C)............	93,000,000	metric tons
Sumatra—Probable Reserve (C and D_1)....	107,650,000	"
Java—Probable Reserve (C and D_1)......	7,700,000	"
Borneo—Actual Reserve (C and D_1)......	774,800,000	"
Borneo—Probable Reserve (D_2)..........	337,000,000	"

The figures for Sumatra in the above table differ a little from those published in the main report for Netherlands India; they have been changed to agree with the following additional particulars regarding the Ombilin field, received from the Government of Netherlands India, after the first report had gone to press.

"The only coal-field now in exploitation is the Soengei Doerian one. The three seams occurring here, the A, B and C seams, are separated by about 20 metres of sand and mud-stones. The seams outcrop all along the western boundary of the coal-field. The strike is south-east—north-west and the dip, from 8° to 25° north-east. The seams are nearly all clean coal, interstratified with but few bands of sand-stone or shales. Both the floor and roof of the seams are very bad, consisting of soft mudstones.

"The coal is of very pure character, containing very little iron pyrites and occasionally small quantities of fossil resin. The percentage of ash is very low. In this respect the coal is one of the best in the world.

"The following are analyses of pure samples of the coal.

	Soengei Doerian No. 1	Soengei Doerian No. 2	Soengei Sapan-dalam	A-Seam Loento	C-Seam Sawah Rasau
	%	%	%	%	%
C	71.26	76.05	74.56	73.68	71.53
H	5.12	6.42	5.88	5.60	5.26
N. and O	12.28	12.46	13.51	14.01	13.34
S	0.79	0.41	0.35	0.45	
Ash	0.86	0.70	0.45	0.87	2.07
Hygroscopic moisture	9.69	3.87	5.25	5.39	7.80
Totals	100.00	100.00	100.00	100.00	100.00
Coke	65.84	56.57	61.63	57.45	59.06

"Specific gravity: 1.23 to 1.29.

"Calorific value: 7,300 to 7,600 calories.

"Ash: white, grey, red and violet in colour.

"Coke: sandy.

"The coal is hard, homogeneous, has a conchoidal fracture and is without any distinct cleavage. It burns with a long, smoky flame, without softening or any appearance of incipient fusion. When boiled in a strong solution of caustic potash, the filtered liquid is colourless or takes a pale yellow colour. Hydrochloric acid does not cause any precipitate.

"As may be seen from the above, the Ombilin coal must be placed with the bituminous black coals and in Class C of the proposed classification. It is a good steam coal and is, therefore, sought after by railway and shipping companies, which, in fact, are the principal consumers. The firing of the Ombilin coal is very easy, but, owing to its being a long-flaming coal of rapid combustion, it requires to be burned with a shortened fire and plenty of air at the back of the fire-bridge.

"A serious drawback in mining the coal is the tendency of the small coal to spontaneous combustion, which already has caused many underground fires in the thick seam C. The removal of all small coal and hydraulic filling with sand now tend to reduce this danger to a minimum."

COAL RESOURCES OF THE OMBILIN RIVER COAL-FIELDS

GROUP I

Including Seams of 1 foot or over, to a Depth of 4,000 feet

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		
	No.	Thickness in metres	Area in sq. km.	Class of Coal	Metric Tons	Area in sq. km.	Class of Coal	Metric Tons
Soengei Doerian..	3	2–2.20, 1.50, 6–7	14	C	93,000,000			
Sigaloet..........	4	1–2.30, 1.20–1.50, 1–1.50, 1.....	....	....	....	23.5	C	79,300,000
Sigaleot, Seam B..	1	1	....	....	....	1.5	C	700,000
Soegar...........	2	2–2.20, 6–7	....	....	....	Approximate 5	C	*
Parambahan.....	4	1.50, 2–2.50, 3, 10	....	....	....	Approximate 3	C	20,000,000
West of the river, Loera Gedang .	3	2, 1.50, 1.50	....	....	....	2	C	4,000,000

* Possible reserve, moderate.

Philippine Islands

(F. A. Dalburg)

The coal-seams of commercial importance in the Philippines are of Tertiary age and for the most part belong to the Miocene series. The coal ranges in quality from lignite to bituminous, sub-bituminous coals and black lignites making up by far the largest part of the whole reserve of 66,336,400 tons, divided into 4,355,600 tons actual and 61,980,800 tons probable reserve. The total area of the known coal-fields is about 53 square miles; the area known to contain mineable coal is estimated to be less than 7 square miles. The coal-fields are made up of small, widely-separated areas, which may be grouped under six general geographical provinces.

1. Batan.—As far as known an area of 11 square miles, in Batan, contains

25,996,000 metric tons of lignite and 2 square miles, 277,600 metric tons of sub-bituminous coal. The workable beds are from 2 to 8 in number and average 3 to 12 feet in thickness. The beds in the eastern part of the island lie in the form of a monocline dipping 10° to 30° to the north-west.

2. Cebu.—The most promising coal-field of the Philippines is situated on the east side of this island, in folded and faulted Tertiary beds. The coals are all sub-bituminous. The total estimate (mostly probable reserve) is 30,241,600 metric tons, in four districts, in which from 3 to 4 seams are known, having a thickness of from 15 to 29 feet of coal.

3. Polillo, where the strata carrying coal-seams flank an igneous complex, and are somewhat folded from the effect of an east-west lateral thrust. The two seams of workable thickness have about $9\frac{1}{2}$ feet of coal. The probable reserve is 1,331,200 tons of bituminous coal.

4. Mindanao, where there are two seams, 5 and 8 feet thick, of bituminous coal. The coal is firm, does not air-slack and makes a hard, coherent coke. The reserve is estimated to be 3,628,000 tons of bituminous coal.

5. Masbate.—In Masbate the coal-bearing rocks, of upper Oligocene or Miocene age, are flexed and folded, with a N.W.-S.E. strike. Three seams, having from 3 to $4\frac{1}{2}$ feet of sub-bituminous coal, are known. The reserve is estimated at 612,000 tons.

6. Mindoro.—Six seams, from 3 to 12 feet thick, are reported to occur in the southern part of the island. The reserve is estimated to be 4,096,000 tons of lignite.

7. Sugud.—Seams from 10 to 27 feet thick, of Tertiary age, occur in the southern part of Luzon island. The coal is firm and does not air slack. The coal reserve is estimated at 154,000 tons of sub-bituminous coal.

Antarctic

(T. W. E. David)

The coal-fields of the Ross Quadrant (or Australian Sector) of Antarctica are of great, but as yet unknown, extent and probably reach from the south pole to 73° S. latitude, a distance of over a thousand miles. Coal has been found at Mount Buckley, at the head of the Beardmore glacier, also at Mackay glacier, two localities separated by 605 geographical miles. The structure of this field is that of an immense, long and narrow "horst" bounded by faults. There is probably an area of 12,000 square miles of coal-bearing rocks. The concealed field under the vast area of inland plateau to the west, is also very large, six coal-seams with with 22 feet of coal are reported. The age of the rocks containing the coal-seams is believed to be Permian.

Subsequent to the printing of the main portion of the monograph a letter was received from Dr. David in which he says: "The fact is forced upon me that I have omitted to allow for no doubt a considerable amount of either glacial or fluviatile erosion of the coal-measures on the western side of the great horst of the Antarctic Andes in the eastern hemisphere, and on the eastern side of the same range in the western hemisphere. Antarctica is, of course, a mirror image of South America, and such a vast tectonic range, of such antiquity as the one just mentioned, cannot fail to have had large subsequent rivers or glaciers, or both, in Tertiary time, running over and eroding the Coal-Measure rocks. I think, therefore, that some allowance in the way of deduction must be made for the coal removed from these old consequent valleys."

ASIA

China

(*Noah Drake and K. Inouye*)

Coal is widely distributed over China. Two of the coal-bearing areas are very large; one, in northern China, overlying most of the southern part of Shansi; and one, in the south, extending, in isolated patches and large fields, over southern Hunan, Kueichou, Yunnan and Szechuan. Deposited in apparent conformity on the eroded surface of Ordovician (Sinian) limestone are a succession of beds ranging in age from Pennsylvanian to Tertiary. Coal occurs in all the systems, with the probable exception of the Cretaceous; but is found most abundantly in beds that are probably Permo-Carboniferous. Fossil plants, found in the lowest coal-beds, show a mingling of Pennsylvanian and Permian forms, and there is now a tendency among geologists who have studied them, to call even these Permo-Carboniferous. In variety, the coals range from hard, dry anthracites to lignites with woody structure. There are extensive deposits of each kind.

Chihli.—An area of 469 square miles is estimated to contain; anthracitic coal, 10,027,000,000 tons; bituminous coal, 11,691,000,000 tons; coal with high volatile, 950,000,000 tons.

Shan-tung.—All the coal-fields of importance in Shan-tung are of Permo-Carboniferous age. An area of 218 square miles probably contains; anthracitic coal, 2,000,000,000 tons and bituminous coal, 5,083,000,000 tons.

Shansi.—Practically all of south Shansi is one great coal-field. It is an elevated plateau, dissected by valleys. Sinian limestone underlies the most of this field, in flat beds. The coal of the largest seam averages 25 feet in thickness. The area estimated as coal-bearing, 23,225 square miles, contains; anthracite, 300,000,000,000 tons and bituminous coal, 414,340,000,000, tons.

Shensi.—It is doubtful whether or not the coal-bearing areas of southern and central Shensi are of much value; but it is probable that there are good coal-lands of considerable extent in the northern part of the province. It is estimated that 100 square miles contains 1,050,000,000 tons of bituminous coal.

Kansu.—The province of Kansu is not well known; but it is reported to rival Shansi in the richness and extent of its coal-fields. An approximate estimate of the reserve, underlying 510 square miles, is 5,129,000,000 tons of bituminous coal.

Honan.—The coal-areas in Honan are affected by block faulting and folding. Many of the fault blocks are covered by the loess and alluvium of the coastal plains. The coal-seams, which probably average 20 feet in aggregate thickness, occur in Permo-Carboniferous rocks. An estimate of the reserve underlying 515 square miles is; anthracite, 6,575,000,000 tons; bituminous coal, 2,700,000,000 tons.

Kiangsu.—The best known fields in Kiangsu lie along the sides of the Nan King hills. The reserve is estimated to be 10,000,000 tons of anthracite.

Anhui.—All the known coal-fields in the province lie to the east of the Yang-Tse river. A very conservative estimate of the reserves includes an area of 35 square miles containing 187,000,000 tons of coal, mostly semi-anthracite, though analyses show that bituminous coals, generally non-caking, occur in the Hsuan-cheng field.

Hupei.—Six thin coal-seams are found in the lower Mesozoic in Hupei province. The coal is mined and made into briquettes. A small area of 10 square miles is estimated to contain 17,000,000 tons of bituminous coal and other fields in the province, 100,000,000 tons.

Chekiang.—It is estimated that Mesozoic coal (B_2 of the Schedule) underlies 36 square miles in Chekiang, to the amount of 120,000,000 tons. The Carboniferous coals of this province are generally dirty and crushed. In 10½ square miles the reserve is estimated to be 18,700,000 tons of anthracite and about 6,000,000 tons of bituminous coal.

Kiangsi.—Several large areas of Permo-Carboniferous measures are found in this province, including the fields of Feng-cheng, Ping-Hsiang, Hsin-yu and Hsing-an. They are estimated to contain 720,000,000 tons of bituminous coal. For the whole province, the reserve is estimated to be 3,395,000,000 tons of bituminous coal.

Fukien.—Two coal-fields are known in Fukien, in neither of which has much mining been done. The reserve is estimated to be 80,000,000, tons of anthracite.

Kuangtung.—The coal-beds of Kuangtung range in age from Permo-Carboniferous to Jurassic. Nearly all the principal coal-fields lie north of Shao Chow; one lies to the west of Canton. The reserve in the province is estimated to be 1,009,000,000 tons, divided between bituminous and semi-anthracite and anthracite, in the proportion of one-third to two-thirds.

Kuangsi.—Very little is known of the coal-fields of Kuangsi. At Hoshien, where the Chinese Government is opening a mine, there are nine seams, with an aggregate thickness of 27.2 feet. The reserve of coal in the province has been estimated to be not less than 500,000,000 tons.

Hunan.—Both anthracite and bituminous coal are mined in Hunan, the annual output of the province being about 5,000,000 tons. In the Sieu river district, one of the principal fields for the production of anthracite, an average thickness of 15 feet of coal is found, in crushed and folded strata. In places one of the seams has a thickness of more than 50 feet. It is estimated that in the Sieu River field an area of 2,700 square miles contains a reserve of 48,000,000,000 tons of coal; that in the Siang River field an area of about the same size contains 41,500,000,000 tons of bituminous coal and that other fields in the province contain 500,000,000 tons.

Szechuan.—The coal-bearing area in Szechuan probably exceeds in size that in any other province, while the mineable area is less than in Shansi, Hunan or Kansu. The thickness of coal, also, is probably less than in other provinces. The best coal is found in the northern part of the basin and is bituminous.

The anthracite of the southern part occurs in measures reported to be Silurian (?) In all, an area of 15,000 square miles is probably underlain by seams with an average thickness of 5 feet. The estimated reserve of coal is apportioned as follows; lignite, 500,000,000 tons; bituminous coal, 60,000,000,000; anthracite, 20,000,000,000 tons.

Kueichou.—In Kueichou, coal occurs in strata of Carboniferous, Permian and Rhætic ages; a coal-bed, from one to one-and-a-half metres in thickness, is found in each of these groups. The Carboniferous coal, though bituminous in places, generally approaches anthracite in composition. The Rhætic coal is higher in volatile matter; but does not make as good coke. It is estimated that an area of 10,000 square miles contains a reserve of 30,000,000,000 tons of coal, mostly bituminous.

Yunnan.—Palæozoic (probably Carboniferous), Rhætic and Pliocene coals are found in Yunnan. The Palæozoic coals give good strong coke; but some of them are rather low in volatile matter for bituminous coals and the ash content is high. The Rhætic coals give lighter coke and contain less ash. The Pliocene coals are lignites and underlie only a small area. Owing to the disturbed condition of the strata, probably only one third of the coal-bearing area of 10,000 square miles is available for mining. The reserves are estimated to be, 100,000,000 tons of lignite and 30,000,000,000 tons of bituminous coal.

The coal reserve of all China is estimated to be:

Coal of Class A..........	387,464,700,000	metric tons
Coal of Class B..........	606,573,000,000	"
Coal of Class C..........	950,000,000	"
Coal of Class D..........	600,000,000	"
Total...............	995,587,700,000	metric tons

COREA

(*K. Inouye*)

The most important coal-bearing measures in Corea are of Mesozoic age, although coal occurs also in Palæozoic and Tertiary rocks. The Palæozoic coals are not important. The floor of the Palæozoic coal-bearing formations (the Corean formation) in part represents the Sinian of China. Both Palæozoic and Mesozoic coals are altered by igneous intrusions and the coal reserve consists mainly of anthracitic coals with a small amount of bituminous coal and brown-coal. The Tertiary deposits lie near the coast and produce lignite.

The coal-bearing areas of the Carboniferous system are small; two only, situated in Phyöng-an-dō, seem to be of importance. The coal is anthracitic but contains a high percentage of water.

The Mesozoic (Jurassic) coal-bearing rocks are spread over a large region in southern Phyöng-an-dō, where they lie on a basement of gneiss or Palæozoic limestone.

The Tertiary deposits are made up mostly of shale, sandstone, conglomerate and tuff, intruded by andesite and basalt and, in places, covered by basalt.

The coal-seams of all ages, in Corea, are irregular in thickness and, in estimating the reserve, the various areas are assumed to have only an average of three feet of coal, although occurrences of 20 feet are reported.

An area of eight square miles is estimated to be probably coal-bearing and to contain the following reserves:

Anthracite and semi-anthracite...	40,820,000 metric tons
Bituminous coal...............	14,130,000 "
Lignite.......................	27,000,000 "
Total...................	81,950,000 metric tons

Manchuria

(*K. Inouye*)

The coal of Manchuria occurs in the Carboniferous, the Jurassic and the Tertiary. The most important mining area is in the Fu-shun valley, where Tertiary coal is being mined, though Carboniferous coal-bearing rocks are very widely spread and contain a large reserve.

The basement complex is a gneissic system, on which the Takushan and Sinian formations have been deposited in small areas, in which basins of Carboniferous Coal-Measures are found. These basins are confined mainly to the province of Hsing-King, although small outliers are found in the southern part of Hei-lung-kiang and near K'uan-chieh, in the province of Chi-lin. The coal-bearing Jurassic is found chiefly in the province of Chi-lin, where it rests directly on the gneiss or other older formations. The Tertiary is found only in the Fu-shun valley. It, also, lies directly on gneiss and is intruded by basalt. The Tertiary coal-bearing area is only 48 square kilometers in extent; but its coal reserve is the most important in Manchuria.

The Manchurian coal is of three kinds, anthracite, semi-anthracite and bituminous coal. The Carboniferous coal is all anthracite and semi-anthracite. The Jurassic coal is semi-anthracite and bituminous and the Tertiary is bituminous.

The province of Hsing-King, which is probably the richest in coal, is estimated to contain a reserve of 876,000,000 tons of Tertiary coal; 322,500,000 tons of Carboniferous coal and 3,500,000 tons of Jurassic coal.

The coal of the province of Chi-lin is found mostly in the Jurassic and the reserve is estimated to be 7,000,000 tons of bituminous coal.

For the whole of Manchuria the reserve is estimated to be 1,209,000,000 tons, distributed in the following grades:

Semi-anthracite and non-coking..	68,500,000 metric tons
Bituminous..................	254,000,000 "
Bituminous, with high volatile. .	886,500,000 "
Total.....................	1,209,000,000 metric tons

Japan

(*K. Inouye*)

Coal is widely distributed over all the islands constituting the Empire of Japan. The coal is all found in the later geological systems, the oldest coal occurring in the Mesozoic. Honshu, the largest island, probably has the greatest area of coal-bearing rocks; but in quality and quantity of coal, the islands Kyūshū and Hokkaidō are of greater importance. The mines situated in the northern part of Kyūshū furnish about 50% of the total output, which for 1911 was 17 million tons, of which about one-fifth was exported.

The most important coal deposits of Japan are found in the Tertiary, in beds of about Miocene age. Triassic coal occurs in the province of Bitchū and Rhætic coal in the province of Nagato. Jurassic areas in central Japan contain coal but it is of little importance; coal is found in the Cretaceous, on the island of Amakusa, south of Nagasaki; and coal of inferior quality is found also in small quantity in the Pliocene.

In character the coal ranges from lignite to anthracite, bituminous coal constituting the most valuable part; semi-anthracite coal occurs mostly among the Mesozoic, bituminous coals, in the Miocene; and lignites, in the Pliocene.

The areas for which reserves are calculated amount to 1786 square kilometres.

The total reserve contained in areas that are fairly well known is estimated to be:

Anthracite	16,500,000	metric tons
Semi-anthracite and dry coals	45,500,000	"
Bituminous and gas coals	7,130,000,000	"
Sub-bituminous coal and lignite	779,000,000	"
Total	7,971,000,000	metric tons

Federated Malay States

(*J. W. Evans*)

An important discovery of coal, apparently in two seams, in the Tertiary, has been made seven miles west of Rawang. The larger and upper seam is more than twenty-four feet in thickness and has been traced half-a-mile on the strike. It is a lustrous coal with conchoidal fracture and burns with a long smoky flame.

Siam

(*John H. Heal*)

Brown-coal has been reported to occur in several districts in Siam. Beds prospected in the province of Gherbi are thick and appear to be of fair extent; but there is not enough information available to allow of an estimate of reserves being made.

India

(*H. H. Hayden*)

The coal-fields of India are of large extent and probably contain an enormous reserve. Sufficient information is available for an estimate of the reserves near the surface only, or to a depth of considerably less than 4,000 feet. The fields may be divided into those of the Gondwana (Permo-Carboniferous) and those of the Tertiary, of which the first are the more important, from which 96% of the output of coal is derived.

The coal-bearing rocks of the Gondwana are preserved as small patches, let down by faulting into the great crystalline mass of the peninsula. A string of these patches, which determines the direction of the Damuda river, includes the most valuable of the coal deposits. The Gondwana is divided into Upper and Lower and it is only in the lower that coal-seams of importance have been found. The divisions of the lower Gondwana are, in descending order:

Panchet series	
Damuda series	Raniganj stage, coal-bearing. Ironstone stage, barren. Barakar stage, coal-bearing.
Talchir series	

The Talchir series, the basal beds of which are a boulder slate, universally regarded as of glacial origin, lies unconformably on all older beds. The Damuda series supplies all the coal that is being exploited.

The total superficial area for which an estimate is made, is 3,333 square miles and the total tonnage is 58,801,344,000; of this, the bituminous coal, that is probably of coking quality, may be estimated at 11,446,000,000 tons, the remainder being partly domestic and steam coals of lower calorific value than those above, and falling in grades B_3 and D of the schedule. The Mesozoic and Tertiary fields of India are widely distributed.

In Assam, the coal-fields form two groups, (a) a belt of coal-bearing rocks extending along the north-east frontier for about ninety miles and (b) scattered fields in the Khasia, Garo and Jaintia hills. The mines at Margherita, in measures of the first group, produce about 300,000 tons of coal annually. The seams worked aggregate 80 feet in thickness. The seams in the second group are thin.

In Baluchistan, thin seams are found in many different localities but the quality of the coal is not high and the quantity is small; and in Burma, Kashmir and Jammu, inferior coals are known to occur.

In the Punjaub, coal is found in the districts of Jhelam and Shahpur, lying below the nummulitic limestone of the Salt Range. The seams are thin and the coal is of poor quality; but it has been worked at Dandot. At Isa Kehl a seam 2 feet 3 inches in thickness has been proved over a small area.

In Rajputana, lignite has been discovered at Palana, at a depth of 200 feet below the surface.

The reserve of Mesozoic and Tertiary coals is estimated to be:

Class C....................	147,153,000 metric tons
Class D....................	52,500,000 "
Total..................	199,653,000 metric tons

The reserves for the whole of India are estimated to be:

Classes B_2 and C...........	11,593,153,000 metric tons
Classes B_3 and D..........	67,407,844,000 "
Totals................	79,000,997,000 metric tons

Persia

(*H. L. Rabino*)

Persia apparently contains large, undeveloped coal resources, about which there is little available information; coal is mined in many places but in a primitive manner.

The Teheran coal-field is estimated to have an area of 1,000 square miles, largely covered by alluvium, but probably underlain by coal-measures since they outcrop in small areas in the hills to the north. For this field 1,858,000,000 tons of coal is estimated as a possible reserve. The field is divided into north-western and north-eastern districts; the output of the north-western part is estimated at 11,000 tons yearly and of the north-eastern at about 4,000 tons. In the Khorasan coal-field, the seams are reported to be thin and no coal is being mined. In Astrabad, Shahrud, Bastam and Semnan districts, in the north-eastern part of Persia, good bituminous coal is known to occur; the seams are not thick, 5 feet being the largest reported. In the Mazanderan district, coal of poor quality has been found at several places and anthracite is reported to occur in Kerman and Yezd. A. F. Stahl*, in a paper on the Geology of Persia, states that the coal occurrences in northern Persia are of lower Jurassic and upper Liassic ages.

Indo-China (French)

(*H. Lantenois*)

Both anthracite and bituminous coals are found in Tonkin and Annam, anthracite being by far the more important.

In Tonkin, the coal-beds all belong to the Rhætic formation. The principal areas are: the basin of Hongay (the most important), the basin of Kébao island and the basin of Dong-Triêu. The superficial area of the fields is about 1,000 square kilometres and they contain an estimated reserve of 20,000,000,000 tons of anthracite.

In Annam, the basin of Nong-Son is the largest coal-bearing area. For this

* Supplement No. 122 to Peterman's Mitteilungen, Vol. XXVI, 1896-7, p. 9.

basin M. Edmund Fuchs (Anal. des Mines, Vol. II, 1882, p. 247) gives an average thickness of 2.50 m. of coal and a minimum available tonnage of 2,500,000 tons.

Bituminous coals are known to occur only in sporadic basins near Thai Nguyên, Cho-Bo, and Phu-Ly.

Arabia (Oman)

The following information is supplied by Major S. G. Knox, H.B.M. Consul, Muscat.

There are no coal resources in the portion of Arabia under British influence except those of Oman. The coal reported near Soor has been declared by expert opinion to be unworkable at a profit in present circumstances, owing to its unfavourable situation at a distance from the coast and for other reasons.

Coal is known to occur also at Masweh and Fisao; there are about 21 seams, from 1 foot 6 inches to 4 feet 6 inches thick, extending over an area of one-quarter of a square mile. The coal resembles Assam coal in quality, that is to say, it is bituminous.

The estimated reserve is 250,000 metric tons.

AFRICA

Egypt

(W. F. Hume)

No coal of commercial importance has been discovered as yet in Egypt, but very thin seams both of lignite and coal have been found in various wells and borings, in beds of Oligocene or Eocene age and in the Nubian sandstone.

Although rocks of the Carboniferous system are represented in Egypt, the Coal-Measures appear to be wanting.

Sudan and Abyssinia

(S. C. Dunn and G. W. Grabham)

With the exception of a lignite seam, nine centimetres thick, discovered when sinking a well in the town of Dongola, no coal has been found in the Anglo-Egyptian Sudan, although it is rumoured among the Arabs that coal or lignite occurs in Darfur.

In Abyssinia, near Addis Abbaba, the capital, coal is mined by the natives for fuel. The existence of coal has been reported from the vicinity of Lake Tsana, from the valley of the Didessa river, and from Chelga, about 30 kilometres north of Lake Tsana. At the last-named locality, seven seams of good lignite were found, varying from 15 to 53 centimetres in thickness. They are supposed to be of Tertiary age.

East African Protectorate

(*J. W. Evans*)

No important coal deposits have yet been discovered in the East African Protectorate. Some carbonaceous material of lignitic character has been found near Mivele, south-west of Mombasa. It is probably Pleistocene in age.

Southern Nigeria

(*J. W. Evans*)

Valuable seams of both lignite and sub-bituminous coal occur in Southern Nigeria, the former being found in the Lignite series, of Tertiary age, and the latter in rocks which have been referred to the Mesozoic, and are usually considered to be late Cretaceous in age.

The two best known lignite-bearing districts are situated on either side of the Niger river, in the neighbourhood of Onitsha and Asaba. The total areal extent of the Lignite series is not known but a number of seams have been discovered at various localities. At Obompa, 24 miles north-west of Asaba, six seams have been noted, ranging from 8 to 20 feet in thickness and containing a total of 77 feet of lignite in about 250 feet of measures.

The lignites of Southern Nigeria compare favourably with those of Europe. A sample was sent to Germany for briquetting trials and hard, black, lustrous briquettes were obtained which gave good results in steam-raising.

Seams of sub-bituminous coal have been found outcropping at several points along the eastern escarpment of a plateau about 45 miles east of the Niger. As many as five seams have been found, varying in thickness from 1 foot 11 inches to 5 feet 8 inches.

The actual reserve has been estimated at a minimum of 80,000,000 tons and the probable reserve must be greatly in excess of this figure, as it is thought that the coal underlies an area of over 2,000 square miles. The coal may be classed as D_1.

Rhodesia

(*H. B. Maufe*)

In Rhodesia the greater part of the coal is found in the Lower Matobola beds, near the base of the Karroo system, which are supposed to be equivalent to the Ecca series of Cape Colony. The Karroo system, as a whole, occupies large areas, but owing to an extensive overlap of the upper members, the coal-bearing series is confined chiefly to the lower-lying ground. The Rhodesian coal-fields are, as a rule, shallow, but it seems probable that a concealed field exists to the north-west of the Wankie field, which is bounded in that direction by the Deka fault, with an estimated throw of not less than 2,000 feet.

In the Wankie field, the only one where coal is at present being mined, a seam of bituminous coal from 6 to 12½ feet thick is worked.

The total coal resources of Rhodesia have been estimated at 569,411,000 tons, of which 419,317,000 tons has been considered as actual reserve. About 74% of the total has been placed in Class B, the remainder being classed as A and C.

Nyasaland

(*J. W. Evans*)

The coal of Nyasaland occurs in rocks of the Karroo system. Areas of coal-bearing rocks are found both in the north and along the south-west border.

In the north, they occur as fault blocks in crystalline schists and, by reason of the soft, easily eroded nature of the rocks, usually occupy low ground. Several seams are known with an aggregate thickness of from 6 to $22\frac{1}{2}$ feet, in a coal-bearing series with a maximum thickness of 150 feet. The seams are usually lenticular and variable in character. The coal is bituminous and in places, as in Mount Waller area, is suitable for the manufacture of metallurgical coke.

In the Lower Shire district, on the south-west border, the Karroo system underlies an area of about 800 square miles and is known to contain a few, thin seams of non-caking, bituminous coal.

Union of South Africa

(*Department of Mines*)

All the coal in the Union of South Africa, with the exception of some unimportant lignite beds in Cape Colony, is contained in rocks of the Karroo system.

In the Transvaal, the Karroo system is comparatively thin and the coal-seams occur usually within a vertical distance of 200 feet above the basal Glacial conglomerate. The coal-bearing strata are usually nearly horizontal and occupy the higher parts of the country. The several areas have been separated by denudation.

In the Witbank coal-field, the best known in the Transvaal, five seams occur, ranging from 1 to 20 feet in thickness, with an aggregate of 56 feet of coal.

The number and thickness of the seams varies considerably in the different districts. It is estimated that an average thickness of 6 feet of coal underlies an area of 5,000 square miles and that the total reserve is about 36,000,000,000 tons, 80 per cent. of which is classed as B_2.

In the Cape of Good Hope, the Karroo system attains its greatest development, reaching a maximum thickness of 18,000 feet. All the coal in the Cape Province is found in the Molteno stage of the Stormberg series, one of the upper divisions of the Karroo series, and probably of Rhætic age. In many places the coal-bearing beds have been intruded by dolerite, in the form of dikes and sills, which has in many cases anthracitized the coal. The seams are usually thin and often contain shale partings. The thickness of the seams generally worked is from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet. Indwe is the most important mining centre, while coal is mined over a wide area in the vicinity of Molteno, Cyfergat and Bamboes Spruit.

It is estimated that, in the Cape, Orange Free State, Basutoland and Swaziland, there is a total area of 1,000 square miles underlain by an average of 4 feet of coal and containing about 4,800,000,000 tons, of which 60% can be classed as B and 20% as A.

The total coal reserve for the whole Union of South Africa is estimated at 56,200,000,000 tons, ranging from Class A to C.

Madagascar

(*F. Bonnefond*)

Coal has been found in two areas in Madagascar, known as the Ianapera and Ambohibaty basins. In both areas the coal-bearing beds are supposed to be of early Permian age and may probably be correlated with part of the Karroo system of South Africa. The coal-bearing areas occur in basins in Archæan gneisses and schists; but their areal extent has not as yet been closely defined.

The coal-areas are situated near together, at the south-western extremity of the island, on the Onilahy river.

Four seams have been discovered in the larger or Ianapera area, ranging from about 1 foot to 8 feet 4 inches in thickness. The coal resembles boghead or cannel, being hard and tough and having a conchoidal fracture. It contains a rather high percentage of ash.

Belgian Congo

(*Armand Renier*)

Two coal-bearing areas are known in Belgian Congo, one on the Lukuga river, between Kingombe and Milange, and the second on the upper Lualaba river and its tributaries, the Luweisha, Shiwa and Kasope rivers.

In the first-named field, the rocks occur below the Kundelungu formation, and are believed to be equivalent to the base of the Karroo system and to be of Permo-Carboniferous age. The strata, which lie almost horizontally, contain three coal-seams, with a minimum thickness of 3 metres, and underlying an area of at least 30 square kilometres. The coal contains about 40% of volatile material and 10% of ash.

The rocks of the Lualaba area are younger than those of the Lukuga field and are believed to be either upper Permian or Triassic in age. A number of coal-seams occur, with thicknesses of one metre or more. The coal-bearing beds outcrop over an area 38 kilometres in length and from 5 to 7 kilometres in width containing about 225 square kilometres; they dip gently to the north-west, under younger rocks. The coal is, as a rule, dirty and high in sulphur; an average analysis from the best seams shows 29% volatile material, 48% fixed carbon and 9.5% ash; other seams yield from 40 to 50% ash.*

* The author has made no attempt to estimate the coal reserve but, from his figures, the probable reserve may be estimated as follows:

Lukuga	90,000,000 tons.
Lualaba	900,000,000 "
Total	990,000,000 tons.

Countries which have reported no known Coal Resources

Country	*Authority*
French Equatorial Africa	Le Gouvernement Général de l'Afrique équitoriale française.
Algeria and Tunis	M. Jacob, Inspecteur Général des Mines, Alger.
Gold Coast	J. Cogill, Secretary for Mines.
Liberia	J. G. Boulton, H.B.M. Consul, Monrovia.
Mauritius	J. Middleton, Colonial Secretary.
Morocco	Sir Reginald Lister, H.B.M. Min. Plen., Tangier.
Northern Nigeria	Sir H. Hesketh Bell, Governor of Northern Nigeria.
Seychelles	The Governor of the Seychelles.
Sierra Leone	G. B. Haddon-Smith, Colonial Secretary.
Somaliland (British)	H.B.M. Commissioner in Somaliland.
Zanzibar and Pemba	H.B.M. Consul General.

NORTH AMERICA

Newfoundland

(*J. P. Howley*)

Carboniferous rocks underlie two large areas in Newfoundland, the larger situated on the south side of St. George bay and the smaller on the shores of Grand lake and in the valley of the Humber river.

In both areas, the strata have been severely folded and remnants, only, of the Coal-Measures, are found, in comparatively narrow and shallow, synclinal troughs; the greater part of the Carboniferous areas being underlain by the lower unproductive beds.

In the St. George bay area, the most important coal-bearing trough lies parallel to the shore, its axis being about eight miles inland; the width of the area is about two miles and its length, so far as determined, five miles. Nine coal-seams, over one foot in thickness, have been found, with an aggregate thickness of 23 feet 3 inches. The quality of the coal in some of the larger seams is excellent; an analysis of a $4\frac{1}{2}$-foot seam gave: moisture, 3.036%; volatile matter, 30.344%; fixed carbon, 60.142%; sulphur, 1.963%; ash, 4.515%; the coal, therefore, falling in the Class B_2 of the schedule.

In the Humber river district, a narrow synclinal trough of Coal-Measures, with a known length of eleven miles, occurs near the foot of Grand lake. The highly tilted, coal-bearing beds contain as many as fifteen seams, nine of which, one foot or over in thickness, have an aggregate thickness of 18 feet 8 inches. The coal is of good quality and can be included in Class B_2.

As sufficient information is not available no attempt has been made to estimate the coal reserve.*

* The thickness of the coal and the known extent of the areas would seem to warrant a minimum estimate of 500,000,000 tons for probable reserve.

Canada

(*D. B. Dowling*)

Canada has very large supplies of coal, situated in the Atlantic and Pacific coast regions, in the mountains of British Columbia and Alberta and in the Plains region of the central interior. The coal-fields of both coasts, as well as many separate areas in the interior, are being actively mined and for these the reserves can be estimated somewhat closely, but there are large areas in the provinces of Saskatchewan and Alberta which are classed as coal-fields on geological evidence alone.

Age of the deposits.—Interglacial deposits of lignite, of no present value, are found in Ontario and southern British Columbia. Small areas of Tertiary sediments with mineable lignite deposits are found in British Columbia, Yukon and the Arctic islands. In the Lower Tertiary sediments of Alberta and Saskatchewan, valuable lignite and sub-bituminous coals occur. A great reserve of coal is found in rocks representing the close of the Cretaceous period in the great coal-fields in Alberta and southern Saskatchewan, while upper Cretaceous coals are found on the Pacific coast, on Vancouver island and in the region of the great plains. The bituminous coals and anthracites of the Rocky mountains and the coals of many areas in British Columbia and Yukon are of lower Cretaceous age and occur near the base of that system. The bituminous coal of Nova Scotia occurs in the Carboniferous Coal-Measures. In New Brunswick, a few coal-seams are found in the so-called Millstone Grit, which underlies the productive measures in Nova Scotia. Below the Carboniferous limestones, a series of sandstones and shales, in parts of Nova Scotia, contains thin coal-seams; and important deposits of cannel and oil shales in the Arctic islands are credited to the same age.

Distribution.—On the Atlantic and Pacific seaboards, bituminous coals are extensively mined. The interior fields supply coals of various kinds, the coals of the mountains being the most important and of the highest grade. The coal-fields of Manitoba and southern Saskatchewan supply coals, lignitic in character, that are well adapted to domestic use. The extensive coal-fields of Alberta, which contain coals of a wide range of character, form Canada's largest coal reserve. The interior portion of British Columbia has many areas of coking coal. The fuels of the Arctic islands may, like the Spitzbergen coals, be mined at some future time.

Area and reserve.—In estimating the reserve of coal, the area, for which a fairly close approximation of the reserves has been made, embraces, 26,219 square miles. A larger area, with a probable reserve of coal, is estimated at 82,662 square miles, while for deeper mining than is at present contemplated an addition of 287 square miles is made. The coal-areas of Canada have thus an estimated total surface extent of 109,168 square miles. The total coal reserve for the several subdivisions is estimated to be:

Nova Scotia	9,718,968,000	metric tons.
New Brunswick	151,000,000	" "
Ontario	25,000,000	" "
Manitoba	160,000,000	" "
Saskatchewan	59,812,000,000	" "
Alberta	1,072,627,400,000	" "
British Columbia	76,034,942,000	" "
Yukon	4,940,000,000	" "
North West Territories	4,800,000,000	" "
Arctic Islands	6,000,000,000	" "
Total	1,234,269,310,000	metric tons.

Arranged in classes the coal reserves are approximately:

A_2	2,158,950,000	metric tons.
B_1, B_2	139,087,360,000	" "
B_3, C	144,576,000,000	" "
D_1	854,490,000,000	" "
D_2	93,957,000,000	" "
Total	1,234,269,310,000	metric tons.

United States

(*Marius R. Campbell*)

The coals of the United States range in quality from graphitic anthracite to the poorest lignite.

The coal-bearing beds of the great Appalachian region, including the anthracite fields of Pennsylvania and the graphitic anthracite of Rhode Island, are of Carboniferous age. Coals of Triassic and Jurassic age are represented by small areas on the Deep and Dan rivers in North Carolina and the Farmville and Richmond basins in Virginia. In the western part of the country the Cretaceous (including the Laramie) is by far the most important coal-bearing formation. Large areas of lignite-bearing Tertiary rocks of Eocene age occur in Texas and Arkansas and throughout the Rocky Mountain states from New Mexico to the Canadian line. The youngest coal-beds known are probably Miocene and occur in isolated basins in the northern Rocky mountains and in the coast ranges of California.

The United State Geological Survey has adopted the following classification of coals: (1) anthracite; (2) semi-anthracite; (3) semi-bituminous; (4) bituminous; (5) sub-bituminous; and (6) lignite; basing these divisions largely on the physical character and weathering qualities of the coal.

The greatest supply of anthracite is in Pennsylvania, but there are a few scattered anthracite fields in the west, the largest of which is situated in Gunnison county, Colorado.

Semi-anthracite is mined in Sullivan county, Pennsylvania, and is also found in Virginia and Arkansas, but the total amount of this class of coal is not considered as large.

The chief semi-bituminous coal-fields are known as the Clearfield of Pennsylvania, Georges Creek field of Maryland, New River and Pocahontas fields of Virginia and West Viriginia and the Arkansas field. Semi-bituminous coal is also found in Colorado and other western states.

The great bulk of United States coal is classed as bituminous. Most of the coal of the Appalachian region is bituminous, as well as that of northern Michigan; the eastern region of Indiana, Illinois and Kentucky; the western region of Iowa, Missouri, Kansas and Oklahoma; and the south-western region of Texas. Bituminous coal also occurs in a number of western states, as Colorado, New Mexico, Utah, Wyoming, Montana and Washington.

Bituminous coal suitable for coking probably reaches its best development in Pennsylvania; it also occurs in parts of West Virginia, Kentucky and Tennessee and in a few localities in the western states. In general, the coking coal of the west is of lower grade than that of the east.

The distribution of sub-bituminous coals and lignites is indicated on the map in the atlas.

It is estimated that the original amount of coal, in seams of 14 inches thickness and over, to a maximum depth of 3,000 feet, reached the total of 3,225,394,300,000 metric tons, of which 11,220,532,560 tons has been exhausted.

Alaska

(*A. H. Brooks and G. C. Martin*)

The Alaskan coals are of various ages; the oldest known coal-bearing formation being that at Cape Lisburne, which has been assigned to the Mississippian, while the age of that of the Nation River is Pennsylvanian. Jurassic coal is known to occur near Cape Lisburne and in the Matanuska valley and upper Cretaceous coal in the Alaska peninsula, on the lower Yukon, and in the Colville River basin. About 80%, however, of the known coal is of Eocene age. Thin, lignitic beds also occur which are probably of Pliocene, possibly of Pleistocene age.

The Bering River and Matanuska fields contain the largest amount of high grade coal. The Bering River field is known to have an extent of at least 45 square miles, underlain by a large number of seams, containing coal varying in quality from anthracite to semi-bituminous.

The area of the Matanuska field is possibly 100 square miles. The seams are numerous and the quality of the coal ranges from lignite to anthracite, but the greater part appears to be bituminous.

The Cook Inlet coal is of Tertiary age and it is estimated that the total area of the field is 6,035 square miles, chiefly situated in the western part of Kenai peninsula. The coal is lignite and the seams are numerous, but of moderate thickness. A section on Kachemak bay contains 15 seams, with an aggregate thickness of 65 feet.

On the Alaska peninsula both Tertiary and Cretaceous coals occur, but the former are of little value. The two most important fields—Chignik bay and Herendeen bay—have a combined area of about 80 square miles, underlain by bituminous coal of upper Cretaceous age, yielding an average of about 50% fixed carbon.

The Nenana coal-field, in the Tanana valley, has a proved area of 122 square miles, and is probably much larger. Numerous seams, from 3 to 30 feet thick, occur in Tertiary rocks. An analysis of a weathered sample of coal yielded 32% fixed carbon and 6% ash.

In northern Alaska, the Cape Lisburne field is the most important; it includes the Carboniferous coal of the Cape Beaufort district and the Jurassic coal of the Corwin district. The Carboniferous coal-seam, varying from 1 to 5 feet in thickness, underlies a known area of 14 square miles; the coal is bituminous and averages 76% fixed carbon and 3% ash. The Jurassic coal is sub-bituminous in quality and occurs in beds up to 12 feet in thickness; its known areal extent is 200 square miles.

Coal is known to occur at many other localities.

It is estimated that the known coal-fields occupy a total area of 1,210 square miles and contain the following amounts of coal of the several classes.

Lignite	12,612,000,000 metric tons.
Sub-bituminous	3,681,000,000 " "
Bituminous	16,000,000 " "
Semi-bituminous	1,353,000,000 " "
Anthracite and semi-anthracite	1,931,000,000 " "
Total	19,593,000,000 metric tons.

This is considered to be a very conservative estimate, as it does not include large areas probably underlain by coal nor possible coal-bearing areas in unprospected parts of the Territory.

Mexico

(*Robert T. Hill*)

The most important coal-fields of Mexico are those underlain by Cretaceous deposits and are situated near the Texas border, on the Rio Grande and its tributaries. Tertiary coals are found along the border of the coastal plain and the eastern escarpment of the Mexican plateau. Triassic coals occur in two widely separated districts, one in southern Mexico and the other near the west coast.

The Triassic coals.—The coal-fields of the Mixteca district in southern Mexico contain many seams, nine of which appear to be mineable. The coal is semi-anthracitic, but is rather high in ash. In Sonora, in the western part of Mexico, there are several fields; the principal one is the Santa Clara field, where anthracite and natural coke are found, in beds 4.8 and 10 feet in thickness. At Santa Maria, graphite (coal altered by granitic intrusion) is being mined.

The Cretaceous coals.—The coals all occur in the Montana division of the upper Cretaceous and are found in several localities, near the Texas border. The producing fields are the Fuente (Eagle Pass), the Sabinas and the Barroteran districts. Although the same measures are mined in each, the coal of the Sabinas district is superior to that of the other districts.

The Tertiary coals.—Coal-seams are found at the base of the Eocene deposits which are distributed along the east scarp of the Mexican plateau and the border of the coastal plain. The principal area is at Santa Tomas near the Texas boundary and, although the Mexican coals are superior, the present supply is mined in the eastern part of the basin in Texas. In a few localities in the State of Hidalgo coals of Miocene age have been found.

The mines of the state of Coahuila furnish the greater part of the coal mined in Mexico. Up to 1906 the total production did not exceed 850,000 tons; since then there has been a steady increase and in 1910 the output reached 2,700,635 tons.

Greenland

The coal of Greenland is found in rocks of both Mesozoic and Tertiary ages, capped by very thick beds of Tertiary trap. The coal-bearing strata are exposed only in the vicinity of the shore and in erosion valleys. On the west coast, important coal-seams have been found on Disko island and Nugsuaks peninsula, in beds determined by White and Schuchert* to be of upper Cretaceous and Tertiary ages. The Cretaceous rocks are found on both the north and south shores of Nugsuaks peninsula and Tertiary sedimentaries on Disko and Hare islands and at the western end of the peninsula. Small coal-seams are apparently found in both the upper Cretaceous and the Tertiary. A seam at Rittenbenk on the north shore of Disko island has been mined in a small way by the inhabitants. The character of the coal is shown by the following analyses.

1. Analysis of coal from east of Rittenbenks Kulbrud, by Professor Fyfe, of Aberdeen.†
2. Analysis of coal from Atanikerdluk,‡ by Mr. T. W. Keates.

	1	2
Specific gravity	1.369	1.3848
Moisture	0.75%	
Volatile matter	45.45	50.60%
Fixed carbon	47.75	39.86
Ash	5.50	9.54
Sulphur	0.55	
	100.00%	100.00%

Specimen No. 1 was obtained by Sir Edward Belcher from a locality on the shore of Disko island; probably from near Skandsen. Specimen No. 2 was collected by Mr. Edward Whymper.

Captain Inglefield, who found the exposed seam at Skandsen,§ reports that

* *Bull. Geol. Soc. Am.*, Vol. IX, 1898, pp. 343-368, "Cretaceous series of the west coast of Greenland, by David White and Charles Schuchert."

† Inglefields Summer Search for Sir John Franklin, appendix, p. 151.

‡ *Philosophical Trans. Royal Soc.*, London, 1869, p. 449.

§ Further papers relating to the Recent Arctic Expeditions, London, Her Majesty's Stationery Office. 1855, p. 5 et seq.

it is from 1 foot to 4 feet 6 inches thick, but inferior to that found later at the "Kulbrud." He states that the seam outcrops along the shore for a mile and that its thickness is from 3 to 6 feet. Robert Brown* gives for the seam at Rittenbenks Kulbrud a visible thickness of 3 feet of coal exposed at the beach with probably an additional part concealed. Farther north-west, at Heers creek, he gives a section with four seams aggregating 5 feet of coal in a thickness of 15 feet of strata. At Atanikerdluk on the opposite shore of the Vaigat strait, several thin seams of coal (less than 2 feet in thickness), have been found.

On the east coast, coal was found by the second German Polar expedition at Kulin and Sabine islands. The coal-bearing rocks have been described by A. G. Nathorst † as Jurassic and Tertiary in age. The exposures on Kulm island are Jurassic. On Sabine island the exposures are similar to those on Disko island—that is, Tertiary sedimentaries covered by basalts. The economic value of the seams on the east coast does not appear to be great.

CENTRAL AMERICA

Guatemala

The following information has been received from M. Manuel Lemus, Director General of Mines:

Geological exploration has been carried on in the Republic for some time but no true coal has yet been discovered, although bituminous lignites and peat are known to occur at many places.

In the following table the principal localities at which lignites have been found are indicated and analyses are given of the best lignites.

Name of Mine	Department	Municipality	Moisture	Vol. m.	F. C.	Ash
1.	Chimaltenango.	Tecpan..........				
2. La Primera........	Santa Rosa....	Mataquescuintla.	....	....	....	39.7%
3. Agua Tibia........	" "	"				
4. La Montanita......	" "	"				
5. La Reina..........	Izabal.........	Izabal...........	3.2%	32.0%	63.3%	1.5
6. Santa Elena.......	"	"	15.1	34.8	39.9	10.2
7. Carolina del Sur....	Atta Verapaz....	Coban...........	13.4	36.2	22.1	28.3
8. Carolina del Norte.	" " ..	"	16.8	39.0	35.1	9.1
9. San Carlos........	Chimaltenango	San Martin J.....				
10.	"	Purulha.........				

* Geological notes on the Noursoak Peninsula, by Robert Brown, *Trans. Geol. Soc. of Glasgow*, Vol. V, 1873-76, p. 87, etc.

† Bildrag till Nordöstra Grönlands Geologi Stockholm. No. 297, Vol. XXIII, No. 4, 1901, pp. 277-280.

Honduras

(*M. de Montis*)

The coal of Honduras is evidently similar to that of Guatemala and occurs, probably, in Tertiary basins.

M. de Montis estimates the reserve as follows:

Bituminous coal	1,000,000 metric tons.
Sub-bituminous coal	2,000,000 " "
Lignite	2,000,000 " "

Salvador

The information obtained by Dr. don Santiago I. Barberena from the various departmental officials and mine owners in regard to new discoveries of coal was mostly negative. The only true coal known occurs in the jurisdiction of Ilobasco, on the margin of the valley of the Friars on the river Lempa. There are indications of the occurrence of coal in the district of Metapán, but it is brown-coal of poor quality.

Costa Rica

Mr. Frank N. Cox, acting British Consul, in consultation with the leading geologist of Costa Rica, reports that samples of coal of good quality have from time to time been brought to San Jose from various parts of the country, but that upon examination the seams have proved to be of no economic value.

Panama

(*The Secretary of Agriculture*)

From information supplied by the Secretary of Agriculture there appears to be a small supply of lignite in the province of Bocas del Toro. The formation in which the coal is found underlies part of the interior and outcrops on the coast and on islands in Chiriqui lagoon. The coal-bearing beds are, in places, intruded by volcanics. As the vicinity of Chiriqui volcano is approached the amount of sulphur in the coal increases notably. The best seam exposed appears to be from 7 to 9 feet thick and is found on the island of Popa at the entrance to Chiriqui lagoon.

British Honduras

A statement has been received from H. J. Perkins, Surveyor General, that no thorough geological exploration of British Honduras has been made and that no coal is known to occur.

Nicaragua

It is stated that Nicaragua has undeveloped coal resources; but no information regarding it has been received.

WEST INDIES

Trinidad

(*A. P. Catherall*)

Coal-bearing Tertiary beds are found in the eastern part of the island of Trinidad, in two districts. Good sections of lignite beds are exposed near Manzanilla, in the eastern coal district and an outcrop of a faulted bed of lignite has been traced several miles near Sangre Grande, in the Cunapo coal district. In the eastern district, the coal-bearing strata have a thickness of 2,317 feet with 34 lignite seams, ranging in thickness from 2 inches to 4 feet 3 inches and containing altogether 38 feet 6 inches of coal. Of this, 19 feet is made up of seams over 3 feet thick. In the Cunapo district, two seams have been traced for about one mile. The upper seam is about 2 feet thick and the lower about 3 feet, although both vary greatly in short distances. The coal to be of commercial value requires washing. It is reported that other lignite-bearing areas are to be found on the south coast.

Santo Domingo and Haïti

Mr. E. M. de Garston, H.B.M., Acting Consul General at Port au Prince, states that bituminous lignite is reported to occur in the Samana district, in the eastern part of the island, in beds that are probably of Tertiary age.

Countries Which Have Reported no Known C[illegible]

Country	*Autho*[illegible]
Bahamas................	W. Mille[illegible]
Ba[illegible]adoes....	[illegible]

Venezuela

Mr. J. B. Bance, Canadian Commercial Agent at Caracas, Venezuela, writes that coal is mined on a small scale at Naricual, near Barcelona and connected with the port of Guanta by rail; and at Coro which is connected by rail with the port of La Vela. The production at Naricual is confined to the amount consumed by government steamboats. *The Naricual coal-area extends from the river Querecual, to the south, to the mountain chain of Naricual, to the north. A great many seams occur, varying in trend but generally striking east and west and dipping south at angles of about 50°; only a few of the seams have been explored. An Italian engineer, E. Cortese, has estimated the coal-bearing zone to have an area of 800 sq. km., which probably includes the whole eastern region where seams of coal have been found. A. L. Pearse and John Roberts, English mining engineers, have estimated 40 square miles, underlain by the Naricual seam, to contain for that seam, 5,500,000 tons of coal. Miguel E. Palacio states that the valleys of Naricual, Capiricual and Tocoropo contain an inexhaustible amount of coal. The principal exploration has been on the left side of the ravine Aragüita (a tributary of the river Naricual) where the seams outcrop. They have been opened by galleries and six seams have been encountered, viz:

No. 1,	thickness	1 m.	average 1.20 m.
No. 2,	"	0.5 m. to 1.20 m.	
No. 3,	"	1.0 m. to 2.80 m.	
No. 4,	"	up to 3.10 m.	
	"	1.25 m. to 2.0 m.	
		very variable.	

1, 2, 3 and 4 appear to be the most valuable
...ing analyses indicate the quality of the

The Coro mines are situated a short distance from the sea (12 or 15 miles) and are worked on a small scale. Transportation is by carts from the mines to the city of Coro (six or eight miles) and thence, by rail, to the port of "La Vela."

Ecuador

The following information on the coal resources of Ecuador has been furnished by the Legation at Washington.

There are no coal mines actually in operation in Ecuador. Considerable deposits have, however, been found in several places, especially in the province of Cañar, at Cojitambo, Mangán and Biblián, a region not more than fifty miles to the south of the Guayaquil to Quito railway. These coal lands have been located by various persons, between Cañar and Cuenca, and steps have been taken to examine the seam in order to ascertain the quality, extent and attitude of the coal. Samples that have been examined in the United States and England have been pronounced of excellent quality, but lack of rail communication has hitherto prevented the coal being mined with profit.

To the north of Quito, at San Antonio de Pomasqui, there are also seams of anthracite, which have been examined by a company formed in Quito.

Coal is known to occur at a number of other places in the Republic, but the occurrences are not well known; regarding these the work of Teodoro Wolf, on the Geography and Geology of the Republic of Ecuador, may be consulted.

Peru

The following summary statement is taken from a paper by Z. Camilo B. Borlkjof* entitled, "The Coal Deposits of Peru."

Coal is one of the abundant natural products of Peru, although very little is mined; it is found in fifteen principal belts, which contain a probable reserve of 1,000,000,000 tons of commercial coal.

1. *Tumbes.*—In this department coal deposits, 450 square miles in area, are found along the Pacific coast, with seams outcropping near tide level and in the adjacent hills.

2. *Piura.*—Coal-beds are known to occur near Tambo Grande, about 105 kilometres from the coast and 30 kilometres from a railroad.

3. *Lambayeque.*—Coal is known to occur in a zone extending between the districts of Farranafe and Matupe in this department.

4. *La Libertad.*—In the province of Pacasmayo, coal deposits extend from the coast to Cupisnique and Trinidad. At Cupisnique, a seam 0.6 m. thick occurs and an analysis of the coal showed: moisture and volatile matter, 17.5%; fixed carbon, 76.6%; ash, 6%. At other places the seam reaches 1.8 m. in thickness and the coal contains as much as 72% of fixed carbon. In the province of Santiago de Chuco the coal formations form a basin 24 square km. in area, containing seams usually from 3 m. to 5 m. thick, although in places the thickness of the seams reaches 12 m. The coal contains a high percentage of fixed carbon.

Coal is found in the provinces of San Pedro and Otuzco; in the latter

* *Engineering and Mining Journal,* New York, Vol. LXXXVIII, 1909, p. 983.

province, seams attaining 6 m. in thickness occur, the coal containing between 60 and 70% and even as high as 90% of fixed carbon. Near Huaiday, a seam of coal of very high quality, 1.5 m. thick, is found, as well as a lower bed 2.3 m. thick. The reserve of this field is estimated to be over 15,000,000 tons. In Huamachuco province, coal is found in several places and an occurrence of anthracite has been reported at Comunbamba. Coal is found also in the provinces of Pataz and Trujillo.

5. *Ancash.*—Important deposits are found in the province of Cajatambo; at Oyen, the coal is more than 8 m. thick. The provinces of Huari and Pallasca also contain coal. At San Antonio, the reserve is estimated to be not less than 4,000,000 tons of commercial coal.

6. *Cajamarca.*—Coal is found in several provinces; much of it is reported to have less than 50% carbon. Anthracite containing 84 to 87% carbon occurs in Cajambamba province, in a bed 0.75 m. thick. In the province of Chota four seams of anthracite, from 4 to 20 m. in thickness, are estimated to contain a reserve of 700,000,000 tons.

7. *Amazonas, San Martin, Loreto and Huanuco.*—In these departments coal is found in the Andes and near the head waters of the Amazon.

8. *Lima.*—Several important coal-fields are found in this department. At Checras, in the province of Chamcay, there is coal of good quality. The coal-fields, in the provinces of Parquin and Quiruragra, contain beds 4 and 1.5 m. thick, with an estimated reserve of 720,000,000 tons. This is one of the largest and most important coal deposits in Peru.

9. *Junin.*—A large coal-field on the east slope of the Andes, 1,200 sq. km. in extent, contains coal with 50% to 60% carbon and has an estimated reserve of 600,000,000 tons.

10. *Huancavilica.*—Coal is reported to occur in this department.

11. *Ica.*—Coal is reported at Lagunillas, in the department of Ica.

12. *Apurimac and Cuzco.*—Much coal is found on the eastern slopes of the Andes in these departments.

13. *Puno.*—Coal is found in the department of Puno, to the north of Lake Titicaca.

14. *Moquegua.*—Some coal has been mined in this department and an extensive and thick coal deposit occurs at Ichuna.

15. *Tacna.*—Coal is found on the coast, at Morro de Sama.

Brazil

Coal-Measures of about the age of the Karroo and Gondwana series of South Africa and India, are known to cover a large part of southern Brazil.

I. C. White, of the Brazilian Coal Commission, 1906,* concludes that a large area in this region is possibly coal-bearing; the seams, however, are thin and much split up by partings, and the coal contains a high percentage of ash and sulphur.

The coal is found in the lower part of the Santa Catharina system, above

* Commissão de estudos das Minas de Carvão de Perma do Brazil. Relatorio Final. por I. C. White, chefe da Commissão. Rio de Janeiro, 1908.

a basal conglomerate which rests in places upon Devonian shales and in places upon a pre-Carboniferous, granitic complex. The Santa Catharina rocks, which are fresh-water deposits, are about 700 metres thick and are capped by basalts. The system includes beds varying in age from Permo-Carboniferous to Triassic and covers a very large area in southern Brazil and possibly part of Argentina; the mineable area, however, may be confined to zones extending along the margins of the basin of deposition, since, in the central portion, the overlying beds are very thick. The most important seams have been found near the bottom of the system, in a series of sandstones and shales known as the Tubarao series. In the Minas district a number of thin layers of coal, separated by bands of shale, make up a seam 3.3 metres thick, known as the Borito bed; two other, thinner seams, occur higher up in the measures. There seems to be one bed, the Barro Blanco, which is fairly persistent throughout the district; it is made up of two or more thin seams and contains about 1 metre of available coal. The coal is not easily separated from the shale partings and, after being crushed and washed, must generally be briquetted for the market, although a portion of the crushed product is immediately available as nut coal of fair grade. Washing reduces the ash and sulphur content to 14% ash and 1% sulphur, for 38% of the treated material, and 28% ash and 1% sulphur for the remaining 42%.

United States Consul P. Merril Griffith, of Pernambuco, has reported that in 1910 a promising field was discovered farther to the north, in the province of Pernambuco. The area embraces about 250 square miles, lying 300 metres above sea level and the measures, in the opinion of the engineers who examined the field, are of Carboniferous age. The top of the coal-bearing beds lies at a depth of 20 metres. The published analysis gave as the composition of the coal:

Moisture	1.900%
Volatile matter	18.815
Ash	20.520
Carbon	58.733
Loss	.032
	100.000

Analysis of Ash

Lime	6.060%
Peroxide of Manganese	1.078
Peroxide of iron	3.802
Magnesium	1.205
Sulphur	2.200
Carbonic acid	2.350
Silica	3.783
Loss	.042
	20.520

Bolivia

The following extracts are from a monograph on the mineral wealth and industry of Bolivia, by Pedro Aniceto Blanco, Chief of Section of Statistics, La Paz.

"Coal-Measures in Bolivia have been proved upon the peninsula of Copacabana in Lake Titicaca, the outcrop running in a north-westerly to south-easterly direction. The coal-seams are found embedded in thick strata of sandstone, somewhat resembling the Millstone Grit. The coal-seams are small, and, although of fair calorific values, are associated with many impurities. The soft nature of the strata in which they are found increases the cost of working, since timbering on the Bolivian plateau is almost prohibitive in expense, and all adits have to be lined with stone."

"Claims have been staked on this outcrop for some miles in length, but none are now worked. Some thirty years ago, over 700 tons were produced at Yamputa port on Lake Titicaca."

Coal has been reported to occur in various other parts of the Republic, but no trustworthy information is available in regard to the occurrences.

Uruguay

Great hopes are entertained that coal will be found in workable quantities in the sedimentary strata in the northern part of the Republic. Some coal has been discovered, in bores recently made, close to the Brazilian frontier, but so far as known, the coal-seams do not outcrop anywhere in Uruguay owing to the undisturbed stratification; and the continuation of the Brazilian deposits into Uruguay can only be proved by boring.*

Argentina

(*E. Hermite*)

The presence of coal-bearing strata has long been known at various places in the Republic, but at none of the localities has there been any real exploitation. Exploration has begun on the Salagasta seam in the province of Mendoza, and the reserve is estimated to be 5,000,000 tons. The coal is bituminous in character.

Chili

(*Miguel R. Machado*)

The Chilian coals are probably all of Tertiary age, although some of the fossils found in the lower coal-bearing beds show affinities to those of the Upper Cretaceous.

In the neighbourhood of Quiriquina island there is an estimated area of coal-bearing rocks of 248 square kilometres, largely sub-marine. The coal is lignitic and several seams occur, ranging from 1 foot to 2 feet 7 inches in thickness.

The coal-field in the vicinity of Santa Maria island produces the best coal in Chili. Three seams are found, having an aggregate thickness of 9 feet 9 inches, which underlie an area of 2,846 square kilometres, giving a total reserve of coal of 1,026,000,000 tons. The coal gives a brown streak, burns with a long smoky flame and contains from 50 to 60% of fixed carbon and from 2 to 11% of ash.

In the province of Aranco, from two to four seams occur in the different mines; they vary in thickness from 1½ to 5½ feet. It is estimated that the coal-bearing rocks underlie an area of 1,600 square kilometres. The percentage of fixed carbon in the coal ranges from 44 to 57 and that of the ash from 3.6 to 10.3.

* Extract from an article by Dr. G. Guilleman, in *Zeitschrift fur Practische Geologie*, Berlin, September, 1910.

In southern Chili, lignites of inferior quality occur at many points. They carry from 14 to 20% of moisture and disintegrate readily on exposure.

Anthracitic coals, probably of Mesozoic age, are found at various points in the Andes. They have a conchoidal fracture, slightly metallic lustre, ignite with difficulty and burn without flame. The anthracitic nature of these coals is due, probably, to their proximity to younger eruptive rocks.

Countries which have reported no known Coal Resources

Country	*Authority*
British Guiana..............	J. B. Harrison, Director, Science and Agriculture Department.
Paraguay.................	F. Oliver, H.B.M. Chargé d'Affaires.

EUROPE

Great Britain and Ireland

ENGLAND AND WALES

(*A. Strahan*)

Two Royal Commissions have reported on the coal supplies of Great Britain and in the present report the estimates of the Commission of 1905 have been modified by the deduction of the coal mined since then and by information since gained. The coal-fields of England and Wales are discussed under two heads, visible and proved fields, and concealed fields not as yet worked.

Visible and proved fields.—South Wales contains a large field in which both anthracite and bituminous coal is found. The western and northern portions of this field produce anthracite and in the central part the lower seams are probably also anthracitic. In any section, the lower seams contain more fixed carbon than the upper ones. The Somerset and Gloucester coal-fields have workable seams in the upper and lower parts of the Coal-Measures, separated by the Pennant sandstone. In the Midlands, the coal-fields occupy several important though small areas.

The coal-fields of Lancashire and Cheshire, the greater part of which lies to the north of Manchester, are generally well defined by outcrops of lower rocks, but the southern edge is concealed beneath Permian rocks and the extension of the field in this direction is now being proved. In North Wales, the measures of Flintshire and Derbyshire dip to the east and are concealed in that direction and an area is thought to be mineable beneath the estuary of the Dee. The largest field in the Kingdom is situated in Yorkshire, Derbyshire and Nottinghamshire. The measures are concealed to the east and a partly proved area, larger than the visible field, is included in the estimated reserves.

In Northumberland and Durham, the Coal-Measures are exposed over an area of 588 square miles. They extend to the eastward, beneath Permian rocks, to the North Sea and a submarine area of 136 square miles is estimated.

In Cumberland, a land area of Coal-Measures on the south side of Solway Firth is believed to extend beneath the sea for at least twelve miles. It is bounded on the north and south sides by faults.

The Ingleton coal-field is a small outlier in the western part of Yorkshire. It contains about eight seams aggregating 23½ feet of coal.

Concealed coal-fields, not as yet worked.—The coal-field of Kent is covered by 1,000 feet of Cretaceous and Jurassic rocks. In certain bore-holes coal-seams aggregating 13 feet in thickness have been found.

In Oxfordshire and Gloucestershire, the Coal-Measures have been found beneath Jurassic and Triassic rocks. It is supposed that concealed areas exist around the Midland coal-fields; and in Cheshire, between the visible fields of Denbighshire, North Staffordshire and Lancashire. The measures of the Yorkshire and Derbyshire coal-field extend eastward in a synclinal trough and possibly approach the surface in Lincolnshire.

SCOTLAND

The most valuable seams are found in the Coal-Measures, but workable seams occur also in the Carboniferous limestone and sparingly in the underlying Calciferous. The Millstone Grit is barren of coal. In many districts the coals have been burnt and rendered worthless by intrusions of igneous rocks. The coals are generally of a bituminous character, but in Ayrshire, Lanarkshire and Stirlingshire anthracite occurs.

The principal fields are on the Firth of Forth and Clyde river. The measures in Fifeshire are believed to cross beneath the Firth in a synclinal trough and to connect with those of the Edinburghshire field, forming a submarine area of 130 square miles. Smaller fields are found in Ayrshire and Dumfriesshire, and in Argyllshire on the Isle of Arran.

IRELAND

(*Grenville A. J. Cole and E. St. John Lyburn*)

The Irish coal-fields, with the exception of the Tyrone field, occur as isolated areas surrounded by older strata. The upper seams have been mostly worked out and only the lower ones, which are sometimes thin, remain; they lie near the unproductive Lower Carboniferous series. Many districts underlain by the true Coal-Measures contain only small areas with workable seams. The coal-basins were separated by denudation in early Permian times and the only one covered by later sedimentation is that of Tyrone, where the Coal-Measures are in part overlain by Triassic beds.

The Ballycastle coal-field is a small area of a type similar to those in southern Scotland; the coal-bearing beds correspond in age to the Carboniferous Limestone series of England.

The coal-seams of the Tyrone field occur in the lower and middle Coal-

Measures. A part of the field that is concealed beneath the Triassic is thought to contain workable seams.

The Lough Allen coal-field is made up of a number of outliers capping the hills round about Lough Allen. The coal-bearing strata consist of Millstone Grit and lower Coal-Measures lying in shallow synclinal basins and contain a considerable reserve of coal.

The Leinster coal-field is the largest in Ireland. It occupies a high synclinal basin. The coals are anthracitic and the coal not yet extracted belongs to the lower Coal-Measures.

The Tipperary coal-fields consist of a series of synclinal basins. The principal coal-seams are found in the lower Coal-Measures.

COAL RESERVES OF THE UNITED KINGDOM

Bituminous coals make up the greater part of the reserve estimated for the United Kingdom. Anthracitic coals and anthracites are mined, but probably less than 10% of the total reserve is of this class. The reserve, to a depth of 6,000 feet, is estimated to be:

England and Wales—Actual reserve	119,943,409,929	metric tons.
Probable reserve	29,984,000,367	" "
Possible Reserve	16,254,500,000	" "
Scotland—Actual reserve	21,376,493,624	" "
Probable reserve	1,685,000,000	" "
Ireland—Actual reserve	180,506,000	" "
Probable reserve	110,840,000	" "
Total	189,534,749,920	metric tons.

Portugal

(*Ministerio do Fomento*)

In the vicinity of S. Pedro da Cova a narrow block of upper Coal-Measures is found, folded between older beds and containing one bed of anthracite, 1 m. thick. The Cabo Mondego coal-area near Figueira consists of upper Jurassic measures and the coal in the one known seam is bituminous. The reserve for the two areas is estimated to be:

Anthracite	20,400,000	metric tons.
Bituminous coal	150,000	" "
Total	20,550,000	metric tons.

Spain

(*Luis de Adaro*)

Coal is found in many localities in Spain; the most important areas are found in the north-western provinces of Asturias and Leon and in the province of Teruel in the east. The coal varies in quality from anthractie to lignite; that of Asturias and Leon is of Carboniferous age and classed as A. B. and C, while the Teruel coal is placed in Classes C and D, and is pre-Cretaceous in age.

Cretaceous and Tertiary lignites are found in scattered localities in comparatively small areas.

The actual reserve is estimated at 6,220,000,000 tons and the probable reserve at 2,548,500,000 tons, the quality of the coal ranging from Class A, to Class D_2

France

(*M. Defline*)

Although coal is widely distributed in France the country as a whole is relatively poor in fossil fuel. Anthracite and bituminous coal occur in the Carboniferous and Permian systems while lignites are found in rocks ranging from the Triassic to the Tertiary.

The coal-fields may be grouped in five divisions: (1) areas north of the Ardennes *massif*; (2) eastern areas; (3) coal-basins in the Armorican *massif*; (4) coal-basins in the central *massif;* (5) areas in the Alps, the Maures, the Pyrénées and in Corsica.

There are in all about fifty coal-bearing areas and twenty areas containing lignite.

The total estimated reserve is as follows:

Actual reserve (A)	581,100,000	metric tons.
Actual reserve (B and C)	3,622,225,000	" "
Actual reserve (D)	301,000,000	" "
Probable reserve (A)	2,690,600,000	" "
Probable reserve (B and C)	9,058,700,000	" "
Probable reserve (D)	1,331,000,000	" "
Total	17,584,625,000	metric tons

Up to the year 1912 about 1,500,000,000 tons of coal of all classes had been extracted.

a. NORTHERN AREAS

The coal-basin of Valenciennes and the small basin of Boulonnais are the only coal-bearing areas north of the Ardennes *massif*. They constitute the most important coal region of France, both in regard to production and reserves.

The age of the coal-bearing strata is Westphalian, this being the only locality where Coal-Measures of that horizon outcrop in France.

The coal-seams are numerous, but generally thin; their thickness rarely exceeds two metres and is usually from one to two metres. The quality of the coal varies from anthracite to a gassy, bituminous coal.

b. EASTERN AREAS

The Pont-à-Mousson basin is a continuation of that of Saarbrück in Germany. No outcrop of the Coal-Measures occurs but their presence has been proved by boring. The thickness of the overlying, younger rocks in the different bore-holes varies from 659 to 955 m.

From one to seven seams have been found, in strata of Stephanian and Westphalian age, the aggregate thickness of the coal being from 0.65 to 6.30 metres, and in no case has the base of the coal-bearing strata been reached.

The Coal-Measures lie along an anticline, the axis of which has been traced from the German frontier for a distance of 25 km. in a south-west direction.

The Ronchamp coal-field occupies a small basin in Devonian and Lower Carboniferous rocks. The Coal-Measures are of lower Stephanian age and are overlain by the Permian; they contain three coal-seams with an aggregate thickness of from 3 to 6 m. of coal.

c. COAL BASINS IN THE ARMORICAN MASSIF

The Contentin coal-field is divided into small areas by intrusive porphyry masses, which have folded and dislocated the coal-seams in their vicinity. The Coal-Measures are of Stephanian age and are overlaid by the Permian. Two irregular seams of impure coal are known, from 1 to 1.5 m. thick.

The Maine coal-field is situated in the extreme east of the great depression which traverses Britanny from west to east. The Coal-Measures are of Dinantian (Lower Carboniferous) age and occur in a number of parallel, synclinal folds, often with steep dips. The seams are usually about one metre in thickness, but in one mine a lenticular bed was worked varying from 2 to 12 m. in thickness. The coal is an impure anthracite.

In the coal-field of Basse-Loire the coal is found in Lower Carboniferous strata lying in a syncline in older rocks. The coal-seams number about twenty, the thickness of the seams varying from 0.50 to 2 m. The seams are faulted and folded and the quality of the coal is inferior.

In the Vendée district the Coal-Measures are lower Westphalian in age and overlie gneiss and mica-schist, they are cut off to the north-east by a great fault.

The Vouvant area lies to the north-east of the fault and occupies a basin in the mica schists, in the eastern edge of which three nearly vertical seams are mined; they are very irregular and contain in the aggregate from 3 to 6 m. of impure coal.

d. COAL-BASINS IN THE CENTRAL MASSIF

The Saint-Etienne basin is the most important area in the region, both in regard to present production and coal reserve. The Coal-Measures, of Stephanian age, occupy a basin in granite and mica schist, 40 kms. in length and 12 in width. The measures have been sub-divided into two horizons, an upper, the Saint Etienne, and a lower, the Rive-de-Gier horizon.

The lower horizon, 120 m. thick, is known only in the extreme east of the basin and contains five principal seams. The seams are irregular in thickness, the "Grande" seam sometimes reaching 15 m. while the others have maximum thicknesses varying from 2 to 5 m. Two classes of coal occur, one containing from 30 to 35% of volatile matter and the other from 7 to 10%. It is very doubtful if these seams extend to the centre and west of the basin.

The upper horizon, 1,300 to 1,500 m. thick, contains about thirty coal-seams of more than one metre, with an aggregate thickness of from 50 to 80 m. The volatile material in these seams varies from 15 to 38%.

In the Communay basin, which lies to the north-east of that of Saint-Etienne, the thickness of the seams ranges from 0.70 to 1.50 m. and the coal is anthracite.

The Blanzy, Creusot and Bert coal-fields occur around the border of a large Permian basin, the Permo-Carboniferous beds resting on granites and other older rocks.

The coal-areas are divided into: the Blanzy zone, including the outcrops on the south-east border of the basin; the Creusot group, consisting of a number of unconnected outcrops on the north-west edge of the basin and the Permian coal-bearing beds outcropping in the outlier of Bert and in the main basin. It is probable that the outcrops of the Blanzy and Creusot groups are portions of two roughly-parallel synclines, originally separated by a granite anticline which has been deeply eroded and the area subsequently filled with Permian deposits.

In the Blanzy zone, Coal-Measures, of middle and upper Stephanian age, overlie the granite and are overlaid, probably unconformably, by the middle Permian; they dip gently to the north-west but are affected by minor folds and faults. Three coal horizons are recognized, the middle one containing four principal seams which, at Montceau, have an aggregate thickness of 65 m. The percentage of volatile matter at Montceau is from 33 to 45%, while in the district of Magny it is reduced to 12—14%.

The Creusot and Bert groups of coal-bearing areas are of secondary importance.

In the Autun-Epinac basin, which lies in a basin of gneiss, granite and tuffs, coal occurs both in the Stephanian and the Permian, the only workable seam being found in the former series. This seam, at places parting into four, is from 5 to 10 m. thick, the coal containing from 13 to 30% volatile matter. The workable area is small.

In the Decize coal-field, the coal is found in the upper Stephanian. The extent of the Coal-Measures, since they are concealed by overlying Permian beds both to the north and south, is not known. Nine seams occur with an aggregage thickness of 13 m. The coal contains 30% volatile matter.

The Noyant, Saint-Eloy and Champagnac basins are long, narrow troughs of Stephanian beds, enclosed in crystalline rocks. The Noyant area contains one large seam and several smaller ones. The volatile material amounts to from 28 to 35%. The Saint-Eloy trough is long and narrow with almost vertical walls. Three seams occur, from 3 to 25 metres in thickness and workable for a length of 4 km. The coal contains 35 to 40% volatile matter.

In the northern end of the Champagnac basin, four seams occur, three of which are from 1 to 2.50 m. in thickness and the fourth averages 10 m.; in the south, two seams, 4 and 6 metres thick, are known. The volatile matter amounts to only 10% in the northern area and in the south, to from 22 to 32%.

The basins of Brassac and Langeac are made up of measures of lower Stephanian age, deposited in basins in gneiss and mica schist. In the Brassac basin, the lowest horizon carries two seams with an aggregate thickness of from 8 to 14 m. of coal; the middle has three seams, containing from 17 to 21 m. of coal in the aggregate; and the upper horizon, fifteen seams with a maximum aggregate thickness of 40 m.

In the Langeac basin, an irregular seam, 3 to 8 m. in thickness, is found at the base of the measures while in the measures above, three seams containing 3 to 8 metres of coal underlie a small area.

In the Ahun and Bourganeuf basins, upper Stephanian Coal-Measures lie in basins in granite. The Ahun basin contains fourteen seams with 17 m. of coal. The Bourganeuf basin, in the western part, contains eight thin seams which seem to unite in the east into one 10 m. seam. The volatile matter amounts to from 8 to 10%.

The Aubin-Decazeville basin occupies a triangular area with the apex to the north, in which middle and upper Stephanian Coal-Measures overlie sericite schists and granite; the lowest of three coal-bearing horizons contains no important seams; the middle has irregular seams, one of which is, in places, from 25 to 30 m. thick; and the upper horizon contains one large seam with a maximum thickness of 50 m. An ironstone parting occurs in this seam, which, in places, becomes of sufficient importance to be worked as an iron ore. In general the percentage of volatile matter amounts to from 35 to 37%.

The mines in the Carmaux-Albi basin are of lower Stephanian age and overlie schists. The seams are regular with light dips, but are cut by several faults. At Carmaux, ten workable seams contain 30 m. of coal with a volatile content of from 22 to 25%, while at Albi, four seams contain from 12 to 25 m. of coal carrying 29 to 31% volatile matter.

In the basin of Graissessac, lower Stephanian measures lie in a basin in the Cambrian. From five to thirteen irregular seams with a coal content of from 10 to 30 metres are mined. The coal contains from 13 to 25% volatile matter.

The Alais coal-field has probably the largest reserve of any in the central *massif*. The outcrop of the Stephanian Coal-Measures follows the direction of the edge of the mica schists and dips to the east under unconformable Mesozoic rocks. The field has been subdivided into: (1) Bességes; (2) Molières; (3) La Grand'Combe; (4) Laval; (5) Rochebelle.

In the Bességes area, the lowest horizon carries five to six seams with an aggregate thickness of 4.30 to 6.40 m.; the middle horizon has numerous seams, the coal containing from 15 to 32% volatile matter; and the upper horizon contains fourteen thin seams with 8 m. of coal and 20% volatile matter. The Molières area contains twenty-two seams, aggregating 16 m. of coal, the volatile matter amounting to from 16 to 24%. In the Grand'Combe area an upper group of two seams has 14 m. of coal and a lower group has one good seam, 4 to 5 m. in thickness; volatile matter, 8 to 25%. The Laval area has thirteen seams with 17 m. coal which contains from 14 to 20% volatile matter and in the Rochebelle area, there are fourteen seams containing 36 m. of coal, the volatile material varying from 10 to 20%.

The Aubenas basin, in which the Coal-Measures are of lower Stephanian age and overlie granite and mica schist, is divided near the centre by the extinct Jaujac volcano.

Four groups of coal-seams occur, the lowest of which contains two irregular seams with a maximum aggregate thickness of 27 m. The three upper groups contain numerous thin seams. The coal is impure and contains about 9% volatile matter.

e. AREAS IN THE ALPS, MAURES, THE PYRÉNÉES AND IN CORSICA

In the Alps, Carboniferous rocks occur mainly in the neighbourhood of Briançon. They are found in the centre of the fan-like system of Alpine folding and outcrop for a distance of about 100 km.; the measures contain numerous folded and lenticular seams of anthracite, generally from 1 to 1.5 m. in thickness, but showing in places lenses 10 m. thick. The anthracite is friable and impure and contains 5% volatile matter. In the Maures and Pyrénées and in Corsica small coal-bearing areas occur in the older *massifs.*

f. LIGNITE AREAS

The Fuveau basin is the only lignite area of real importance. The lignite-bearing beds belong to the *Fuvélien* formation of the upper Cretaceous and in the Fuveau district dip to the north-east, at from 5° to 10°, under younger rocks. From five to six seams of lignite occur in 175 m. of strata; the lowest seam is of most importance and is from 0.75 to 2 metres thick, the other seams being all less than one metre thick. The aggregate thickness of lignite is from 2 to 5 m. The lignite contains only 6% moisture and, when dried, from 5 to 20% ash. It is possible that the extent of the basin is much greater than the area proved at present. Other small areas of lignite are found in the Vosges mountains both in Triassic and Jurassic rocks and there are a number of lignite-bearing areas of upper Cretaceous and Tertiary age in the Rhône basin.

SWITZERLAND

(*Schweizerische Geologische Kommission*)

Coal has been mined in Switzerland since 1663 but the present output does not exceed 5,000 tons annually and the reserves are correspondingly small. There are a few seams of an anthracitic or even graphitic coal in the Alps but the seams have been so thickened and thinned by the folding of the enclosing strata that mining is expensive. This coal is of Carboniferous, Jurassic and Eocene age. Some brown-coal (Braunkohle, Pechkohle) also occurs in the Molasse (Tertiary) formations between the Alps and Jura mountains; also a little lignite in the Pleistocene.

SUMMARY

	Actual Reserves	Probable Reserves
Anthracite—Carboniferous, Jurassic and Eocene	4,000 metric tons.	50,000 metric tons.
Brown-coal—Tertiary and Pleistocene	500 " "	25,000 " "
	4,500 metric tons	75,000 metric tons

Italy

(*Giovanni Aichino*)

Anthracite, bituminous coal and lignite are all found in Italy; but 99% of the total coal production consists of lignite.

Anthracite is found in many places in the western Alps, from Savona to the Great St. Bernard, the most important occurrences being in the Aosta valley. Most of the anthracite occurs in Carboniferous rocks, in irregular, lenticular and highly folded beds. In quality it is very variable; it is usually graphitic, ignites with difficulty, is fragile and high in ash. In the Thuile basin, in the Aosta valley, the actual reserve is estimated at 1,000,000 tons and the probable reserve at 142,000,000 tons.

Anthracite, of Carboniferous age, is also found in Sardinia, the probable reserve is placed at 1,000,000 tons.

Bituminous coal is mined in the province of Udine. It occurs in upper Triassic rocks, is graphitic, shaly, friable, high in sulphur and is found in seams of 1.5 metre or less in thickness.

Lignite occurs in many localities from the northern to the southern extremity of the peninsula and in Sardinia; the production, however, is confined almost entirely to Tuscany and Umbria. Two varieties are recognized, piciform and xyloid lignites; the former occurs in Eocene and Miocene rocks, is lustrous black in colour, has a conchoidal fracture and a calorific value of 5,500–7,200 calories. It is classed as D_1. The xyloid lignite is of Pliocene or post-Pliocene age, is usually brown in colour, although sometimes black, has a fibrous, woody structure, contains from 20 to 40% moisture and has a calorific value of 2,000 to 3,500 calories. It may be placed in Class D_2.

Piciform lignite occurs in Venetia, Piedmont, Liguria, Tuscany, Abruzzo, Calabria and Sardinia. The Tuscany areas are of the most importance, those in the Bruna valley having been worked for some years. A 6 m. seam occurs at Casteani and a 6.5 m. seam at Montemassi in the upper Miocene. For the whole of Tuscany the probable reserve is estimated at 7,000,000 tons. In Sardinia, two areas containing piciform lignite are known, at Gonnesa and Piolanas.

The most important areas of xyloid lignite are found in Tuscany and Umbria. The San Giovanni Valdarno area in Tuscany is being actively worked; the lignite beds are of lower Pliocene age and contain a seam 30 m. thick, the upper 16 m. being of good quality, the remainder being made up of alternating bands of lignite and shale. The actual reserve of this area is estimated at 50,000,000 tons.

In Umbria, near Spoleto, a lignite-seam, 5–6 m. thick, is being mined, the probable reserve being estimated at 3,000,000 tons, while at Branca, a seam of good quality occurs with an estimated probable reserve of 6,500,000 tons. Summarized, the estimated coal reserve for the known fields of Italy is:

Actual reserve, Anthracite (A)............	1,000,000 metric tons
Actual reserve, Lignite (D_1 and D_2).......	50,700,000 " "
Probable reserve, Anthracite (A)..........	143,000,000 " "
Probable reserve, Lignite (D_1 and D_2).....	48,750,000 " "
Total..............................	243,450,000 metric tons

Greece

(*Department of Mines*)

The reserve of coal in Greece is estimated to be:

Actual reserve (D_2).........	10,000,000 metric tons.
Probable reserve, (D_2).......	30,000,000 " "

The coal is generally of inferior quality and falls in the class of lignites or brown-coals. Coal-bearing measures of Neogene age are widely distributed in Greece and important deposits of lignite are found in Eubœa, at Coumi, Oropos, Aliveri and other places. The coal is mined only at Coumi.

Turkey

(*Leon Dominian*)

ASIA MINOR

Marmora-Ægean.—The lignite beds of the Marmora-Ægean zone are found in Tertiary lacustrine basins of Miocene-Pliocene age. The coals, which are of a high grade lignitic variety, are found at many localities and are occasionally mined for local use.

Black Sea.—The Heraclea coal-fields occupy a belt about 60 km. in length on the Asiatic coast of the Black Sea. The beds outcrop along the coast and are not known to extend more than 8 km. inland, but as no geological work has been done there, the distance they extend from the coast may be greater. The measures are found in three long fault-blocks and can be divided on fossil evidence into three stages.

1. The Aladjaaghzy or lower stage which corresponds to the Culm and Lower Measures of Europe, contains, apparently, about fifteen coal-seams, averaging in thickness about 0.75 m. each; it is possible that some of the seams may be repetitions, due to faulting.
2. The Cozloo stage, corresponding to the Westphalian, includes about twenty-five seams averaging 1.5 m. each in thickness. The Aladjaaghzy and Cozloo stages produce the greater part of the coal mined near Heraclea.
3. The Caradon stage, corresponding to the Stephanian or upper division of the European Coal-Measures, contains eight seams, varying in thickness from 1 m. to 1.5 m.

The coal is bituminous and is slightly higher in ash than the corresponding average type from European basins. The coal from the lower stage contains 40 to 45% of volatile matter and is largely used in the manufacture of illuminating gas, while the coal from the middle or Cozloo stage contains 30 to 40% volatile matter.

Eastern Asia Minor.—Coal is reported from many localities in the province of Mamouretulaziz and lignite is being mined in the province of Erzroom, while in the province of Bitlis, bituminous and anthracite coal is reported in the mountains east of the Mush plain. The province of Van is also well supplied with coal.

Mesopotamia.—Coal has been mined near Bagdad and also in the north-eastern part of Mesopotamia.

Syria.—Two lignite deposits near Beyroot are being mined. Lignite is reported to occur in the Lebanon district, the province of Damascus and south-east of Aleppo.

TURKEY IN EUROPE

The principal coal-field that has been exploited lies in the environs of Keshan in the province of Adrianople. The coal is bituminous and one of the seams contains coal resembling cannel. At Boztepe, west of Keshan, similar hard cannel has been discovered and several seams are known to occur on the Marmora coast and also at the head of the Gulf of Saros.

Tertiary coals, similar to those of the Marmora-Ægean areas, are found on the Marmora coast and at several other points, including the deposits mined at Telvino and Triano.

BULGARIA

(*G. Bontchew*)

Anthracite, bituminous coal and lignite are all found in Bulgaria; they occur in Carboniferous, Cretaceous and Tertiary strata respectively.

The two principal anthracite fields are situated in the Isker valley, north of Sophia and in the vicinity of Belogradtschik. At both localities the seams are thin and irregular; the coal is black and lustrous, ignites with difficulty, burns with a short bluish flame and contains from 1.5 to 3.75% volatile matter and a rather high percentage of ash.

Bituminous coal of Cretaceous age is found in the upper Balkans. This field, known as the Balkan basin, is very extensive, but has not been studied in detail throughout. In the western end of the basin, at the "Prince Boris" concession, the coal-measures are repeated three times by folding. In the central outcrop three seams occur, 0.8–3 m., 0.4–3 m., and 0.6–1.2 m., respectively; in thickness. The coal is very friable and gassy; it burns with a long flame, contains from 30 to 35% of volatile matter and makes a fairly hard coke.

In the central part of the basin several seams occur, varying in thickness from 0.4–1 m. The coal is much crushed; it contains from 15 to 20% volatile matter and is readily manufactured into briquettes or coke.

Tertiary lignites occur in many isolated areas in Bulgaria, six of which are of importance.

In the Pernik-Bobovdol basin four seams occur ranging in thickness from 0.60 to 3.40 metres. The fuel is black, with a resinous lustre and conchoidal fracture, it burns with a long, smoky flame and disintegrates readily on exposure to the air. The following analysis may be considered as typical: moisture, 14.29%; volatile comb., 38.04%; fixed carbon, 40.18%; ash, 7.49%; sulphur, 2.50%.

In the small Tcham-déré basin, only one seam is worked, 1.2 m. in thickness.

The Black Sea basin covers an area of 110 sq. km.; in it three or four workable lignite seams occur with an aggregate thickness of 3.5 metres. The lignite is brown in colour, has a conchoidal fracture and burns with a long flame. An analysis is as follows: moisture, 17.60%; vol. comb., 47.20%; fixed carbon, 24.65%; ash, 10.55%.

The lignite of the Lom basin, situated on both sides of the Danube, is of much the same character as that in the last-mentioned areas. From four to seven seams are known, their several thicknesses varying from 0.60–1.20 m.

The Traquie basin is a large one but the seams are small; the lignite is similar in character to that in the other areas.

The Sofia basin is situated in the northern part of the Sofia plain; the seams are numerous but thin, the thickest being only from 0.4 to 0.6 m. This lignite is brown in colour, with a woody structure, burns with a long smoky flame and leaves much ash.

The total probable coal resources of Bulgaria, excluding the anthracite deposits, is estimated to be 387,650,000 metric tons.

Denmark

(including iceland and the faröe islands)

(*N. Hartz*)

Although no coal is now mined in Denmark, there was, previous to 1880, a small coal-mining industry on the Island of Bornholm. Small quantities of lignite are mined in Iceland and the Faröes for local use.

In Jutland, coal of Class D (lignite) is associated with Miocene micaceous clays, in the central part of the peninsula and in small outlying areas; a total of 1,930 square miles may be classed as coal-bearing. Several borings have been made to test the area and three or four seams, ranging in thickness from less than 1 m. to 2.5 m. have been found. The coal has a high moisture content.

On Bornholm island, coal is found in a narrow strip of Rhætic-Liassic strata on the south-west coast. Three coal-bearing series have been recognized; the Lenka, with about 5 m. of coal in 17–19 beds; the Bagaa, with eight coal-beds and the Sorthat series, with eighteen beds containing an aggregate thickness of about 5 m. of coal. Analyses show that this lignite is of somewhat better quality than the Jutland lignite, but is not a high class fuel and disintegrates on exposure to the air.

In the Faröes, coal-seams have been found on the island of Syderö, lying between Tertiary basaltic flows. The area on Syderö island, thought to be coal-bearing, is estimated to be 25½ square miles of which about ten square miles is beneath the level of the sea. An estimate of the amount of coal, assuming 0.6 m. as the aggregate thickness of the seams, would be over 50,000,000 tons.

Two kinds of coal occur, slaty and glance coal, the latter being anthracitic in character; both kinds are, in places, found as alternating bands in the same seam.

The Icelandic coal-bearing beds, like those of the Faröe Islands, are covered by basaltic flows of Tertiary age. The coal is composed of compressed and carbonized stems of trees. Some coal is mined for local use in the north-west part of the island.

Netherlands

(*W. A. J. M. van Waterschoot van der Gracht*)

The greater part of the Netherlands is covered by alluvial deposits, the older formations, consisting of Tertiary and Palæozoic strata, appearing only in the southern and eastern parts of the country. The underlying formations have been investigated by borings and a section of post-Carboniferous strata, possibly 4,000 metres in thickness, is found in the northern provinces, which decreases in thickness to the south, where Carboniferous rocks outcrop on the frontier. Fault-blocks or "horsts" of the Coal-Measures and older rocks are found, in places, standing above the general level of the base of the post-Carboniferous basin and in five of these blocks the coal-bearing beds lie at depths accessible for mining.

The Coal-Measures are of the same age as those in the Westphalian and Belgian coal-fields—the Dutch measures connecting the two, and showing the characteristics of both. The following are the principal coal-fields:

1. *South Limburg.*—An area of 22,500 hectares has been proved to be workable and a possible extension of 6,500 hectares remains to be proved. The average thickness of workable coal is from 29 to 38 metres.

2. *Southern Peel.*—An elevated horst has been proved by borings to extend in a north-westerly direction from the village of Swalmen toward Griendtsveen. An area of 16,600 hectares is considered to contain workable coal-seams and there is a further area of 10,000 hectares in which practical mining is questionable, owing to the great depth or smaller number of the workable seams.

3. A possible field, north of the Southern Peel area, is being tested by borings.

4. *Winterswyk.*—An isolated discovery of coal at this place, in the province of Guelderland, is being followed by further boring.

5. Boring operations, to test a possible field in the province of Overyssel, have been instituted at Buurse.

The coal reserve is estimated to be:

Actual Reserve	(A_2 and B_1)	209,071,000	metric tons
Probable Reserve	(A_2 and B_1)	455,020,000	" "
" "	(B_2)	1,328,970,000	" "
" "	(B_3 and C)	62,210,000	" "
Possible Reserve	....	2,347,580,000	" "
	Total...............	4,402,851,000	metric tons

Belgium

(*Armand Renier*)

All the Belgian coal occurs in the Carboniferous Coal-Measures, which have been subdivided into the following divisions:

Coal-Measures	Upper (Stephanian)	Flénu zone.
		Charleroi zone.
		Chatelet zone.
	Lower (Namurian)	Andenne zone.
		Chokier zone.

Three coal-fields are recognized: (1) the Dinant field in the south, consisting of a number of small, isolated basins occurring in a great synclinal fold; (2) the Namur field, situated in the central part of the Haine-Sambre-Meuse trough; and (3) the Campine field, in the north.

The Namur is the only field now being worked; the Campine field, however, has been tested by bore-holes and it is expected that mining will soon begin there.

The coal-seams are numerous but usually thin; rarely reaching 1.50 or 2 metres in thickness, the average thickness of the seams worked in the Namur field in 1910 being only 0.65 metres. Most of the workable seams are found in the Flénu and Charleroi series. Three classes of coal occur, bituminous, cannel and semi-cannel, but the first only is of any great industrial importance. The bituminous coals are of widely different characters, the volatile matter ranging from 16%, in anthracite varieties, to 37 or 40% in long-flaming coals.

The reserve of coal in the Dinant field is considered to be unimportant; in the Namur field it is estimated to be about 3,000,000,000 metric tons and in the Campine field, 8,000,000,000 tons. This estimate, in the case of the Campine field, takes into account all seams 40 cm. in thickness and over, to a depth of 1,500 metres. About one-half of the whole reserve consists of coking coal.

Germany

INTRODUCTION

(*H. E. Böker*)

The German Empire contains both hard coal (Steinkohle) and lignitic coals (Braunkohle) in important amounts. The former occur almost exclusively in the Carboniferous, only small quantities being found in the Permian and Cretaceous. The commercially valuable brown-coals are confined to the Tertiary, those in the Pleistocene not being mined.

SUMMARY

District	Age	Actual Reserves	Probable and Possible Reserves
		Million Tons	Million Tons
1. Saar	Carboniferous, mainly	16,548	..........*
2. Westphalia and Rhine province	Carboniferous	56,344	157,222
3. Lower Silesia	Carboniferous	718	2,226
4. Upper Silesia	Carboniferous	10,325	155,662
5. Saxony	Carboniferous and Permian	225	..........†
6. Left of the Rhine	Carboniferous	10,458	
7. Other districts	Cretaceous, etc	247	..........†
Totals		94,865	315,110
	Brown Coal		
1. Prussia and North German States	Eocene to Miocene	6,069.2	3,675.9
2. Saxony	Oligocene-Miocene	3,000	
3. Bavaria	Tertiary	75	293.6
4. Hesse	Tertiary	169.6	98.9
Totals		9,314.3	4,068.4

* Possible reserve, large † Possible reserve, considerable

Steinkohlen

SAAR DISTRICT

(*H. E. Böker*)

Portions of Alsace-Lorraine, Prussia and the Palatinate are underlain by an elliptical area of coal-bearing Carboniferous measures, about 120 kilometres long from N.E. to S.W. and 40 kilometres in maximum width. The originally flat-lying strata, which were deposited in an inland basin formed in Lower Carboniferous or Devonian time, are now folded into a great N.E.–S.W. anticline and have also been extensively faulted. The cover of Permian and Mesozoic rocks has been eroded from most of the district, except in the S.W. portion where it grows thicker and, owing to its thickness and water-carrying properties, seriously interferes with mining. Coal is confined mainly to the Upper Carboniferous (Ottweiler and Saarbrück formations) but also occurs in small amount in the Permian.

WESTPHALIA AND RHINE PROVINCE

(*Prof. Krusch, Dr. Wunstorf, Bergassessor Kukuk and Dr. Mintrop*)

The coal-bearing districts on either side of the Rhine and in Westphalia are connected with one another and with those of south Holland, Belgium and northern France. Coal of about the same age as the coals in the Saar district occurs in the Upper Carboniferous and, to a less extent, in the Lower Carboniferous. The coal-bearing formations are overlain chiefly by Tertiary deposits, though Cretaceous and Triassic deposits also occur in Westphalia. The thick Tertiary quicksand formation, on the left side of the Rhine, renders special mining methods necessary. The coal formations on the right side of the Rhine and in Westphalia are folded into five, broad, northward-pitching troughs but are affected only to a minor extent by faulting while those on the left side of the Rhine are little folded and chiefly disturbed by faulting with development of horsts, grabens and step faults.

LOWER SILESIA

(*H. E. Böker*)

The coal formations of southern Silesia lie in an elliptical basin, 60 kilometres long and 30 to 35 kilometres in width. This basin extends into Austria, but the more valuable part of it lies in Prussian territory. As in the case of the Saar district, the coal-bearing Carboniferous and younger rocks were deposited in an inland basin, toward the centre of which they now dip. Owing to this dip and to the great thickness of the overlying Cretaceous and other rocks, the coal formations in the centre of the basin lie below the 2,000-metre horizon. The coal is contained principally in the Upper Carboniferous and to a much less extent in the Lower Carboniferous The coal formations have been disturbed by faulting and brecciation. They have also been affected to a notable extent by eruptive rocks, which in some cases form irregularities in the floor of the basin, separating it into several smaller basins and in other cases have intruded and metamorphosed the coal. Mining is also rendered difficult and somewhat dangerous by the exceptionally gassy character of the coal.

UPPER SILESIA

(*R. Michael and W. Quitzow*)

This district, which is the second in importance in Germany, occupies the extreme south-eastern portion of Silesia and extends also into Austria and Russia. The Prussian productive portion includes about 2,800 square kilometres. Coal is found in the Upper Carboniferous, which varies in thickness from 7,000 metres in the south-western part of the area to 2,000 in the north-east and is overlain by 150 metres or less, of Miocene and Pleistocene materials. The coal formations are divisible into a lower marine portion (Randgruppe) and an upper, brackish portion (Muldengruppe); the base of the upper group is characterized by unusually thick and valuable coal-seams (Sattelflöze). The district has been closely folded but faulting plays an unimportant part.

SAXONY

(*K. Pietzsch*)

Coal has been mined in Saxony since the fourteenth or even the tenth century, but the output at the present time is not great and is used principally for briquetting purposes. The Lower Carboniferous deposits in the Hainich-Ebersdorf district are no longer productive. Most of the present production is from Upper Carboniferous and Permian formations in the Erzegebirge, where there are three small areas.

OTHER DISTRICTS

(*H. E. Böker*)

Minor quantities of coal are found at some eight or more other localities in Germany, including Baden—in the Carboniferous, Permian, Jurassic and Cretaceous (Wealden coal formations of N.W. Germany).

Braunkohlen

PRUSSIA AND NORTH GERMAN STATES

(*H. E. Böker*)

The numerous coal-basins in northern Germany are almost wholly Tertiary, Eocene-Oligocene or Miocene. To the former belong the great district of Saxony-Thuringia, which produces 47% of the whole German output, and comparatively unimportant districts on the Main and near Cassel. All the others are Miocene, the more important being those of Cologne, Lusatia, Cassel, Westerwald, Frankfurt (on the Oder) and Görlitz. In addition to briquetting, the more bituminous of these brown-coals are utilized for the extraction of paraffin and mineral oils.

II—SAXONY

(*K. Pietzsch*)

The brown-coals in north-western Saxony are of the same age as those just mentioned and lie in a bay-like extension of the Oligocene and Miocene deposits in the Saxony-Thuringia region. They underlie an area of 1,000 sq. km. at depths ranging from 0 to 85 metres toward the north-west.

III—BAVARIA

(*W. Koehne and F. Münichsdorfer*)

Exceptionally good brown-coal (Pechkohle), approximating D_1 in quality, occurs in the Molasse formations (Tertiary) at the foot of the Alps in Upper

Bavaria. It is an autochthonous deposit of Oligocene and Miocene age laid down at the sea-margin. The beds have since been folded so as to form a number of separate basins.

Younger brown-coals, ranging from lower Miocene to Pleistocene in age, underlie the Schwabian-Bavarian plateau and extend across the Danube, but the seams are thin and the coal poor in quality.

Lower Miocene brown-coal is also mined at Wackersdorf in the Bavarian Rhone district.

IV—HESSE

(*A. Steuer*)

A small area of upper Eocene brown-coal is worked at Messel; likewise an area, 20 km. by 5–6 km. in extent, of upper Pliocene coal, in the valley of the Wetter. Oligocene and Miocene deposits of little commercial value are also known.

V—BADEN

(*Dr. Ziervogel*)

Thin seams of brown-coal, that are probably unworkable, are widely spread in Baden and there are unimportant reserves of Carboniferous coal.

Hungary

(*Louis de Lóczy and Charles de Papp*)

The Hungarian coals may be classed in three groups; bituminous coal, brown-coal and lignite. Coal is found in almost all the formations from the Carboniferous to the Upper Tertiary.

The actual reserve of bituminous coal is estimated to be 7,473,700 tons, underlying a total area of 53.5 sq. km. and the probable reserve to be 133,795,000 tons; it is all classed as B_3. The greater part of the bituminous coal reserves is contained in the Krassószörény areas and in areas in the vicinity of Pécs, the former being Carboniferous in age and the latter Liassic. The best coal is found in Carboniferous beds at Szekul and Ujbánya; this coal has a calorific value of about 7,000 calories.

The second, or brown-coal group, is the most important commercially; the actual reserve being estimated to be 342,776,718 tons, contained in a total area of 234.9 square km.; and the probable reserve to be 1,100,504,000 tons. The brown-coal is all placed in Class D and Class E (a class including lignite of a quality inferior to D). This class of coal occurs in the Eocene, Oligocene and Miocene formations and the quality appears to improve with the age of the formation. The most important brown-coal areas are those of Tatabánya, Nyitrabánya and Zsil, the first two producing a superior quality of coal; the Zsil basin is, however, credited with the largest probable reserve. The calorific value of the brown-coals is from 4,000 to 7,000 calories.

The third, or lignite group has an estimated actual reserve of 7,703,000 tons and a probable reserve of 124,450,000 tons which is practically all classed as E.

The lignite is of Pliocene age and occurs at a number of localities, the more important being situated in Croatia, Slavonia and the extreme south-eastern districts of Hungary; the calorific value of this fuel varies from 1,900 to 3,800 calories.

The total coal resources of Hungary are estimated as follows:

Actual reserve......	357,953,418 tons in	316 sq. km.
Probable reserve....	1,358,749,000 tons in	1,100 sq. km.
Total..........	1,716,702,418 tons in	1,416 sq. km.

The possible reserve is not large.

Austria

(*W. Petrascheck*)

For the purpose of making a comprehensive survey of the coal resources of Austria a special examination was made by the author, in which the aid of many specialists was obtained. As a result the coal reserves are stated to be, approximately:

Actual reserve (*steinkohle*)...	2,969,700,000	metric tons.
Actual reserve (brown-coal)..	12,230,800,000	" "
Probable reserve............	38,675,700,000	" "
Total..................	53,876,200,000	metric tons

A—COAL-FIELDS OF THE ALPS

Northern and Central Alps.—Coal-bearing beds are found in the Triassic (Lunzer series), Jurassic (Grestener series) and in the Gosau series of the upper Cretaceous.

The Lunzer series belongs to the Keuper or upper Triassic and consists of shales overlain by coal-bearing sandstones, the whole being overlain by the Opponitz limestone. The coal-seams are not thick; in estimating the reserves a thickness of 0.5 m. of coal was assumed. The coal is generally obtained in a crushed condition, but it is very suitable for blacksmith's use. A crushed and faulted seam of Jurassic age, 2.5 m. thick, is mined at Hinterholz. The Cretaceous coal-bearing strata contain numerous seams of very variable thicknesses, none of them being very thick.

Miocene brown-coals are found in the districts of Mürz and Mur and in lower Austria. In the Tyrol on the river Inn, a seam of sub-bituminous coal, 6 m. thick, is found at the base of the Oligocene. Diluvial deposits of lignite in Styria appear to be of value.

Central and Southern Alps.—Carboniferous coals are found near Turrach in the south-western corner of Styria. Miocene coal-bearing beds occur in many localities on the slopes of the Karawanka mountains and Tertiary coals are found in the Sotkzka series of Sarmatian age in Styria. The Drau-Save coal district is the most important in Austria, south of the Danube.

Triassic coals, generally in thin seams, have been found in the province of Krain, but are not being mined. Upper Tertiary (Miocene) basins containing brown-coal have been mined for some time, principally near Johannestal where two seams occur. The upper seam contains lignite and is 5 m. thick; the lower seam, about 12 m. thick, is composed of a better quality of brown-coal which is used in gas making.

The province of Istria contains lower Eocene deposits which at many points carry coal-seams. Five workable seams have been found with thicknesses varying from 0.4 to 4 m.

B—TERTIARY BROWN-COAL AT THE FOOT OF THE ALPS

Several areas of Miocene coal-bearing beds, described in the report, are situated to the west of Graz and contain important reserves of lignite. In Lower and Upper Austria, Miocene coals are found in several basins on both sides of the Danube.

C—THE COAL DISTRICTS OF NORTHERN AUSTRIA

In north-west Bohemia, brown-coal is known to occur both in the upper Oligocene and lower Miocene, the latter containing the most important coal deposits. There is an unconformity or discordance between the two formations.

Galicia contains a large number of Miocene basins, lying partly in the Carpathian mountains and partly in the Podolic plateau. The coal in the mountain areas is probably of better quality than that of the plateau. The basins of the plateau although not much disturbed contain a good grade of brown-coal.

The middle Bohemian fields consist of two large and several small basins. The coal-bearing rocks occur in the upper and middle Coal-Measures (Carboniferous). The middle Coal-Measures contain workable seams and, occasionally, one seam in the upper measures is mined, but its thickness is rarely more than one metre. The lowest seam mined has a maximum thickness of 3 m., but contains many slate partings; in the Pilsen area it is cleaner than elsewhere but is only from 1 to 2 metres thick. The chief seam, known as the Radnitz seam, is from 1 to 4 m. thick in the Pilsen area, about 10 m. in the Radnitz area and from 1 to 11 m. in the Kladno-Rakonitz area.

Small basins containing Upper Carboniferous and Permian coal-bearing rocks occur, chiefly in Bohemia; they are of very small extent and valuable coal-seams are found only in the Brandau district, in the mountains bordering the north-western part of Bohemia. In the Brandau basin, 4 seams of anthracite occur, the thickest of which (about 1 metre) is nearly worked out.

Three seams of good smithing coal occur in the upper Coal-Measures of Rossitz in an area west of Brünn in Moravia; the largest seam is 2 to 3 m. in thickness; the other two vary from 0.3 to 0.8 m.

The coal-bearing rocks of the Schatzlar-Schwadowitz field, which extends into Prussian Silesia, outcrop on the edge of a basin thickly covered by Permian and Cretaceous rocks. The Carboniferous is represented by the Schatzlar series, containing from 14 to 30 seams of coal, of which a few are worked in the southern part of the district.

In the Ostrau-Karwin-Krakau district a large area of Carboniferous coal-bearing rocks, extends across the Prussian boundary. It is mostly concealed by Tertiary deposits which increase in thickness to the south owing to the dip of the beds being in that direction. The coal-seams are in the Schatzlar series and have been proved by borings.

COAL DEPOSITS OF DALMATIA

(*F. von Kerner*)

The coal-beds of the upper Butisnica valley were formerly considered as Carboniferous but are now thought to be Triassic. Lower Tertiary brown-coals are mined on the slopes of Mount Promina and a few unimportant upper Tertiary areas contain lignite seams.

BOSNIA and HERZEGOVINA

(*Friedrich Katzer*)

Practically all the mineable coal in Bosnia and Herzegovina is confined to the Tertiary, although coal occurs in very small quantities in the Carboniferous, Permian, lower Triassic and Cretaceous formations and it is estimated that there are about 1,000,000 tons of reserves in the upper Triassic. There are two principal Tertiary coal-bearing horizons, one extending from low down in the Oligocene upwards into the Miocene; the other occurs in the Pliocene. The greater part of the Tertiary coals are found in the north-eastern part of Bosnia, north and east of Sarajevo.

The upper Tertiary coal is of good quality, but the seams are so thin that it is mined only on a small scale for local consumption.

The Oligo-Miocene deposits are mined at many localities, of which the most important are: (a) Zenica-Sarajevo, a triangular area of 800 sq. km. in which the coal-bearing strata dip south-west at 10° to 15° and carry three main groups of coal-seams, of which the middle or "hauptzug" group is much the most important. As a rule the thickness of the seams and the quality of the coal limits the depth of the mines to 1,000 metres. The probable reserve is estimated to be 1,000,000,000 tons; (b) Ugljevik-Priboj, with a productive area of only 30 sq. km., containing about 120,000,000 tons of coal; (c) Banjaluka, a rectangular "Senkungsfeld" of 80 sq. km., bounded by faults, containing an estimated reserve of 30,000,000 tons.

Almost all of the Pliocene deposits occur in the Tuzla basin, north-east of Sarajevo. This basin is 400 sq. km. in extent and contains three main coal-seams, each 10 to 20 metres in thickness, separated by 45 to 135 metres of intervening beds. The strata have been slightly faulted and otherwise disturbed.

The total reserve is estimated to be:

Actual reserve (Brown-coal, D_1 and D_2).....	1,700,000,000 metric tons
Probable reserve (Brown-coal, D_1 and D_2)...	1,976,300,000 " "
Total..........................	3,676,300,000 metric tons.

Montenegro

(From information obtained through the British Legation)

Bituminous coal occurs to the east of Nikchitche in the central part of Montenegro; in the valley of the Lim river, in the extreme south-eastern part of the country, and near the Albanian frontier within a short distance of Podgoritza, as well as in scattered patches near Cettinje and in other parts of the country.

In the first-named locality, near Nitchitche, it is possible that there is a coal-field, covering perhaps a hundred square miles, containing coal of fair quality in seams of workable thicknesses. On the Albanian frontier a seam $6\frac{1}{2}$ feet thick, containing coal of better quality, is reported to occur in an area which might be connected by a short line of railway with the most thickly settled part of the country, in the vicinity of Podgoritza and Lake Scutari.

Lignite has been noted in the district of Velestevo, situated about 40 km. to the north of Cettinje.

Servia

(F. A. Milojkovitch)

Coal occurs in small quantities in the Carboniferous in Servia and, in greater abundance, in the lower Jurassic and Cretaceous.

Carboniferous Coal-Measures occur north of the mountainous region between the Pek and Mlava rivers, underlying an area of about 120 sq. km. The coal-bearing beds have been correlated with the upper productive Coal-Measures and are deposited on the surface of crystalline rocks. Three seams, between 0.2 and 2.5 m. in thickness, contain extremely brittle and somewhat impure coal.

In the Mesozoic coal-bearing formations the upper Cretaceous beds contain the thickest seams and are the most widely distributed; Liassic coal-beds occur in one or two areas in the north-eastern part of Servia only. Both of these formations are found filling basins in crystalline rocks whose surface had been deformed by faulting previous to the deposition of the coal-bearing beds. Tertiary eruptions have subsequently disturbed the Mesozoic strata.

The relative importance of the coal of Liassic age would probably be increased if the areas were more thoroughly explored since it resembles in character the Carboniferous coal and has a calorific value in places of 8,000 calories, though like the Carboniferous coal it requires picking and washing.

The Cretaceous coal is cleaner and stronger than the Liassic and stands transportation well; it is mined in the following districts: Rtanj, Bucje, Vina, Podviss and Oresac.

The coal-beds in the Tertiary are generally easily explored and can be mined without deep workings. Many of the mines being situated near the State railways and forest reserves, transportation facilities are good and mine timber is accessible. As the coal is firm and clean it enters largely into use as fuel for mills and other industries.

The following is an estimate of the coal reserves:

Actual reserve (*steinkohle*)	2,000,000	metric tons.
Actual reserve (brown-coal)	27,600,000	" "
Actual reserve (lignite)	30,100,000	" "
Probable reserve (*steinkohle*)	10,500,000	" "
Probable reserve (brown-coal)	82,950,000	" "
Probable reserve (lignite)	99,100,000	" "
Possible reserve	276,500,000	" "
Total	528,750,000	metric tons

Roumania

(*L. Mrazec and I. Tănăsescu*)

The Roumanian coals may be grouped, according to geological age and quality, in four divisions, namely: (1) Carboniferous coal, (2) Mesozoic coal, (3) Miocene coal, and (4) Pliocene coal and lignite.

Carboniferous rocks containing lenticular seams of anthracite occur in the northern part of the Middle Carpathians. Anthracite is mined on a small scale at Schela in the Gorj district.

Bituminous coal occurs in the upper valley of the Jalomitza river in both Liassic and upper Cretaceous rocks; although the coal is of superior quality it is much crushed and the seams are very irregular.

Small Miocene areas, containing seams of black, lustrous coal, are found in the Bahna and Cerna valleys.

Commercially, the most important fuels in Roumania are the Pliocene lignites; they can be divided into two classes, the black, lustrous, lower Pliocene lignites of the Comănesti basin and the upper Pliocene brown lignites.

The Comănesti basin has an area of 100 sq. km. and several coal-seams outcrop in it at a number of points. In the Supan valley, at Galleon, two seams occur, 1.05 m. and 0.80 m., respectively, in thickness. The lignite is compact, black and lustrous, does not disintegrate on exposure to the air, and does not coke.

The upper Pliocene lignites are found at several localities. In the district between the Danube and Oltul river, lignite seams, with an average thickness of 2.5 m., outcrop at numerous points over an area of 140 by 30 km. Lignite-bearing beds, underlie an area of about 80 sq. km. in the district between Boteni and Curtea-de-Arges; two seams are known, the upper 0.50 to 0.70 m. thick and the lower one 2.50 to 3.20 m. thick. The lower seam contains lignite of good quality which is mined at several places. In the Jalomitza valley an area of 45 sq. km. is underlain by upper Pliocene strata containing two coal-seams; the upper seam is from 3.90 to 5.10 m. in thickness including partings, and the lower seam varies in thickness from 5 to 6.50 m., including several partings.

The upper Pliocene lignites are, generally, dark-brown in colour, have a laminated structure and disintegrate readily on drying.

No estimate has been made of the reserves of Carboniferous or Mesozoic coals; for the Pliocene coals and lignites the actual reserve has been estimated to be 2,560,000 metric tons and the probable reserve, 36,000,000 metric tons.

Sweden

(*Edvard Erdmann*)

Although coal has been known to occur in the province of Skåne in southern Sweden for several centuries it has been mined only during the last forty years. The coal-bearing beds are of Rhætic-Liassic age and underlie an area of 800 sq. km. The most important and largest coal-bearing area, situated in the north-western part of the province, has an areal extent of 732 sq. km., with, probably, a submarine extension, extending under the Öresund. All the coal mines worked at present, viz., those of Höganäs, Billesholm, Bjuf, Hyllinge, Skromberga and Ormastorp, are in this field.

The main portion of the coal-bearing formation consists of sandstone, shales and clays amongst which the coal-seams are found. Fire clays also occur, in conjunction with the coal-seams.

The Rhætic-Liassic series contains coal-seams of moderate thickness at several horizons, the two lowermost seams in the Rhætic being generally workable. The Liassic portion of the series is generally of marine origin and is found in some districts to be very thick so that workable coal-seams are not definitely known to occur, at moderate depths, under the whole Liassic area.

The coal-bearing deposits at Estöf in the Stabbarp district belong to the lower part of the Rhætic and the greater part of the coal-bearing series in the Kurremölla belt is Liassic and partly marine in origin. The two workable seams in the Rhætic are generally from three to ten metres apart; but in the mine at Ormastorp the vertical interval is so small that they are worked from the same gallery. Ten to thirty metres below the lowest seam the coal-bearing formation rests on clays and sands usually of a red colour and regarded as typical Keuper beds.

The beds of the coal-bearing formation are for the most part in a horizontal position or only slightly inclined, except in the southern district where they dip steeply. The strata are broken by minor faults which interfere somewhat with mining. The different fields are limited by a series of prominent faults.

The coal-seams consist of alternate beds of coal of superior and inferior quality with, in places, partings of black shales; the thickness varies not only in the different coal-fields, but also in different places in each mine. The thickness of the coal in the two seams, as measured in the mines is:

	Lower Seam	Upper Seam
At Höganäs	59 to 70, average 62 cm.	Not worked
At Billesholm	27 to 85 " 49 "	27 to 74, average 50 cm.
At Bjuf	30 to 65 " 47 "	19 to 69 " 41 "
At Skromberga	30 to 98 " 59 "	7 to 25 " 18 "
At Hyllinge	43 to 68 " 56 "	10 to 20 " 15 "
Ormastorp new shaft	" 85 "	" 45 "

The coals are of three qualities:

No. 1—compact and lustrous black, with an average ash content of from 1 to 13%.

No. 2—compact and black, with dull and lustrous layers and containing from 14 to 35% of ash.

No. 3—mainly dull with some lustrous streaks, containing from 36 to 50% of ash.

The estimates of coal reserves, based on an assumed area of 18,609 hectares for actual and 1,191 hectares for probable reserve, is as follows:

Actual reserve (B_3)..........	106,482,000 metric tons.
Probable reserve (B_3)........	8,265,000 " "
Total..................	114,747,000 metric tons.

Norway and the Arctic Islands North of Europe

(*Hans Reusch*)

Andö Island on the north-west coast is the only locality in Norway where coal has been found. The beds there are of upper Jurassic age and contain a seam of cannel coal about 1 metre thick. The coal is high in ash and has not been mined.

On Buren island, sandstones, presumably of Devonian age, contain coal-seams, some of which may possibly be workable. Traces of coal have been found in Franz Joseph's land and thin seams of brown-coal in Iceland.

In Spitzbergen, important coal-seams are known to occur in the Carboniferous, Jurassic and Tertiary. The Tertiary coal of Spitzbergen is mined at Advent Bay.*

Spitzbergen

(*Bertil Högbom*)

The surface of Spitzbergen is to a large extent covered by perpetual snow and ice and the knowledge of its geological structure has been gained chiefly from exposures in the vicinity of the coast. A mountainous region underlain by pre-Carboniferous rocks extends along the west coast, which is succeeded to the east by a plateau country underlain by Carboniferous, Jurassic and Tertiary deposits, all of which are coal-bearing.

The extent of the Carboniferous coal-fields is imperfectly known and although they probably cover large areas, as shown on the geological map, they have not everywhere been proved to be of value and the problem of the continuity of workable Carboniferous coal-seams beneath the newer rocks is still unsolved. The only area proved to contain workable coal is in the vicinity of Billen and Sassen bays at the head of Icefiord, where a seam 7 m. in thickness occurs.

A thin coal-seam, containing several shale partings which are hard to separate from the coal, has been found in the upper Jurassic of Advent and Sassen bays.

One or more fairly persistent mineable coal-seams occur at the base of the

* See also Spitzbergen.

Miocene which is composed of a great thickness of sandstone and shale. As this coal is of excellent quality and easily accessible, it appears to be at the present time the most important coal reserve in Spitzbergen. The best known Tertiary coal-field is situated on the peninsula between Icefiord and Mijen bay, where the thickness of the coal is extremely variable; but its quality is excellent.

The known coal-bearing areas of Spitzbergen are estimated to be 2,430 sq. km. in extent and the reserve to be as follows:

Probable reserve (B_2).........	8,000,000,000 metric tons,
Probable reserve (B_3).........	750,000,000 " "
Total....................	8,750,000,000 metric tons.

Russia

(*Th. Tschernyschew*)

The very large reserves of coal in Russia can only be conjecturally estimated for a large portion of the Empire. While the reserve can be calculated somewhat closely for the Donetz and Dombrova basins, the principal sources of supply in European Russia, that of the great regions of Central Russia, the Urals and the Caucasus can be very imperfectly estimated. The information also regarding the reserve of Turkestan, the Kirghiz steppes and the very rich basin of Kuznetz is very meagre. The reserve for the whole of Russia is estimated to be:

Probable reserve (A).........	18,001,000,000 metric tons,
Probable reserve (B, C and D)	215,996,000,000 " "
Total...................	233,997,000,000 metric tons.

The coal-bearing areas may be considered in districts, taken in order from west to east:

1. The Dombrova Basin

(*S. Czarnocki*)

The coals of the Dombrova basin occur in a thick series of Carboniferous measures which present, structurally, two folds, the axes of which lie in an east-west direction. The structure of the field is further complicated by zones of faults—both strike-faults and faults crossing the strike. The seams are very numerous and in places are of great thickness. The coal of the upper seams, in respect to quality, is inferior, being friable and containing a large quantity of ash; the coal of the lower seams is a good, non-coking dry coal. In the northern part of the basin there are thick beds of brown-coal which are somewhat extensively mined.

2. The District of Moscow

(*M. Prigorovski*)

The Moscow basin, embracing the coal-fields of central Russia in Europe, has the form of an arc open to the east and north-east. The coal is found in the Lower Carboniferous and has been mined principally near the southern rim of the basin, where the coal-bearing series outcrops or approaches the surface; nearer the centre of the basin, where the principal seams have been proved to be present by boring, the series is covered by a great thickness of Carboniferous limestone. The coals vary considerably in character, but may be classed in two main groups, "Boghead" gas-coals which are comparatively rare and smoky coals which are widely distributed, both falling in Class D of the schedule. In production the Moscow basin stands fourth among the coal districts of European Russia.

Brown-coal is known to occur in seams of considerable thickness at a number of places in the north-western part of the district, but the information relating to its occurrence is very general in character.

3. THE DONETZ BASIN

(*L. I. Lutugin and P. I. Stepanoff*)

The Donetz is the greatest of the coal-basins of European Russia. In the central part of the basin coal-bearing Carboniferous measures outcrop or are covered only by thin alluvium, over a wide area. To the east and west of the central field, isolated groups of outcrops are found, principally in the river valleys. The coal deposits occur in the Upper, Middle and Lower Carboniferous, in numerous seams which include 30 to 40 of workable thickness, occurring principally in the middle and upper divisions. The measures are considerably folded and faulted and are covered, over large areas, by Permo-Carboniferous and Permian sediments, so that the conditions for mining are, to some extent, unfavourable. The coals are of many different kinds, including anthracite and the five groups of Grüner, the anthracite forming about 13% of the output and the soft coals the remainder.

The coal reserve is estimated to be:

Smoky coal..............	18,014,000,000 metric tons.
Anthracite...............	37,599,000,000 " "

4. THE SOUTHWEST PROVINCES, NEW RUSSIA, LITTLE RUSSIA, WHITE RUSSIA, AND LITHUANIA

(*A. Faas*)

Tertiary brown-coals have a wide distribution in the south-west provinces where they are mined at a number of points, principally in the provinces of Kiev and Volyn. In New Russia, seams of brown-coal of workable thickness have been found in many of the provinces; but none of the deposits has been thoroughly examined. In Little Russia and White Russia brown-coal has been discovered at a number of places, some of which occurrences may probably be of value. Coal has been found in the post-Tertiary, Tertiary and Jurassic in Luthuania, but none of the occurrences has much present importance.

5. THE WEST SLOPE OF THE URALS

(*A. Krasnopolski*)

All the mines now in operation on the west slope of the Urals are working seams which occur in measures underlying the Carboniferous limestone. The measures are much folded, the seams occurring in a series of anticlines and synclines. Most of the coal is bituminous in character and of good quality, but it varies considerably in degree of excellence in different mines and even in different parts of the same mine. The annual output for the whole field is about 700,000 tons and the reserve about 60,000,000 tons.

6. THE EAST SLOPE OF THE URALS

(*A. Karpinsky*)

On the east slope of the Urals coal is found in the Lower Carboniferous, Mesozoic and Tertiary systems. In the Carboniferous the coal-bearing strata occur as narrow zones, in measures which occupy narrow troughs enclosed in older formations. The beds are much disturbed both by folding and faults. In the northern part of the main coal-bearing band the coal is anthracite but to the south much of it is coking coal. Mesozoic coal or lignite is mined at many widely separated points in the region. The seams of Rhætic age seem to have been deposited in isolated basins of small size. The reserve of coal of this age, tributary to the three mines that are in operation, is about 9,378,987 metric tons. Seams of workable thickness have been found also in the upper Jurassic and lower Cretaceous. Tertiary brown-coal (lignite) seams of workable thickness are known at many places and have a prospective value.

7. THE CAUCASUS

(*V. Veber and S. Czarnocki*)

Coal in the Caucasus is found in beds of both Jurassic and Tertiary ages. The workable beds of Jurassic coal are found in the middle division of that series. The areal extent of the measures is large but most of the workable seams lie in mountainous areas difficult of access. Mining is being carried on only in the Suchum, Kutaiss and Kuban districts. The coal is generally a bituminous, coking coal of good quality. The only Tertiary beds that are worked are the upper Miocene seams of the Olti district in Kars; the coal occurs in four principal seams which vary greatly in short distances both in thickness and in the quality of the coal.

8. TURKESTAN

(*V. Veber*)

The coals of Turkestan are of poor quality and are used only because of the scarcity of wood for fuel. Non-coking coal, occurring in measures of Mesozoic (Jurassic or Rhætic) age, in small basins mainly in the Fergana valley, supplies 95% of the total output. Coking coal is mined in small quantities in the region of the mountains; it is of Rhætic age. Coal is found also in lenticular seams in the rocks of the Palæozoic complex, in belts of Carboniferous or Devonian age; it approaches anthracite in composition and has great heating power, but attempts to mine it have been unsuccessful.

9. THE KIRGHIZ STEPPES

(Krasnopolsky)

The Steppe district of West Siberia has many coal-fields, the coal-bearing series lying conformably above the Carboniferous limestone. The deposits occur in small, isolated basins, covered in places by flat-lying Tertiary sediments. The coal-seams vary greatly in thickness; in places they are many metres thick and in places less than one metre. The coals range from a coking, bituminous coal to anthracite and generally contain a high percentage of ash.

Brown-coal also is found in basins both in the eastern and western part of the steppes. In most of the districts the age of the containing measures is not known but those at Baikouvur, which are mined by an English company, are probably Tertiary.

10. SUDJENSK AND KUZNETZK

(Krasnopolski and A. Derjavin)

The coal deposits of the Sudjenski district overlie the limestone of the Lower Carboniferous. As many as seventeen seams with an aggregate thickness of 105 feet have been found in places; in the Sudjenski mine ten seams have an aggregate thickness of 75 feet 3 inches and, generally, over a large area good workable seams are known. The coal is a bituminous coking coal or a semi-anthracite.

The Kuznetzky basin, of which the Sudjenski is a north-westerly continuation, occupies a depression between the Salarisky and Allatan mountains. Forty-five outcrops of coal-seams are known to occur in the field, much the greater number being met with in the southern part where the measures are more disturbed than in the north. Two mines are operating in the district, the coal mined consisting of both gas-coal and dry coal. The probable reserve of coal is estimated to be 1,125,000,000 metric tons and the possible reserve to be 12,500,000,000 metric tons.

11. YENISEISK

Minussinsk. (V. Boreisha and J. Edelstein)

On the left bank of the Yenisei river, in the district of Minussinsk an extensive basin with a diameter of 22 miles embraces three coal-fields. The coal-bearing series in the three fields lies discordantly upon the older Palæozoic and is probably of Permian age; the beds are very little disturbed and dip at low angles. From two to four workable seams are found generally in the mines; the coal ranges from a sub-bituminous to a bituminous coal.

Yenisei. (L. Jaczewski)

In the valley of the Yenisei river and on its tributaries many discoveries of coal have been made, mainly since the opening of the trans-Siberian railway.

Along the Angara river coal-bearing beds occur for a distance of 120 miles and extend widely to the east and west; on the Lower Tunguska river coal outcrops through 14 degrees of longitude; at the east end of the Argy mountains a promising basin is found. The age of the beds in all these areas is probably Permian. Tertiary coal is found in the Atchinsk district and in Kuzkun, and there is reason to believe that coal occurs at many other points, principally in the region of the lower Yenisei.

12. Siberia and the Amour

(*S. F. Maliavkin*)

Jurassic coal-bearing beds underlie a long, narrow basin in Irkutsk, and contain an estimated reserve of 15,000,000,000 tons, the greater part of which is brown-coal, but a portion is coking coal. The seams are mined at a number of places and are found to be irregular in thickness, but generally to have, in the aggregate, a thickness of nearly 10 metres.

Many small Jurassic coal-bearing areas occur in isolated basins in the Trans-Baikal province. Jurassic coal-bearing deposits are found in the Amour district where the total area covered by them is very large. Similar deposits are found in the Primorski region where they occupy comparatively small areas; the coal is partly coking and partly semi-anthracite and anthracite. On the Muravieff-Amour peninsula also, seams of workable thickness are found in middle Jurassic measures along the shore of the Sea of Japan.

Brown-coal beds of Tertiary age are known to occur at many points, particularly in the South Ussuri district and in various parts of the district of Primorsk. In the Yakutsk district, coal of Mesozoic, Tertiary and post-Tertiary age has been found in many places, but the district is little explored and the occurrences have not been examined in detail.

13. Russian Sakhalien

(*N. N. Tikhanovich*)

Coal is found in Sakhalien varying in age from upper Cretaceous to post-Pliocene. The principal mines are in the district of Rudnik on the west coast, where beds of Tertiary age are worked. The total reserve of coal in Sakhalien probably amounts to 548,200,000 tons. The coal, exclusive of the post-Pliocene lignite, is principally dry, long-flaming coal, containing 60% to 70% carbon, to which class the greater part of the Miocene coal belongs, and coking coals containing 70% to 85% carbon.

Finland

Mr. J. J. Sederholm, the Director of the Geological Survey, states that Finland is without coal deposits of economic value. In the eastern part of the country, in Suojärvi and Salmis, there are beds of Schungite (anthracite) of the same character as the well-known occurrences of Schunga, north of Lake Onega in Russia. They are of scientific interest, occurring as they do in what is probably the oldest coal-bearing beds yet known, but up to the present they have not been used commercially.

OCEANIA

THE COAL RESOURCES OF NEW SOUTH WALES

BY

EDWARD F. PITTMAN, A.R.S.M.

Government Geologist

(With one map in the Atlas)

THE coal-bearing rocks of New South Wales have been classified as follows:

Geological Age	Maximum Thickness of Strata	Locality	Character of Coal
I—TERTIARY—			
Eocene to Pliocene.......	About 100 feet...	Kiandra, Gulgong, Chouta bay, etc................	Brown coal or lignite (not worked).
II—MESOZOIC—			
Triassic or Trias-Jura (?).	About 2,500 feet.	Clarence and Richmond rivers	Coal suitable for local use only (not worked in N.S.W.).
III—PALÆOZOIC—			
Permo-Carboniferous.....	About 13,000 feet	Northern, Southern and Western Coal-fields.....	Good coal, suitable for gas-making and for household and steam-raising purposes.
IV—PALÆOZOIC—			
Carboniferous...........	About 10,000 feet	Stroud.....................	Very inferior coal with bands, of no value.

I—TERTIARY

The Tertiary deposits of lignite or brown coal cannot be considered of commerical importance; at any rate, they are not likely to be utilized for many years to come. They are of limited extent, having been found in alluvial leads, or stream deposits, overlaid sometimes by basalt, in many of the New South Wales gold-fields, such as Kiandra, Gulgong, Forest Reefs and near Millthorpe.

At Kiandra one deposit of lignite was found to have a maximum thickness of thirty feet, but as a general rule the seams vary from a foot to three or four feet in thickness. As the deposits have not been geologically surveyed it is not possible to give an estimate of the area covered by them.

II—MESOZOIC

The age of the Mesozoic Coal-Measures has not been determined beyond all doubt, but they may be regarded as Triassic or Trias-Jura. These measures occupy a considerable area on the Clarence and Richmond rivers on the northern coast of New South Wales, where they contain at least five coal-seams, varying in thickness from two to thirty-seven feet. In every instance, however, these seams are largely made up of shale bands, and it is a rare thing to find a layer of clean coal more than one foot in thickness between the bands.

The coal contains a large proportion of fixed carbon, and should, therefore, be classed as a steam coal; but unfortunately, the percentage of ash is too high to allow of the fuel being exported for this purpose, and it is unsuitable for any other than local use. Just over the Queensland border, near the town of Killarney, a seam of clean coal, three feet in thickness, is being worked commercially, the coal being used on the Queensland Government railways, and it seems more than probable that this seam extends into New South Wales near the head of the Clarence river (Koreelah creek). Mesozoic coal may therefore be worked in this district in the future, but the country is very rough and is at present but sparsely settled, consequently there is not likely to be a local demand for coal for some years to come.

The Clarence Coal-Measures also outcrop on the western flanks of the Main Dividing range, and dip westerly under the central plains. The sandstones of this series form the intake beds of the great artesian basin of New South Wales. In many of the artesian bores put down on the western plains, coal-seams have been intersected, but as the percussion drill is used for all these bores, a solid core cannot be obtained, and consequently it has not been possible to ascertain the exact thickness or the quality of the seams passed through. However, although many thousand square miles of the north-western plains of the State are thus, in all probability, underlain by seams of coal, there is little or no likelihood of their ever being worked, on account of their being associated with beds containing water under pressure.

In the neighbourhood of Sydney, and, in fact, overlying a very large area of the main productive (Permo-Carboniferous) coal basin of New South Wales, is a series of sandstones and shales known as the Hawkesbury series. They are of fresh-water origin and contain very thin coal-seams, which, however, are nowhere workable. These measures have been named as follows, in descending order:

The Wiannamatta Shales.
The Hawkesbury Sandstones.
The Narrabeen Shales.

In lithological characters, the Hawkesbury Sandstones are indistinguishable from the sandstones of the Clarence river, and they were, for many years, regarded as equivalents. More recently, however, it has been considered probable that the Hawkesbury series may be older than the Clarence series. There is apparently a distinction to be drawn between them on Palæontological grounds. Thus, while the most characteristic fossil plants of the Clarence beds are *Tæniopteris Daintreei* and *Thinnfeldia Odontopteroides* (which have been found both in the great artesian basin and in the Clarence river basin), in the Hawkesbury Sandstones *Tæniopteris Daintreei* has not, so far, been met with, although *Thinnfeldia* is plentiful. At Talbragar river, about twenty miles north of Gulgong (N.S.W.), there is a small fresh-water lacustrine deposit occupying a denuded hollow in the Hawkesbury Sandstone. It contains *Tæniopteris Daintreei* and other plants, together with numerous fish remains, and Dr. A. S. Woodward, who examined the fishes, has pronounced them to be of Jurassic age. It seems possible therefore that the most correct classification of the Mesozoic rocks would be as follows:

Talbragar lacustrine beds..................	Jurassic.
Clarence Series..........................	Trias-Jura.
Hawkesbury Series.......................	Triassic.

III—PERMO-CARBONIFEROUS

The Permo-Carboniferous Coal-Measures are so called because the marine beds which accompany them contain fossil forms showing affinities to those of both the Carboniferous and the Permian systems of Europe.

These rocks form the great storehouse of the productive coal-seams of New South Wales. They occupy an area of about 16,550 square miles. The main coal-basin, as indicated on the accompanying map, extends along nearly two hundred miles of the eastern coast of the State, from the neighbourhood of Port Stephens on the north to Ulladulla on the south; from the latter place it trends inland to the west and north-west, the greatest width of the area in an east and west direction being from Newcastle to Rylstone, a distance of about one hundred miles. From Rylstone the main basin extends northwards beyond Gunnedah, and it is bounded thence by a line bearing south-eastwards back to Port Stephens. The deepest part of the basin is somewhere in the neighbourhood of Sydney, where a company known as the Sydney Harbour Collieries, Limited, is working the uppermost seam at a depth of 2,884 feet below the surface of the harbour. From here the Coal-Measures rise towards the north, south and west, as proved by the fact that the coal-seams outcrop at the surface in the neighbourhood of Newcastle, Bulli, and Lithgow, respectively. The measures also rise to the east, under the South Pacific Ocean, in which direction their extension is unknown.

The accompanying geological sections* show the structure of the main coal basin of New South Wales from north to south, and also from east to west, but it must be stated that the information shown in the deeper parts of the basin is more or less theoretical, except in regard to the uppermost seams of coal and overlying strata, where they have been penetrated by bores (as shown in the sections). The depth of the lower seams under Sydney, for instance, may be much greater or much less than that shown in the sections, for there may be a thickening or a thinning-out of the intervening strata.

*Map No. 3 in the Atlas.

The Permo-Carboniferous system has been classified, in descending order, as follows:

1. *Upper or Newcastle Coal-Measures,* containing twelve seams of coal. In the aggregate they contain 35 to 40 feet of workable coal..............	1,400 to 1,500 feet thick.
2. *Dempsey Series*—Freshwater beds, containing no productive coal. This series thins out completely in certain directions..........................	2,200 feet thick.
3. *Middle or Tomago, or East-Maitland Coal-Measures,* containing six seams of coal varying from 3 to 7 feet in thickness. In the aggregate they contain about 18 feet of workable coal..................	500 to 1,800 feet thick.
4. *Upper Marine Series,* specially characterized by the predominance of the fossil brachiopod, *Productus brachythærus*..................................	5,000 to 6,400 feet thick.
5. *Lower, or Greta Coal-Measures,* containing an aggregate of about 20 feet of coal....................	150 to 300 feet thick.
6. *Lower Marine Series,* specially characterized by the predominance of the fossil mollusc *Eurydesma cordata*..	4,800 feet thick.
Total maximum thickness.................	17,000 feet.

The characteristic fossil plant genera of the Permo-Carboniferous Coal-Measures are *Glossopteris, Vertebraria* (believed to be the root of *Glossopteris*), *Nœggerathia*, and *Gangamopteris*. Of these *Glossopteris* is equally common to the Upper, Middle, and Lower Coal-Measures. *Vertebraria* and *Nœggerathia* are found chiefly in the Upper and Middle Coal-Measures; while *Gangamopteris* is most abundant in the Lower, or Greta Coal-Measures, and occurs also at some depth down in the Lower Marine series.

The Permo-Carboniferous Measures are overlaid in many localities by the Hawkesbury series (Triassic), and as a general rule there is no apparent unconformability between them, so far as their stratigraphy is concerned. A notable instance to the contrary, however, occurs near Ællalong, where, according to Professor David's survey, the Hawkesbury series rests upon the Muree beds of the Upper Marine series, and about 7,000 feet of the strata which usually intervene are missing. The Palæontological evidence also shows a marked lapse of time between the depositions of the two formations, the Palæozoic marine fossils and plant remains of the Permo-Carboniferous rocks being succeeded by Mesozoic types of fish, labyrinthodonts, fresh-water shells (*Unio* and *Estheria*) and plants.

1—The Upper Coal-Measures

The Upper Coal-Measures show the greatest surface development of any of the Permo-Carboniferous rocks. Their coal-seams outcrop in the neighbourhood of Newcastle in the north, Lithgow in the west, and Bulli in the south, and they extend continuously under the deep portion of the basin, as illustrated in the geological sections in the accompanying Atlas.

In the *Northern* or *Newcastle Coal-Field* twelve seams (which, with included bands, vary from three feet to about twenty feet in thickness) have been discovered in these measures. They have been named as follows, in descending order:

1. The Wallarah Seam, about 11 feet thick.
2. The Great Northern Seam, about 20 feet thick.
3. The Fassifern Seam, up to 25 feet thick.
4. The Upper Pilot Seam } Not workable.
5. The Lower Pilot Seam } Not workable.
6. The Australasian Seam, from 7 to 20 feet thick.
7. The Burwood Seam, from 6 to 8 feet thick.
8. The Nobbys Seam, not workable.
9. The Dirty Seam, from 6 to 10 feet thick, splits into two in places.
10. The Yard Seam, about 3 feet thick.
11. The Borehole Seam, from 4 to 22 feet thick, usually 8 to 9 feet.
12. The Sandgate Seam, from 4 to 6 feet thick.

Of these twelve seams only five, viz., the Wallarah Seam, the Great Northern, the Australasian, the Burwood, and the Borehole are at present being worked, and by far the greatest amount of work has been done in the last-named seam (the Borehole), which has produced great quantities of exceedingly fine coal, the quality being especially suitable for household and gas-making purposes. None of the other nine seams, so far as they have been prospected in the Newcastle district, has proved sufficiently good to be profitably worked under present conditions.

In the *Southern* or *Illawarra Coal-Field* five seams are known as follows, in descending order:

1. The Bulli Seam, 2 to 11 feet thick, usually 6 to 7 feet.
2. The Four-feet Seam, about 4 feet thick.
3. The Thick Seam, or Dirty Seam, about 17 feet thick. (Several small seams occur between the Thick Seam and the Eight-feet Seam.)
4. The Eight-feet Seam, from 7 to 9 feet thick.
5. The Bottom Seam, about 6 feet thick, including numerous bands.

Only two of the above-mentioned seams have, so far, been worked, viz., the Bulli Seam, and the Four-feet Seam, and the operations on the last-mentioned have only been on a small scale. Almost all the coal produced in the southern coal-field has been obtained from the Bulli Seam, which is the uppermost one of the series. Southern coal is essentially a steam coal, containing as it does about 65 per cent. of fixed carbon; but in addition to this it produces an exceedingly strong coke, which is specially suitable for smelting purposes by reason of its capacity for sustaining the weight of the ore burden in a blast furnace.

In the *Western* or *Lithgow Coal-Field* there are seven seams known, and of these only three are of commercial importance. Coal has actually been recovered from three seams, but by far the greatest proportion has come from the lowest of the series, viz., the Lithgow Seam.

In descending order the seams have been defined by Mr. J. E. Carne, assistant Government geologist, as follows:

1. The Katoomba or Top Seam, from 2 to 6 feet thick.
2. The Dirty Seam; with bands, attains a thickness of 18 feet.
3. }
4. } Thin, unimportant seams.
5. }
6. Upper Irondale Seam, from 5 to 8 feet.
7. The Lithgow Seam, about 11 feet 6 inches thick (lower 6 feet worked).

The Top or Katoomba Seam has been worked to a small extent at Hartley Vale, Main Camp and Katoomba. The sixth seam has been opened in the upper tunnel at Irondale colliery, in Wallace's Black Diamond colliery (?), at Blackman's Flat, and at Cullen Bullen.

All the collieries in the immediate neighbourhood of Lithgow are working the lowest or Lithgow Seam.

Western coal is inferior to southern for steam raising purposes and it has the additional disadvantage of containing a higher proportion of ash.

A feature of the western coal-field is the occurrence in the Coal-Measures of lenticular patches of kerosene shale, a variety of torbanite, cannel coal, or boghead mineral. It is used extensively for the manufacture of kerosene oil, and also for the production of gas. The lenticular patches of shale vary considerably in extent; in thickness they range from an inch or two up to 4 feet 6 inches, while in length or width they seldom exceed a mile. At the edges of the deposits the shale is found to pass into either bituminous or splint coal, or into earthy or stony carbonaceous shale; it is also frequently associated with coal-seams either above or below it. Very rich deposits of kerosene shale occurred at Hartley Vale, near Mount Victoria, and at Joadja near Mittagong, but both these deposits have been worked out. An extensive deposit, extending from the Capertee valley to the Wolgan valley, is at present being worked by the Commonwealth Oil Corporation. While not as rich as the deposits just referred to, it is probably of greater extent. Much less extensive deposits of kerosene shale have been found both in the Greta Measures and in the Upper or Newcastle Coal-Measures in the northern coal-field.

It has already been stated that the *Upper* or *Newcastle* Coal-Measures extend from Newcastle on the north to Ulladulla on the south, and also to Lithgow on the west, and that in the central part of the basin they occur at a depth of some thousands of feet, being overlain by the Hawkesbury series (Triassic). It is not possible, however, to correlate all the seams occurring near Newcastle with those discovered in the southern and western coal-fields; indeed, it will be noticed that nearly twice as many seams have been mentioned in the first-named locality as in the two latter. Doubtless some of the seams thin out altogether between Newcastle and Ulladulla, while others may split and make together again at intervals. It would certainly be remarkable if all the coal-seams followed the same horizons and maintained the same approximate thicknesses for a distance of two hundred miles. It is, nevertheless, believed that the Wallarah Seam of the northern coal-field is identical with the Uppermost or Bulli Seam of the south, and the Top or Katoomba Seam of the west; also that it coincides with the seam met with in the diamond drill bore at Sydney at a depth of nearly 3,000 feet, and which is now being worked by the Sydney Harbour Collieries, Limited. If this be so, the seam has a wonderfully persistent development, though its quality is by no means uniform. For instance, in the southern coal-field the Upper or Bulli Seam consists of good steam coal, in the Sydney Harbour colliery the coal is of about equal quality, while in the Newcastle coal-field the Wallarah Seam is only worked in one colliery, and in the western coal-field the workings in the Top or Katoomba Seam have been unimportant.

2—The Middle or Tomago or East Maitland Coal-Measures

The Middle, or Tomago, or East Maitland Coal-Measures outcrop in the neighbourhood of East Maitland, and their general dip is towards Newcastle under the Dempsey Fresh-water series and Upper Coal-Measures. The following are the principal seams, in descending order:

1. Top Seam, or Donaldson's Seam.............. 4 to 6 feet thick.
2. Big Ben, or Tomago Thick Seam.............. 7 to 10 feet thick.
3. Tomago Thin Seam.......................... $2\frac{1}{2}$ to 3 feet thick.
4. Scotch Derry Seam......................... 9 to $10\frac{1}{2}$ feet thick.
5. Rathluba Seam............................. $5\frac{1}{2}$ to 11 feet thick.
6. Morpeth Seam.............................. $4\frac{1}{2}$ to 8 feet thick.

There are about forty feet of coal (in the aggregate) in the Middle Coal-Measures, and the total thickness of coal actually worked is about eighteen feet.

The Middle Coal-Measures do not occur in either the southern (Illawarra), or the western (Lithgow) coal-field, where the Upper Coal-Measures rest upon the Upper Marine beds. It is evident, therefore, that the Middle Coal-Measures must thin out going southwards from Newcastle—though how far southwards they really extend is a matter of uncertainty at present. The deep bore at Sydney which intersected the Bulli Seam at a depth of nearly 3,000 feet, was not carried deep enough to meet with any other coal-seams, and consequently it is not known whether the measures referred to extend that far south. Going northwards from Maitland, also, there is no certain evidence of any outcrop of the Middle Coal-Measures, though it is somewhat doubtful whether the Rix's creek seams, near Singleton, belong to those measures, or to the Newcastle series.

3—The Greta Coal-Measures

The Greta Coal-Measures outcrop as a narrow belt of conglomerates, sandstones, shales and coal-seams. The total thickness of these beds never exceeds 300 feet. In the neighbourhood of Maitland their outcrop follows a very irregular course and they dip under the Middle and Upper Coal-Measures. To the north of Maitland they have been traced as far as Wingen, and they again occur as an isolated belt to the north of Inverell, extending thence through Ashford to near the Queensland border. The outcrop of the Greta measures is shown on the accompanying map* as a red line. In their normal position they lie upon the Lower Marine and are overlain by the Upper Marine series, but they have been much intruded by igneous rocks, so that it frequently happens that they are bounded on one side by either granite or quartz-felsite, and their angle of dip is often very considerable.

There are two seams worked in these measures, viz.:

1. The Upper Seam, varying from fourteen to thirty-two feet in thickness.
2. The Lower Seam, varying from three to eleven feet in thickness.

A few very small lenticular patches of kerosene shale were found to occur in the upper coal-seam at Greta, and a seam of cannel, about five feet thick, in the same upper coal-seam at Homeville, near West Maitland.

The coal from the Greta measures is very hard, and can therefore be economically worked, inasmuch as it makes a minimum quantity of "smalls"; it is, moreover, of exceedingly good quality, being useful for gas making and household purposes, and also for steam raising, though, on account of its large proportion of volatile hydrocarbons, it has a tendency to burn too fast for use with a forced draught; moreover, it makes too much black smoke for navy purposes. Still, it is undoubtedly the purest and generally most useful coal in the State, while the great thickness of the seams in which it occurs makes it an exceptionally valuable deposit of fuel. One disadvantage from which the Greta coal suffers is that it contains rather a high percentage of sulphur, and this is especially true in regard to the top bands of coal in the Upper or Thick Seam. These are termed by the miners the "brassy tops" on account of the presence of so much iron pyrites in them. They are usually left as a roof and the lower portions of the seam are worked. When the "brassy tops" fall, in the pillar workings, they are very liable to spontaneous combustion.

The Greta Coal-Measures have also been recognized in the Clyde valley in the extreme southern portion of the Illawarra coal-field, but the seams there, as far as they have been prospected, do not appear to be workable under present conditions, the coal being slightly inferior and the seams thin. Kerosene shale, of somewhat inferior quality, has also been met with in this neighbourhood.

In the western coal-field there is no appearance of the Greta Coal-Measures. The Upper Coal-Measures there lie upon the Upper Marine, and the latter rest unconformably upon Devonian strata.

IV—CARBONIFEROUS

In the neighbourhood of Stroud, about forty miles to the north of Newcastle, seams consisting of coal and bands occur in rocks which correspond in age with the Carboniferous system of Europe. The coal is of very inferior quality, however, and certainly cannot, so far as has been ascertained, be regarded as workable. Moreover, the deposits are probably very limited in extent, so that the true Carboniferous rocks may safely be disregarded as a possible source of fuel in New South Wales.

*Map No. 2 in the Atlas.

QUANTITY OF COAL AVAILABLE IN NEW SOUTH WALES

Attempts to estimate the quantity of coal available in any country are more or less hazardous owing to the tendency of the seams to vary in thickness, and of the coal to alter in quality. In a comparatively young country like Australia, this statement is even more applicable than in the case of European coal-fields, for here there has been much less exploration of the seams, and there are, consequently, many more uncertain factors in the calculation. Reference has already been made to the fact that the coal-seams of the Upper Coal-Measures outcrop at the surface in three widely separated districts, viz., Newcastle, Illawarra, and Lithgow, and that they dip under the intervening country, and attain their greatest depth, probably, near Sydney. The only knowledge which we possess of the deposits of coal in their deepest parts was acquired by boring in the first instance, and subsequently by the sinking of a pair of shafts to the top seam, which was penetrated at a depth of about 2,900 feet in the Sydney Harbour collieries. It has never been ascertained how many of the other seams of the Upper Coal-Measures underlie this seam, whether the Middle Coal-Measures occur there, or not, nor at what depth the Greta seams occur, nor whether they maintain their quality. As the Greta seams outcrop in both the northern and southern coal-fields, it is probable that they do underlie Sydney, but their depth from the surface there is doubtless very great indeed, probably 8,000 or 10,000 feet, so that there is very little chance of their ever being worked. While it is impossible to correlate with certainty many of the coal-seams of the northern coal-field with those of the southern and western fields, we are in a position to say that the seams which contain the best coal in any one field are of inferior quality or unworkable in the others. In other words, there is such variation in the quality of the coal that it is impossible to say over what area any particular seam may or may not be workable.

It is clear, therefore, that any estimate of the quantity of coal in New South Wales must be based upon very uncertain data. For the purposes of an approximate estimate, however, we may assume the following:

Area within which the Upper and Middle Coal-Measures are productive within 4,000 feet of the surface......	15,800 square miles.
Area within which the Greta Coal-Measures are productive, in the northern district, within 4,000 feet of the surface....................................	250 square miles.
Area within which the Greta Coal-Measures are productive, in the southern district, within 4,000 feet of the surface....................................	500 square miles.
Total area................................	16,550 square miles.

In their most productive areas the Upper Coal-Measures contain about 40 feet of workable coal; the Middle Coal-Measures contain about 18 feet of workable coal; the Greta Coal-Measures contain about 20 feet of workable coal. There is, therefore, a maximum thickness of about 78 feet of workable coal in the Permo-Carboniferous rocks. It would, however, be very unsafe, in estimating our coal resources, to assume that anything approaching that thickness of coal is available under the area mentioned above, for reasons which have already been given.

It seems preferable, therefore, to base the calculation upon the assumption that a thickness of only ten feet of workable coal underlies an area of 16,550 square miles. Taking 84 pounds as the average weight of a cubic foot of coal, and deducting one-third of the gross weight for loss in working, impurities, etc., this would represent a total quantity of 115,346,880,000 tons of available fuel within a depth of 4,000 feet.

No estimate of the coal obtainable in the Middle and Upper Coal-Measures, between depths of 4,000 and 6,000 feet, can be attempted, because the necessary data are not available, no bore or shaft having ever penetrated deeper than the uppermost seam of the Upper Coal-Measures in the deeper parts of the basin. The Greta Coal-Measures are of wide extent, but as they are separated from the Upper and Middle Coal-Measures by a thickness of about 6,000 feet of Marine beds, and are therefore concealed for the greater part, the quantity of coal available in them between 4,000 and 6,000 feet below the surface can only be estimated under a limited area which has recently been surveyed by Professor David. Within this area, which is in the vicinity of Kurri Kurri and Cessnock (*vide* map) south of the Hunter river, they are estimated to contain 1,893,000,000 tons of workable coal above a depth of 4,000 feet under an area of 158 square miles, and an additional 1,200,000,000 tons between 4,000 and 6,000 feet under an area of 100 square miles.

ANALYSES OF NEW SOUTH WALES COAL

During the past three months proximate analyses have been made of thoroughly representative samples of coal taken from all the collieries now working in the State. In all the larger collieries, at least two samples have been taken from points as far removed from one another as possible. The samples were taken by the Government inspectors of mines in accordance with the following directions:

> "Details to be observed in taking samples of coal for analysis. The samples should be taken from two of the working faces of the colliery as far from one another as possible. A strip of coal should be carefully cut out with a pick for the whole thickness of the seam as worked, so that the sample may represent the coal actually sent to market. The strip of coal should be the same width (say three inches) all the way from the roof to the floor, and the depth of the cut should also be uniform. If any bands occur, which are usually picked out before the coal is sent to market, they should also be excluded from the sample, but all those which are usually left in the coal sent to market should also be included in the sample. Before taking a sample the floor of the working place should be cleared, and a large strip of brattice cloth should be spread out so as to catch all the coal cut out of the strip. The entire quantity should then be broken down care-

fully to the size of small nuts, and thoroughly mixed. One half of this should then be again well mixed and halved, and the mixing and halving should be continued until a sample of about a pound and a half in weight has been obtained. It is especially desired that the greatest care be observed in attending to all the above details."

In all, 194 proximate analyses have been made by Messrs. J. C. H. Mingaye, H. P. White, and W. A. Craig, of the Geological Survey Laboratory.*

The average composition of the coal from the Upper or Newcastle Coal-Measures in the northern coal-field, as calculated from the analyses of seventy-eight samples, is as follows:

Hygroscopic moisture	2.01%
Volatile hydrocarbons	36.01
Fixed carbon	53.27
Ash	8.71
	100.00
Sulphur	0.468%
Calorific value	12.7

The average composition of the coal from the Middle or Tomago Coal-Measures in the northern coal-field, as calculated from the analyses of five samples, is as follows:

Hygroscopic moisture	1.88%
Volatile hydrocarbons	35.71
Fixed carbon	52.77
Ash	9.64
	100.00
Sulphur	1.185%
Calorific value	12.5

The average composition of the coal from the Lower or Greta Coal-Measures in the northern coal-fields, as calculated from the analyses of fifty-one samples, is as follows:

Hygroscopic moisture	1.84%
Volatile hydrocarbons	41.61
Fixed carbon	49.52
Ash	7.03
	100.00
Sulphur	1.291%
Calorific value	13.07

*See "Coal Resources of New South Wales," by E. F. Pittman, Geological Survey of New South Wales, 1912.

The average composition of thirty-one samples of the coal from Greta seams as *actually worked* in the northern coal-field, is as follows:

Hygroscopic moisture	1.89%
Volatile hydrocarbons	41.35
Fixed carbon	50.51
Ash	6.25
	100.00
Sulphur	1.014%
Calorific value	13.2

The average composition of the coal from the Upper Coal-Measures in the western coal-field, as calculated from the analyses of twenty-five samples, is as follows:

Hygroscopic moisture	2.05%
Volatile hydrocarbons	32.31
Fixed carbon	53.08
Ash	12.56
	100.00
Sulphur	0.672%
Calorific value	11.9

The average composition of the coal from the Upper Coal-Measures in the southern coal-field, as calculated from the analyses of thirty-five samples, is as follows:

Hygroscopic moisture	0.71%
Volatile hydrocarbons	23.65
Fixed carbon	63.98
Ash	11.66
	100.00
Sulphur	0.470
Calorific value	12.68

THE COAL RESOURCES OF VICTORIA

COMPILED BY

THE DEPARTMENT OF MINES OF VICTORIA

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)
	No.	Thickness	Area	Class of Coal	Metric Tons	
Gippsland.......	1	1 ft. to 1 ft. 9 inches	12 sq. miles	B_3	15,000,000	Impossible to estimate even approximately.
Otway..........	1	1 ft. to 1 ft. 6 inches	$\frac{1}{2}$ sq. mile	B_3	100,000	
Merino.........	1	1 ft. to 1 ft. 3 inches	$\frac{1}{4}$ sq. mile	B_3	50,000	

GROUP II

INCLUDING SEAMS OF 2 FEET AND OVER, AT DEPTHS BETWEEN 4,000 AND 6,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons
Gippsland.....	1	2 ft. to 9 ft...	6 sq. miles.	B_3	25,000,000	5 sq. miles	B_3	12,000,000

The data are insufficient to form any estimate of the possible reserves.

THE COAL RESOURCES OF QUEENSLAND

BY

B. DUNSTAN

Government Geologist of Queensland

(With one map in the Atlas)

CONTENTS

INTRODUCTION

In Queensland vast regions of magnificent coal-bearing country are distributed over its area of 670,500 square miles, the deposits being mostly confined to the central and southern portions of the State. The south-eastern portion of its sea-board for 200 miles is furnished with Coal-Measures, whilst inland there is an uninterrupted stretch of Coal-Measures, belonging to two ages, extending over a distance of 600 miles.

The area of the geologically surveyed Coal-Measures of the State is estimated to be 73,000 square miles, which is 15,000 square miles greater than the area of the whole of England and Wales. Of this area 20,000 square miles is made up of recognized coal-fields, the remainder consisting of lands known to contain coal in places but not proved, up to the present, to be valuable for coal-mining purposes.

The geological formations containing Coal-Measures belong to the Mesozoic and Palæozoic ages, the systems represented being: (1) *Upper Cretaceous* (Desert Sandstone and Rolling Downs formations); (2) *Trias-Jura* (Ipswich, and (?) Burrum formations); and (3) *Permo-Carboniferous* (Tolmies, Clermont, Dawson and Mackenzie formations—Upper, Middle, and Lower Bowen formations). Of these coal-bearing formations the Cretaceous deposits are of minor importance, the Trias-Jura measures being those from which most of the coal supplies are now obtained. In future, with railway communication established, the inland Permo-Carboniferous formations will be an important source of supply, but most of these deposits remain untouched at the present time.

The estimation of actual, probable, and possible reserves of coal in an undeveloped country like Queensland is attended with many difficulties, and it is with a great deal of hesitation that the estimation of quantities is submitted with this article. Nevertheless, the whole question has been considered as carefully as circumstances would allow, and the results may be taken as a summary of the information accumulated officially during the last twenty-five years. References which accompany the Table of Resources show the general character of the seams, and other details bearing on their stratigraphical features.

Coal-Measures which have been geologically examined, but not tested for coal-seams, have received some attention, and areas around centres of population have been specially considered with a view of development being undertaken in the future. References are therefore given to all unprospected coal areas in the vicinity of Brisbane, Maryborough, Gladstone, Rockhampton, Mackay, Townsville and Cooktown.

Attention is paid to the connection of the various coal-fields with ports and railways, and some information is given concerning the coal-areas and their position with regard to existing railway lines, and also their prospects of trade when other lines, under consideration or approved by Parliament, have been opened for traffic.

The quality of coal occurring in the numerous areas is shown in an Analytical Table, the percentages of the ash, fixed carbon, etc., being the means of many hundreds of analyses made for the Queensland Geological Survey. References to the Table of Analyses also show the special purposes for which the coal is adapted.

Some statistical notes are included to show the value of the output of the coal mines since 1860, the year when returns were first officially recorded. Prior to that year perhaps 100,000 tons of coal were mined in the State, and since then 12,000,000 tons have been taken out. Comparing this quantity with the probable coal reserve and the possibilities of much larger quantities being available, some idea can be obtained of Queensland's potentialities in its coal resources.

Each area under the headings, Table of Coal Resources, Notes on Table of Coal Resources, Table of Proximate Analyses, Notes on Table of Analyses, and Railway and Port Facilities has a distinguishing number, which will facilitate cross references and avoid repetition.

CRETACEOUS COAL-MEASURES

The strata belonging to this system extend over a very large area in Western Queensland, reaching from the Gulf of Carpentaria down to the southern and south-western borders of the State, the area embracing 4,000,000 square miles. It has been found to be coal-bearing in a great number of the localities where artesian bores have been sunk, but the records which have been made of these occurrences are very imperfect. It has been proved, however, that some of the coal-seams were penetrated at shallow depths and that others were found at depths between 1,000 and 2,000 feet.

Coal-seams and bands are known to occur at Croydon, Flinders river, Warreah, Marathon, Mount Sturgeon, Kynoona, Winton, Vindex, Malta, and several other localities, and, as the result of observations extending over a period of many years, it may be taken for granted that the Cretaceous beds offer inducements for prospecting operations in the western districts of the State, except where they are close to Palæozoic or Trias-Jura Coal-Measures, the two latter being much preferred on account of the better quality of the coal they produce and the greater thickness and number of the seams they contain.

TRIAS-JURA COAL-MEASURES

Localities where Trias-Jura Coal-Measures occur, are, with one exception, confined to the south-eastern quadrant of the State, the larger area of coal-bearing lands being about Moreton bay, and in the districts to the south and west of Brisbane, other important areas being on the coast about Hervey bay near Maryborough, and at the Styx river near Broadsound, whilst inland there are large tracts of Coal-Measures north of the Western Railway line as far as Taroom, also at Callide creek to the south of Port Curtis, Waterpark to the north of Rockhampton, and at Stanwell west of Rockhampton. The only area outside the south-eastern quadrant is that on the Endeavour, Laura, and Deighton rivers, to the west of Cooktown, in the far north. This has recently been classed as a Lower Mesozoic formation, previously being referred to the Cretaceous.

Some doubt has arisen regarding the age of some of the coal-bearing strata near Maryborough, and probably the Burrum coal-field will require to be classed as a sub-division of the Cretaceous, recent developments revealing the occurrence of an apparently underlying marine series containing typical Cretaceous fossils. With the new classification, the Cretaceous system would embrace an important series of coal-bearing strata.

PERMO-CARBONIFEROUS COAL-MEASURES

There is a large extent of Permo-Carboniferous Coal-Measures in the central districts of Queensland, the eastern boundary of the area being the Main Coast range east of the Dawson, Mackenzie and Isaacs rivers, the western limit being close to the Nogoa river and to the Clermont Railway, with an extension northerly from Clermont to the Bowen river. The northern boundary on the

Bowen river is at the apex of the converging eastern and western boundaries, the southern limit being along the Carnarvon and Lynd ranges and across the Dawson river near Taroom, about 70 miles north of the Western Railway.

Other areas exist at Mount Mulligan, near the Chillagoe Railway line, and at Little river, 80 miles west of Cooktown.

APPROXIMATE AREA OF COAL-MEASURES

The Cretaceous Coal-Measures

From the numerous bores for water which have been sunk it is evident that the country extending from the north of Hughenden to the south of Winton in Western Central Queensland—a distance of 200 miles—may be considered to be underlain by proved Coal-Measures, the width of this belt being about fifty miles on either side of a line joining these two towns, the area forming a quadrangle of about 20,000 square miles.

Trias-Jura Coal-Measures

The coal-lands occurring at Little river and Oakey creek in the Cooktown district are 1,000 square miles in extent, those at Styx river, Waterpark creek, Stanwell, and Callide creek each having an area of about 100 square miles.

The coastal Coal-Measures extending from Baffle creek, north of Bundaberg, to Noosa Heads, embrace Littabella creek, Howard, Burrum, Torbanlea, Aldershot, Maryborough, Tinana creek, Colton, Pialba, Tiaro, Miva, Gundiah, and Gunalda. They have a seaboard of 150 miles, and are contained in an area of 3,000 square miles.

Southwards from Noosa Heads the coastal measures extend to Southport, a distance of 100 miles, and embrace an area of 2,000 square miles. They include Landsborough, Caloundra, Nundah, Bribie Island, Caboolture, Moreton Island, Stradbroke Island, Tingalpa, Capalaba, and the northern end of Southport.

The Ipswich Coal-Measures south of Brisbane include Walloon, Ipswich, Bundamba, Goodna, Beenleigh, Beaudesert, Boonah, and the Albert and Logan rivers, this group being contained in an area of 5,000 square miles.

The Darling Downs coal-area extends from Toowoomba to Warwick and Chinchilla, embracing Gowrie, Kingsthorpe, Clifton, Jondaryan, Jimbour, Dalby, Allora, Tannymorel, Killarney and Pittsworth, the whole aggregating 5,500 square miles.

The southern Leichhardt Coal-Measures between Taroom and the Western Railway line embrace the whole of the area drained by the Dawson river above Taroom and also portions drained by the Maronoa and Condamine rivers, and is 6,000 square miles in extent.

Permo-Carboniferous Coal-Measures

All along the Central Railway line between Emerald and Duaringa, a distance of 100 miles, there is a pronounced development of Coal-Measures. North of the railway line for 30 miles there are exposures of these measures which connect with the Mackenzie river on the east and Capella on the west, the whole forming an area of 4,000 square miles.

Between the Central Railway and an east-and-west line about 40 miles to the south joining Springsure and the Dawson river, there is another area of Coal-Measures, 4,000 square miles in extent.

To the north of the Mackenzie river and Capella, along the Isaacs and Bowen rivers and then west to Clermont, there is a vast extent of Coal-Measures covered in places by alluvium and Cretaceous deposits and having an area of 11,800 square miles.

To the south of the east-and-west line from Springsure to the Dawson river and extending to the Upper Dawson river as far as Taroom, there is another area of Coal-Measures containing 9,000 square miles.

North and south of Mackay a small area exists, being about 1,200 square miles in extent.

APPROXIMATE AREA OF COAL-FIELDS

Cretaceous Coal-Fields

The coal-area between Winton and Hughenden may be considered as proved, coal-seams having been found at Warreah, Flinders river, Blantyre, Lammermoor, Winton, Marathon, and Vindex, the extent of which is 2,000 square miles.

Trias-Jura Coal-Fields

Coal-seams have been proved to exist at Ipswich, Loamside, Walloon, Bundamba, Rosewood, Beaudesert, Boonah, Logan river and Brisbane river, some of the seams being of workable thickness and of splendid quality. These fields are contained in an area of 600 square miles. Gunalda, Tiaro, Burrum, Torbanlea, and Howard coal-fields in the aggregate have an area of about 300 square miles; Chinchilla, Jimbour, Jondaryan and Dalby, 300 square miles; Gowrie, Kingsthorpe, and Clifton, 200 square miles; Tannymorel and Killarney, 200 square miles; Callide creek, 60 square miles; Styx river, 240 square miles; Waterpark creek, 100 square miles; the total area of the Trias-Jura coal-fields being 2,000 square miles.

Permo-Carboniferous Coal-Fields

The Clermont coal-field has an area of 20 square miles of good coal land, but there are possibilities of a much larger extent below flows of basalt on the Drummond range, while the immense fields of Dawson, Mackenzie, Isaacs and Bowen rivers, with their wonderful coal-seams, embrace an area of nearly 16,000 square miles.

TOTAL AREAS OF COAL-MEASURES AND COAL-FIELDS

Coal-Measures (as outlined by Queensland Geological Survey)—*Cretaceous*, 20,000 square miles; *Trias-Jura*, 23,000 square miles; *Permo-Carboniferous*, 30,000 square miles, equals 73,000 square miles.

Coal-Fields (proved to contain coal-seams, workable and otherwise)—*Cretaceous*, 2,000 square miles; *Trias-Jura*, 2,000 square miles; *Permo-Carboniferous*, 16,000 square miles, equals 20,000 square miles.

COAL RESERVES—ACTUAL, PROBABLE, POSSIBLE

It will be necessary to state, in forming an estimate of coal reserves, that *total* quantities, not *available* quantities have been taken as a basis for calculation, and it may be as well to again express the hesitation felt in giving results on such clearly defined divisions as "Actual, Probable and Possible."

The probable and possible quantities have been given with due regard to the general stratigraphical features of the measures, and the absence or otherwise of disturbing elements, and that the estimate may be within the limit of safety, a square mile around a locality where a seam of coal has been opened is generally taken as the limit of probability and three square miles the limit of possibility. Exceptionally favourable circumstances have allowed these limits to be extended in some cases, and bad conditions have caused their being reduced, while occasionally circumstances have necessitated the probable and possible limits being shown practically the same.

From a general review of the table it is seen that the extensive basin of the Dawson-Mackenzie rivers contains far more "probable" and "possible" resources than all the other parts of the State put together.

Conspicuous amongst the large number of known seams in this basin is the 20-foot Mammoth seam in the Mackenzie river area and the 66-foot seam in the Clermont area, both coals being of good quality, other noticeable occurrences being the 20 feet of fine coal in the nine seams of the Burrum area, the 20 feet of coal in the Callide area, and the 60-foot seam at Waterpark creek.

The table of coal reserves has been built up exclusively on Group 1 (coal not less than one foot thick, and not more than 4,000 feet below the surface), the estimation of quantities below 4,000 feet being found to be impracticable at the present time.

UNPROSPECTED COAL-MEASURES

Brisbane has a large extent of Trias-Jura Coal-Measures in its vicinity, to the north and south-east, and there is an extension of the same series to the east, about the shores of Moreton bay. This area, which may be termed the East Moreton basin, embraces Caloundra, Bribie Island, Humpy Bong, Sandgate, Nundah, Brisbane river, Tingalpa, Logan, and Southport, together with Moreton and Stradbroke Islands. In this basin, which is about 80 miles long and has an average width of about 12 miles, a few coal outcrops have been exposed, but a large area exists which has not been tried in any way.

The Ipswich Trias-Jura Coal-Measures, south-east and south of Brisbane, contain areas of good coal-lands under mining development, but there are many portions which have not yet been prospected. On the Darling Downs, to the west of the Ipswich area, and about Beaudesert to the south, operations during recent years have shown coal to exist in many localities, but the area proved is exceedingly small when compared with that which has not been tested.

MARYBOROUGH is the centre of a large extent of Trias-Jura Coal-Measures. At several localities to the west and south of the town, coal outcrops occur which have not been examined, and at Urangan, the proposed deep-water port, the horizontally-bedded measures are known to carry small coal-seams. Nothing, however, has been done to prospect this area, although it is a continuation, or extension, of the Burrum field which contains several seams of coal of first-class steaming and coking qualities.

GLADSTONE is about fifty miles from the Callide creek coal deposits, but with which it is not yet in railway communication. The Callide field has been paid but little attention, and although some of the seams have been exposed, much more remains to be done before the examination of the whole of the Trias-Jura coal-field is completed.

ROCKHAMPTON is seventeen miles from the centre of the Stanwell Trias-Jura Coal-Measures and the centre is about two miles from the Stanwell railway station. The measures here are known to contain small coal-seams in nearly horizontal strata, and no disturbances are apparent, notwithstanding which the centre of the field has not been prospected except by a shallow bore and a few shallow wells. To the north of Rockhampton, at the Styx river, about 80 miles distant, no action has been taken to open up the Trias-Jura coal-areas known to exist there, but railway connection is being established and the line will traverse portions of the field where coal outcrops are exposed. West of Rockhampton the Dawson-Mackenzie river areas are undergoing development in the Permo-Carboniferous Coal-Measures, but only a few square miles out of its many thousands have been examined, while at Waterpark creek, between Rockhampton and Mackay, fine brown-coal deposits are lying dormant.

In the MACKAY district, close to the coast, there are large tracts of Permo-Carboniferous coal-bearing country, and although much of it is disturbed by volcanic intrusions, large areas, apparently undisturbed, remain untouched.

Close to TOWNSVILLE at Stewart's creek there are Trias-Jura Coal-Measures which have been prospected to a very limited extent, but the possibilities of the field are by no means exhausted. The coal-fields about Hughenden also remain idle, although a thick coal-seam is said to have been proved by boring.

The COOKTOWN and Little river coal-fields both contain good coal-seams, but neither is being worked. Other deposits farther north, at Lloyd bay and Pascoe river, have not been examined, and persistent reports have been made by travellers that coal occurs in several other places in Cape York peninsula, north of Cooktown.

In WESTERN QUEENSLAND the coal-seams existing in the Cretaceous beds are but little known. As previously stated they have been penetrated in sinking for artesian water, and data concerning the strata passed through have not been recorded for future reference, those interested in finding water having no interest whatever in looking for coal-seams. The mistake is now apparent, for railway construction is taking place over the whole length and breadth of this artesian water-bearing country.

NOTES ON THE TABLE OF COAL RESOURCES

1. Beaudesert. The coal generally occurs in seams a few inches thick, but some are large enough to work. A special feature about Beaudesert coals is their high quality for gas making.

2. Burrum. The Howard, Burrum and Torbanlea areas have been opened up by several collieries and large quantities of good coal have been taken out. The Burgowan (Bellert) area has recently been prospected, and a colliery is now established on it, but the coal country on the Isis and Cherwell rivers has not yet been touched. The coal-seams tend to thicken and thin within small areas, and the measures have usually a gentle dip. Faults occur in places, and one at Torbanlea has produced a serious disturbance, beyond which the coal has not yet been found.

3. Callide. There is a possibility that the five square miles, estimated as the possible area of coal-bearing country, will prove to be too small an estimate for this field, as the measures appear to be uniform and undisturbed. The deepest shaft is only 60 feet, so that sinking might reveal other seams.

4. Chinchilla. Some of the seams are several feet thick, and the country, apparently, has not been disturbed. Four of the localities where workable seams occur are within two miles of the railway. There are no records, however, of trials of the coals being made.

5. Clermont. Two seams so far have been discovered, the top 4-foot small seam is bright and of fine quality, the lower one, 66 feet thick, being rather dull, but excellent for steaming purposes, both coals having non-coking qualities. Nothing is known of the measures below 140 feet, so other seams might be found by sinking deeper.

6. Cooktown. The 15-inch seam occurs at Deighton river, but many others less than a foot thick are known. Much remains to be done before the field is thoroughly prospected.

7. Dalby. Very little has been done to prove the resources of the field, the seams which are known being discovered only accidentally when sinking wells in dry country.

8. Dawson River. Stratigraphical movements have disturbed the coal-seams in places, a belt of broken country apparently traversing the measures in a N.N.W. direction, parallel with the range to the east of the river; other such belts may be expected to be found, but of less frequency, farther west, in which direction the coal probably continues below the Expedition range towards the Comet river. Also, in this direction, the coal may be expected to become less anthracitic, and to have coking properties.

9. Hughenden. Flinders river is the site of a coal outcrop, and its discovery here induced the starting of operations at Blantyre, near the railway line to the north of Warreah. A bore in the vicinity is said to have penetrated a thick seam of coal and afterwards a shaft was sunk to work the seam. Large quantities of water were struck at 500 feet and prevented the shaft being sunk to the depth required.

10-11. Ipswich-Walloon. These fields have been worked for many years, and instead of becoming exhausted, indications seem to show that the coal exists far beyond its previously supposed limits. In the Ipswich area the seams vary very much in thickness within short distances, and the coal is inclined to be friable, although excellent for steaming, and, in one portion of the field, also for coke-making. The Walloon coals are very firm and specially desired for gas making.

12. Little River. The measures are somewhat disturbed by folding along the line of a fault, and the coal in consequence is inclined to be low in volatile matter. There is a possibility of other seams existing, as the exposures of coal outcrops are nearly all along one line of strike.

13. Mackenzie-Central Railway Area. The large extent of coal country comprised in this area, the regularity of its stratification, the absence of disturbances and the presence of thick coal-seams, all indicate the probable presence here of enormous quantities of coal. The field has been examined to some extent between the Mackenzie river and the railway line to the south, but to the north-west nothing has been done to show what seams exist there, although coal has been seen in the banks of creeks, and penetrated in wells and water bores between the river and Capella railway station.

14. Mt. Mulligan. A recently discovered field. It should be of great benefit to the Chillagoe district if the seams prove to be of good quality and of workable thickness. There is a large area of country yet to be examined in the field.

15. Nebo. The Coal-Measures here are a continuation of those on the Dawson and Mackenzie rivers and carry the same kinds of coal. The strata are regular and are without disturbing features where exposed, although crumpling of the beds probably exists farther east. The coal is anthracitic, one seam containing about 3 per cent. of moisture and $3\frac{1}{2}$ per cent. of ash.

16. Nundah. Little is known about this area, but if the operations now in progress show that the coal is of good quality, there will be some inducement to open up adjacent lands which are also known to be coal-bearing. This is the only spot in the East Moreton coal basin where development is taking place, but there are many localities where coal is known to exist, which are well worth attention.

17. Styx River. The area of this field is not very large, and being without railway communication no development has taken place. When the railway now under construction to the field is completed, coal mines will be established. The coal is good both for coking and steaming and is comparatively low in ash.

18. Tiaro. Some of the seams in this area are of workable thickness and they produce a good steaming coal. The district is rather disturbed by volcanic intrusions, and some difficulty has been experienced in finding places where prospecting can be carried on free from this trouble.

19. Toowoomba. Coal-seams are being vigorously worked at several centres and the area of good coal-bearing lands is continually being added to. Basalt, however, has been found to occupy depressions in the Coal-Measures, and might effect the coal-seams in places. The coal is very firm, and while good for steaming purposes, is specially suitable for gas-making.

20. Warwick. The coal-fields in this district have been worked at Tannymorel, but there are other localities close to the railway which are worthy of attention, and perhaps of development. The coal is gaseous, like all the Darling Downs coals. It is also in demand for use in locomotives.

21. Waterpark Creek. This is the only known area of brown-coal deposits in Queensland. The quality of the coal is undoubtedly good, but beyond some preliminary boring operations no attempt has been made to develop the seam of clean coal which is known to be 52 feet thick.

NOTES ON THE TABLE OF COAL ANALYSES

The accompanying Table of Analyses shows the general character of the coals in each group of localities, and the variation of range in the percentages of the substances in the composition of the coals, also giving references to Queensland Geological Survey and other official publications dealing more fully with the subject.

Hydrous coals are contained in the deposits at Callide, Hughenden, and Waterpark creek, but while the percentages of moisture in the two former coals are sometimes high, it is only the Waterpark coal which can be considered a brown-coal. The other extremes in average moisture percentages are Dawson, Mackenzie and Little rivers, the Dawson containing a mean of 1.3 per cent. Nundah coal is also low in moisture, but the coal tested is only from one mine and higher percentages may be expected. Some of the coals show a very low amount of moisture, but this is only a local effect produced by volcanic or other disturbances.

Gas coals are well represented by the deposits of Walloon, Warwick, Waterpark and Dalby, all of which are in undisturbed areas of coal-measures. Coals containing very little volatile matter include those of Dawson river, Nebo, and Little river.

Coals high in fixed carbon occur at the Dawson, Mackenzie and Little rivers. These coals, however, have not proved very successful up to the present on account of their density, combined with certain physical defects. The best steam coals are those at Burrum, Ipswich, Styx river and Clermont. Defective mining methods are the cause of some of these coals being put on the market in a dirty condition, but when free from impurities, which can be easily eliminated by mechanical means, the coal is usually of a high quality.

The Clermont coal is particularly free from bands of dirt or stone, and from a stoker's point of view is an ideal one for steaming purposes. The individual coals highest in fixed carbon are those at Bee creek near Nebo, and Mount Bopple near Tiaro, the latter being not far from a volcanic intrusion which has altered one small seam of coal to anthracite and another parallel seam to true graphite, the two being separated by a few inches of baked shale.

The Ipswich and Burrum coals have proved their excellence for coke-making, and cokes made from both are in demand for smelting operations. The Styx river coal, and some of those about Dalby and Warwick are also well adapted for coking. The coal-seams on the Mackenzie river and near the Central Railway have slight coking qualities and experience has shown that if a small proportion of tar is introduced as an additional ingredient to the coking charge a very hard and compact coke is produced.

Coal-washing machinery has not yet been installed at any of the mines, but its introduction would be the means of producing a fine class of coke, as most of the ash ingredients are confined to the bands and are not distributed throughout the body of the coal.

Friability is a noticeable feature in some of the Styx river and Ipswich coals, the Burrum, Clermont, Mackenzie river, Central Railway, Walloon, Toowoomba, and Warwick coal being better in this respect.

Sulphur determinations have been made only occasionally, but, generally considered, Queensland coals have a fairly low percentage of this ingredient. The highest recorded is that in coal at Cooktown (1.8%), the lowest being from the Styx river (0.2%). Between these extremes there are the Ipswich, Beaudesert, Burrum, Clermont, Dawson river, Mackenzie river, Central Railway and Waterpark creek coals, that at Ipswich varying between 0.4 and 1.7 per cent., the others between 1.1 and 1.4 per cent.

Ash percentages vary considerably. The Burrum coal average is the lowest, some of the seams worked in this area having yielded thousands of tons of run-of-mine coal containing no more than 5 per cent. of ash. The 66-foot Blair Athol seam at Clermont, and the 20-foot Mammoth seam in the Mackenzie-Central Railway area, each contain about 7 per cent. of ash, the 52-foot seam of brown-coal at Waterpark containing 7½ per cent. Styx river coal is also low in ash, while the Dawson seams average about 9 per cent. Ipswich coals fluctuate above and below 10 per cent. and the Toowoomba and Warwick coals may be considered to be good, in their district, if the ash percentages are less than 12 per cent. The composition of the ash in the coal has been determined in a few cases, but the results could not be quoted as averages.

Calorific values have been estimated by Goutal's formula. For the sake of uniformity the few results obtained from the Mahler-Krocker bomb calorimeter have not been included, but from comparisons made it is found that the estimated results are generally, although not always, higher than those determined experimentally.

Boiler tests have been made by the Admiralty, American fleet, Harbours and Rivers Department, Mount Morgan Gold Mining Company and the Rockhampton Waterworks. Railway tests have been made to show the suitability of various coals for locomotive purposes, but these would be only of local interest.

Admiralty trials have been made of coal from the Dawson river and the Mackenzie River Central Railway area to determine their value for warship purposes. The coal trials were satisfactory in many ways, but the refuse in the ash pit was high, on account of the coal deflagrating into small particles and falling through the grate. The combustion was slow and the heat generated very intense and local, the latter defect causing damage to the fire bars. The Harbours and Rivers Department at Brisbane, and the Waterworks Board at Rockhampton had similar experiences, the Mount Morgan Company, however, showed that with step-grates designed for burning sawdust the coal gave very satisfactory results, so much so that when railway communication has been established between Mount Morgan and the Dawson mines, the company will be a large consumer of the coal.

Experiments in suction gas plants have been made with the Dawson coal, and although the results were not as satisfactory as those from coke or charcoal, it has been conclusively shown that the coal can be utilized for this purpose without previously undergoing any coking process.

RAILWAY AND PORT FACILITIES

1. The Beaudesert group of coal-fields are around the terminus of the Beaudesert Branch of the South Coast Railway line and are between 40 and 47 miles from Brisbane. Private extensions of this line continue to Lamington (22 miles) and Rathowney (22 miles) close to the MacPherson range and the southern border of the State.

2. The Burrum Fields are situated between eight and twenty miles from the port of Maryborough, with which they are connected by railway. A deep water port is being established at Urangan on the south shore of Hervey bay and a railway connection is about to be made with the existing line at Pialba, $4\frac{1}{2}$ miles distant, which will bring the Burrum collieries within 30 miles of deep-sea vessels.

3. The Callide creek area is about 70 miles W.S.W. of Gladstone, and a trial railway survey has been made to determine the route of a railway to connect the field with this deep-water port.

4. The Chinchilla area is 203 miles from Brisbane on the Main Western Railway. Beyond Chinchilla the railway extends 300 miles farther west beyond Charleville. Between Brisbane and Chinchilla there are several other coal centres, but to the west there are no known coal-deposits. A railway has been approved by Parliament to connect the line at Charleville with Camooweal, via Windorah and Boulia, a distance of 700 miles, and the same authority has been given to construct a branch about 200 miles long joining this proposed line at Windorah with the existing Rockhampton-Blackall line. Other connections are to be made with this proposed trans-State line at Winton (200 miles extension) and Cloncurry (70 miles extension).

5. The Clermont area is situated at the terminus of a branch line 66 miles from Emerald, a station on the Central Railway, and 240 miles from Rockhampton. It is the farthest-west developed coal-field and must ultimately be a big factor when the supply of fuel, required for railway purposes in the far western lines, comes under consideration.

6. The Cooktown field is between 45 and 60 miles west of the coast and is the farthest-north field in the State which has been proved to contain areas of workable coal. There is railway communication with the field, but the main coal outcrops are 14 miles east of Deighton railway station and 59 miles west from Cooktown.

7. The Dalby area is about 100 miles from Brisbane and close to the Western Railway line, the position being about 50 miles farther east than the coal-deposits at Chinchilla. Branch railway lines are being constructed from Dalby to various centres, and this will cause some activity in mining development later on.

8. The Dawson river coal-field is being connected with the existing line at Mount Morgan, the distance from this mine being about 60 miles, and from Rockhampton, 85 miles. A contemplated railway from Miles on the Western line, will extend to Juandah, 40 miles to the north, and although no coal-seams are known in the neighbourhood, the Dawson Coal-Measures must extend south in this direction.

9. The Hughenden area is about 200 miles from Townsville, and is about midway between this port and Cloncurry in Western Queensland. Coal could

be sent westerly via Cloncurry to Camooweal, and south-easterly to other stations on the proposed line to Charleville.

10-11. The Ipswich and Walloon coal-fields are on the main Southern and Western Railway line, the distance varying from 18 to 35 miles from Brisbane. Besides the trade with the latter port, coal is taken south towards Warwick and the southern border, and also west towards Toowoomba.

12. The Little river coal-area is about 90 miles westerly from Cooktown, the nearest point to the railway line being at Laura, 25 miles distant.

13. The Mackenzie-Central Railway area is located between Walleroo and the Comet river, these positions being respectively 73 miles and 141 miles from Rockhampton, the Mammoth coal-seam probably crossing the railway line about the 116-mile peg. To Emerald the distance from the Mammoth seam is about 50 miles. The notes given under Clermont area regarding the coal supply for the western railways would also apply to this area.

14. The Mount Mulligan coal-field has not been connected with the Chillagoe railway, although the distance is only 32 miles from Dimbulah station, and about 100 miles from the Chillagoe smelters.

15. Nebo is situated 50 miles S.W. of the port of Mackay, and 27 miles S.W. of the Eton railway station, both towns being separated from the field by Connor's range. No proposal is forthcoming to cross this steep range by a railway, and until such communication is established the coal-deposits will remain undeveloped.

16. Nundah and Eagle Farm are immediately to the north of Brisbane, being five and seven miles distant, respectively. Pinkenba the deep-water port of Brisbane, is five miles from Nundah railway station and two miles from Eagle Farm railway station.

17. The Styx river field is immediately to the south of the port of St. Lawrence, and is directly on the route of the railway being constructed to connect Mackay with Rockhampton, the centre of the field being about 75 miles from either port.

18. The Tiaro area crosses the North Coast line between Gympie and Maryborough, the centre of the fields being about midway between the two towns. To Urangan, the proposed deep-water port at Maryborough, the distance from this area would be about 50 miles, being between 20 and 30 miles farther away than the Burrum coal mines.

19. Toowoomba, the junction station of the Southern line to Sydney, and the Western line to Charleville and Cunnamulla, is 101 miles from Brisbane, the coal mines being situated at 113, 115, and 120 miles. There is a branch line extending from Toowoomba to Crows Nest, and other lines are under construction, or approved by Parliament.

20. Warwick is 169 miles from Brisbane and is the junction of several railway lines, northerly to Brisbane, southerly to Sydney, south-westerly to Goondiwindi and easterly to Killarney. The Allora and Merivale lines are also close to Warwick. Tannymorel, which is connected with a colliery a few miles away, is 23 miles from Warwick, while Merivale, close to which a coal-seam has recently been exposed, is 19 miles distant. The proposed *via recta* from Warwick to Brisbane will pass through Allora, a few miles from the Merivale coal-field.

21. Waterpark creek brown-coal area is about 34 miles N.N.E. of Rockhampton and 20 miles from Mount Etna, the latter being about the nearest point of connection with the line now under construction from Rockhampton to Mackay. The distance to Rockhampton via Mount Etna would be about 38 or 40 miles.

STATISTICAL NOTE

The coal production in the chief countries of the world for the year 1910 is estimated, approximately, at 1,121,536,190 long tons, to which amount the Australian States contributed 7,659,767 long tons. This is equal to 0.68 per cent. of the world's yield. The coal output of Queensland for the year 1910 is estimated at 871,166 long tons, this being a percentage of 11.37 of the Australian yield of coal, and 0.07 of the world's production for that year. A comparison of the 1911 yields cannot be made on account of insufficient data.

The coal output of the collieries in Queensland has been gradually increasing from a yield of 323,068 tons in the year 1895 to 891,568 tons in 1911. The production in the latter year is valued at £323,998, the value percentage being 6.43 of all the coal produced in the State up to the end of 1911, the quantity percentage being 6.73.

The Ipswich and West Moreton coal-field, including the few collieries on the Darling Downs, has yielded an estimated coal output of 10,869,186 tons, between the years 1860 and 1911, the Burrum coal-field producing 2,077,650 tons, and the Clermont coal-field 219,594 tons. The percentages of the above outputs of coal to the estimated total coal production of Queensland are as follows, viz.: Ipswich and West Moreton, including Darling Downs, 82.02; Burrum, 15.67; and Clermont, 1.65.

Queensland's total output up to the end of 1911 is estimated at 13,251,883 tons, valued at £5,038,971, this being equivalent to 5.05 per cent. of the total value of all the minerals produced in the State to the end of the same year, estimated to be £99,833,636.

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GROUP I

Including Seams of 1 Foot or over, to a Depth of 4,000 Feet

District	Coal-Seams			Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Total Thickness		Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
		Ft.	In.							
1. Beaudesert Group—										
Pitts	1	1	0	....	......	....	1 sq. mile	C	1,000,000	3,000,000
Goulds	1	1	4	....	......	....	1 "	C	1,400,000	4,000,000
Stanfields	1	1	0	....	......	....	1 "	C	1,000,000	3,000,000
Palem Creek	1	3	0	....	......	....	1 "	C	3,000,000	10,000,000
Widgee Creek	1	8	0	....	......	....	1 "	C	8,000,000	20,000,000
Mount Lindsay	2	17	0	....	......	....	1 "	C	17,000,000	50,000,000
2. Burrum Group—										
Howard	1	4	0	80 acres	B_2	500,000	2 "	B_2	52,000,000	130,000,000
	10	20	0	....	..	....				
Burrum	1	3	0	80 acres	B_2	400,000	1 "	B_2	26,000,000	52,000,000
	8	21	6	....	..	....				
Torbanlea	1	4	6	80 acres	B_2	600,000	1 "	B_2	22,000,000	88,000,000
	7	16	0	....	..	....				
Burgowan	1	3	0	40 acres	B_2	200,000	½ "	B_2	1,600,000	6,000,000
Isis River	1	2	8	....	..	....	½ "	B_2	1,500,000	6,000,000
Cherwell River	1	2	0	....	..	....	½ "	B_2	500,000	2,000,000
3. Callide Creek	1	21	0	1 sq. mile	B_2	20,000,000	5 "	B_2	100,000,000	500,000,000
4. Chinchilla Area	7	40	0	....	..	....	½ "	C	20,000,000	100,000,000
5. Clermont Area	1	4	0	2 "	B_2	8,000,000	3 "	B_2	13,000,000	13,000,000
Clermont Area	1	65	0	3 "	B_2	200,000,000	5 "	B_2	300,000,000	1,000,000,000
6. Cooktown Field	1	1	3	....	..	....	2 "	B_2	2,800,000	140,000,000
7. Dalby Area	3	14	2	80 acres	C	1,900,000	2 "	C	30,000,000	60,000,000
8. Dawson River—										
East Side	2	14	0	60 "	A_2	1,500,000	½ "	A_2	7,800,000	60,000,000
West Side	2	14	0	½ sq. mile	A_2	7,800,000	4 "	A_2	62,000,000	400,000,000

GROUP I—(*Continued*)

District	Coal-Seams			Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Total Thickness		Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
		Ft.	In.							
9. Hughenden Area....										
Flinders River..................	1	1	1	....	..	....	1 sq. mile	B_3	1,200,000	3,000,000
Warreah......................	1	1	2	....	..	....	1 "	B_3	2,800,000	8,000,000
10 Ipswich Area—										
(*a*) Bundamba,										
West Moreton................	1	1	6	....	..	....	2 "	B_2	3,300,000	33,000,000
Aberdare......................	1	11	6	1 sq. mile	B_2	12,300,000	4 "	B_2	49,000,000	92,000,000
	1	5	6	¼ "	B_2	1,500,000	1 "	B_2	6,100,000	
Four-foot (Swanbank No. 1)	1	4	0	1 "	B_2	4,500,000	4 "	B_2	18,000,000	200,000,000
		3	0	⅛ "	B_2	....				
Bergins (Swanbank No. 2, Old Aberdare)..................	1	3	3	¼ sq. mile	B_2	910,000	2 "	B_2	7,200,000	36,000,000
		7	6	¼ "	B_2	2,100,000	½ "	B_2	4,200,000	168,000,000
Striped Bacon (Rhondda, Perkins)	1	5	9	½ "	B_2	3,220,000	2 "	B_2	12,800,000	193,000,000
New Chum No. 1...............	1	4	6	⅛ "	B_2	630,000	2 "	B_2	10,000,000	150,000,000
Rob Roy......................	1	3	0	....	..	....	2 "	B_2	6,700,000	100,000,000
New Chum No. 2..............	1	5	0	....	..	....	2 "	B_2	11,200,000	168,000,000
Braeside (New Chum No. 3 Dobby)	1	3	0	....	..	....	2 "	B_2	6,700,000	100,000,000
(*b*) North Ipswich—										
Garden........................	1	7	0	⅛ sq. mile	B_2	980,000	2 "	B_2	15,600,000	235,000,000
Tantivy	1	3	0	⅛ "	B_2	420,000	2 "	B_2	6,700,000	100,000,000
Fiery (Cuffe's Upper or Bell)....	1	3	6	⅛ "	B_2	490,000	2 "	B_2	7,800,000	114,000,000
Waterstown (Cuffe's Lower).....	1	3	4	⅛ "	B_2	460,000	2 "	B_2	7,300,000	110,000,000
Tivoli........................	1	3	3	⅛ "	B_2	450,000	2 "	B_2	7,200,000	121,000,000
Bishop's (Big)..................	1	10	10	⅛ "	B_2	1,500,000	2 "	B_2	2,400,000	42,000,000
Benley........................	1	11	3	⅛ "	B_2	1,580,000	2 "	B_2	25,200,000	442,000,000
11. Walloon—										
Caledonian and Walloon........	2	7	0	⅛ "	C	980,000	4 "	C	31,000,000	196,000,000
Loamside (Speedwell, Good Hope)	1	6	0	⅛ "	C	840,000	2 "	C	13,400,000	168,000,000

District	Coal-Seams			Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Total Thickness		Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
		Ft.	In.							
12. Little River	3	1	9	3 acres	B_2	10,000	1 sq. mile	B_2	2,000,000	8,000,000
13. Mackenzie River, Central Rail Area—										
Mammoth	1	20	0	5 sq. miles	B_2	112,000,090	40 "	B_2	450,000,000	5,356,000,000
Bluff	1	6	0	160 acres	B_1	800,000	10 "	B_1	60,000,000	500,000,000
Stanley	1	6	0	80 "	B_1	400,000	5 "	B_1	30,000,000	400,000,000
Tolmies	1	3	0	80 "	B_2	400,000	1 "	B_2	3,000,000	9,000,000
14. Mount Mulligan	2	7	0	2 sq. miles	B_2	15,000,000	8 "	B_2	60,000,000	150,000,000
15. Nebo Area	1	4	6	....	..	....	4 "	A_2	20,000,000	100,000,000
16. Nundah, Eagle Farm	1	3	0	80 acres	B_2	400,000	5 "	B_2	10,000,000	30,000,000
17. Styx River	5	8	3	160 "	B_2	2,700,000	1 "	B_2	8,000,000	120,000,000
18. Tiaro Area—										
Tarryalba Creek	4	14	0	....	..	....	1 "	B_2	12,000,000	60,000,000
Redbank Creek	1	4	0	....	..	....	½ "	B_2	2,000,000	8,000,000
Munna Creek	2	5	8	....	..	....	1 "	B_2	6,000,000	18,000,000
19. Toowoomba Area—Rosewood	4	16	0	80 acres	C	1,100,000	½ "	C	8,800,000	26,000,000
Kingsthorpe	5	15	0	40 "	C	1,000,000	½ "	C	8,000,000	24,000,000
20 Warwick Area—										
Clifton	3	7	6	80 "	C	1,000,000	½ "	C	4,000,000	24,000,000
Tannymorel	2	5	0	80 "	C	700,000	½ "	C	2,800,000	15,000,000
Allora	1	2	0	80 "	C	250,000	½ "	C	1,000,000	6,000,000
Merivale	1	3	9	....	..	....	½ "	C	2,000,000	12,000,000
Emu Vale	1	5	0	....	..	....	½ "	C	2,500,000	15,000,000
Swan Creek	1	5	0	....	..	....	½ "	C	2,500,000	15,000,000
21. Waterpark Creek	2	57	6	26 acres	D_1	2,600,000	1 "	D	64,000,000	800,000,000
Totals	..	....		20¼ sq. miles	..	412,120,000	161½ sq. miles	..	1,685,000,000	13,122,000,000

TABLE OF PROXIMATE COAL

	Moisture		Volatile Hydro-Carbons		Fixed Carbon		Ash	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1. Beaudesert Area	5.0	8–2	33.0	40–13	45.0	58–13	17.0	25–11
2. Burrum Area	2.0	3–0.1	27.0	31–24	66.0	68–62	5.0	8–4
3. Callide Creek	7.5	12–0.8	26.5	28–23	54.0	59–41	12.0	20–4
4. Chinchilla Area	...	......	No reli	able analy	sis.	.....	...	.....
5. Clermont Area	4.5	5–0.8	32.0	57–21	57.5	62–53	6.0	10–4
6. Cooktown Field	2.5	8–0.3	24.0	30–19	59.5	72–34	14.0	26–8
7. Dalby Area	5.4	6–5	39.6	40–39	42.5	42–41	12.5	12–13
8. Dawson River	1.3	3–1	9.5	14–6	80.1	86–74	8.9	17–4
9. Hughenden Area	9.5	15–7	31.0	32–18	50.5	51–34	9.0	31–8
10. Ipswich Area	1.5	2–07	27.0	33–21	58.5	72–50	14.0	21–4
11. Ipswich (Walloon)	6.0	8–4	39.0	40–23	44.0	48–29	11.0	25–6
12. Little River	1.5	3–1	11.5	26–6	75.0	83–58	12.0	17–6
13. MacKenzie River (Central Railway)	1.5	3–0.4	14.0	24–7	77.0	81–43	7.5	29–5
14. Mount Mulligan	2.5	.....	24.5	.....	57.0	.....	16.0	.....
15. Nebo (Bee and Walker's Creeks) Area	3.0	3–2.5	10.5	12–8	73.0	84–61	13.5	16–3
16. Nundah—Eagle Farm	1.5	9–0.6	28.5	35–21	51.0	55–39	19.0	26–19
17. Styx River	2.0	2–1	29.0	31–22	63.0	64–59	6.0	12–3
18. Tiaro Area	4.4	12–10	20.0	34–3	61.8	90–39	13.8	21–4
19. Toowoomba Area	4.5	3–5	38.0	40–36	41.0	42.6–40	16.5	17–14
20. Warwick Area	4.5	5–4	41.0	44–39	40.5	44–37	14.0	16–9
21. Waterpark Creek	10.5	10.7–10.2	41.0	41.5–40	41.0	43–39	7.5	10–6

NOTE—Many other areas exist in the State, but there is no direct evidence of their being actually or probably productive.

* Abbreviations—G.S.Q. (Geological Survey of Queensland); Q.G.M.J. (Queensland Government Mining Journal).

ANALYSES—QUEENSLAND COALS

Estimated Calories Mean	Coking Qualities	Character of Ash	Principal References (Official)*
6,802	Slightly cokes	Pink	G.S.Q. Pubs. 51 (1889), 225 (1910).
8,079	Firm coke	Grey, reddish	G.S.Q. Pub. 170.
7,051	Non-coking	White, gritty	G.S.Q. Pub. 80, p. 3. (1891).
.....	....	....	G.S.Q. Pub. 235 (1911).
7,726	Non-coking	White	G.S.Q. Pub. 148 (1900).
7,249	Non-coking	Red	G.S.Q. Pubs. 35 (1887), 70 (1891), 180 (1902, 222 (1910).
7,027	Some seams coke	White-reddish	Q.G.M.J. (1910).
7,763	Parts slightly coke	Brown	G.S.Q. Pub. 155 (1901); Q.G.M.J. (1905).
7,060	Slightly cokes	White	G.S.Q. Pub. 44 (1888); Q.G.M.J. (1909).
7,467	Some seams coke	Light, grey	G.S.Q. Pubs. 92 (1892), 147 (1899).
7,096	Cokes	Greyish	204 (1906).
7,607	Non-coking	....	G.S.Q. Pubs. 91 (1893), 92 (1892).
8,095	Slightly cokes	Brown	G.S.Q. Pub. 155 (1910); Q.G.M.J. (1904-5).
7,095	Non-coking	Reddish	G.S.Q. Pub. 222 (1910).
7,314	Non-coking	White	G.S.Q. Pub. 39 (1887).
7,006	Cokes well	Grey	G.S.Q. Pub. 225 (1910).
8,034	Firm bright coke	White	G.S.Q. Pub. 84 (1892).
7,036	Sometimes slightly cokes.	Grey-white	G.S.Q. Pub. 59 (1890).
.....	Some seams coke		
6,785	Some seams coke	Grey	G.S.Q. Pub. 92 (1892).
6,832	Non-coking	White	G.S.Q. Pub. 174 (1902).

THE OCCURRENCE OF COAL IN SOUTH AUSTRALIA

BY

J. KEITH WARD

Government Geologist

(*With one map in the text*)

THE coal deposits of South Australia have not attracted much attention in the past, for the State has been less favourably endowed with coal resources than the sister States of the Commonwealth of Australia.

The coals and lignites of South Australia are to be grouped into three divisions:

1—The Jurassic coal of the Leigh's Creek Basin.

2—The Lower Cretaceous brown-coal and lignite of the Great Australian Artesian Water Basin.

3—The Tertiary lignite of the southern part of the State.

1—THE LEIGH'S CREEK COAL-FIELD

LOCALITY

The Coal-Measures occupy several connected basins of erosion in the Palæozoic (probably Cambrian) rocks of the Flinders range and are known to extend over an area the maximum length of which is sixteen miles and the maximum breadth six miles. It is possible that future discoveries may be made beyond this area to the northward beneath rocks of later age.

AGE AND CORRELATION

The correlation of the Leigh's creek coal with the Jurassic coals of Queensland, New South Wales, Victoria and Tasmania, is apparently justifiable on account of the fossil evidence obtained from bore cores. The fossils recognized include:

FILICES: *Thinnfeldia Odontopteroides* (Morris).

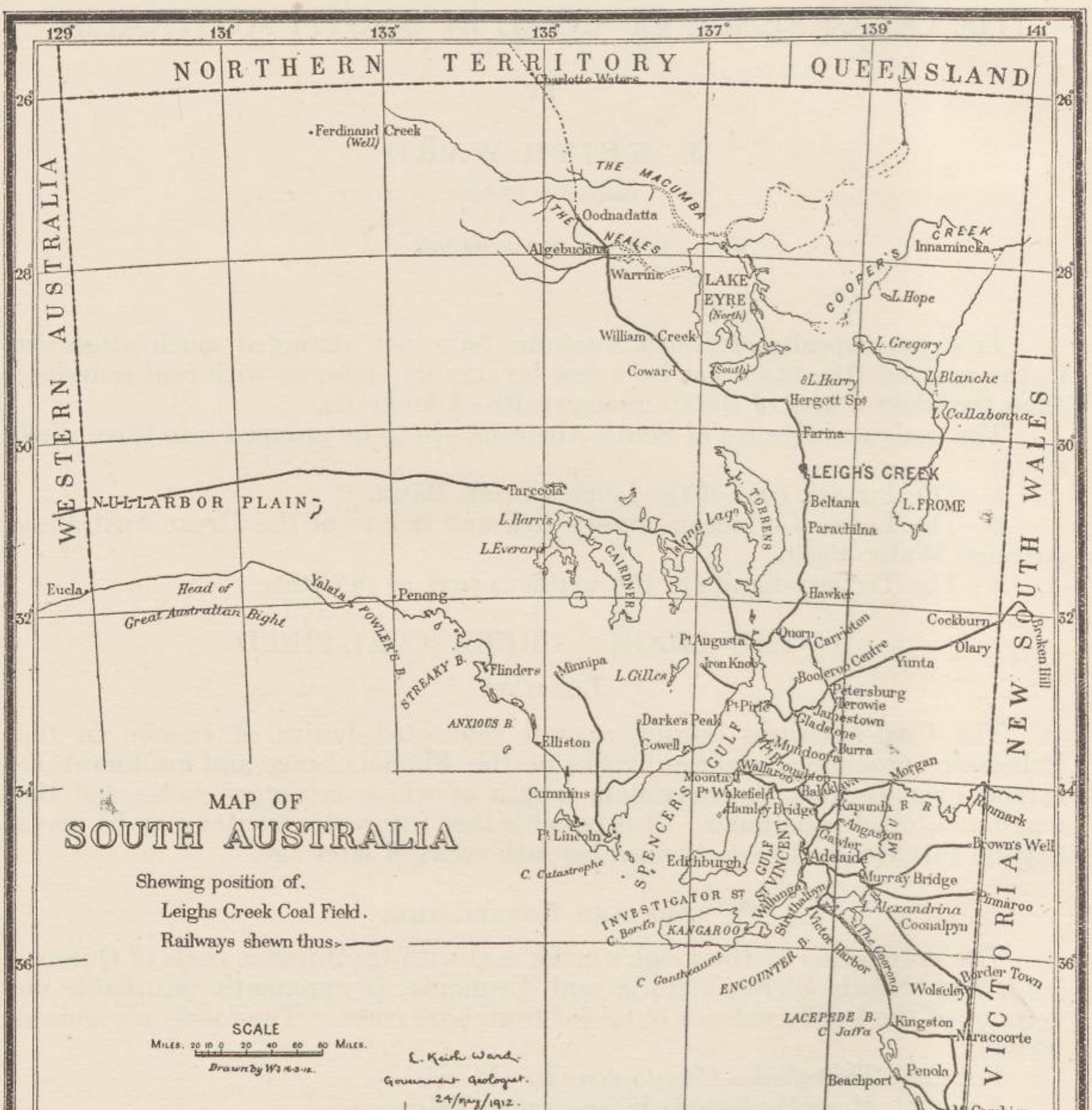
FILICES: *Macrotæniopteris Wianamattæ* (Feismantel).

MOLLUSCA: *Unio Eyrensis* (Tate).

MODE OF OCCURRENCE

The Jurassic coal-bearing beds are overlain at a few points by outliers of Lower Cretaceous sandstones, quartzites, calcareous conglomerates, clays and marls in horizontal beds.

The Coal-Measures themselves consist of blue clay and shale, interstratified with numerous bands of clay ironstone, limonite and sandstone. The shales associated with the coal carry a considerable amount of carbonaceous and bitumi-



nous material—some bands containing over 20% of combustible matter. The beds of the Coal-Measures dip towards the centre of the basin. The shale raised in the form of bore cores, shows evidence of some jointing and faulting. Sections of the Coal-Measures have been afforded by three diamond drill bores located in the central portion of the known coal-bearing basin. The total depth of the basin at its centre appears to be about 2,000 feet.

Prospecting and Exploitation

The coal-field has been prospected by bores and shafts sunk at several points near its centre.

The first bore, situated immediately to the west of the railway line and a little more than six miles to the north of the Leigh's Creek railway station, attained a depth of 170 feet. One seam of coal, two feet in thickness, was passed through at a depth of from 135 feet to 137 feet from the surface. In addition to this seam of coal the carbonaceous shale, from 125 feet to 135 feet below the surface, contains thin layers of coal and carbonaceous matter interstratified with it. The Palæozoic bed-rock was met at 170 feet from the surface.

The second bore, located at a point a mile and a quarter to the south-west of the latter, attained a depth of 1,900 feet before reaching the bed-rock. In this bore the drill passed through 1,496 feet 8 inches of shale, with siliceous and calcareous bands containing a varying percentage of carbonaceous and bituminous matter, before reaching a bed of coal which is 47 feet 10 inches in thickness at the place where it is traversed. Below this bed, carbonaceous shale, carrying occasional, thin seams of coal and coal shale, was passed through to a depth of 1,900 feet, at which depth boring was discontinued owing to the Palæozoic rocks having been met.

Two shafts were sunk between the sites of these two bores and some 12,500 tons of coal were raised from a depth of 300 feet. The coal-seam which was worked is seven feet in thickness. The coal won from these shafts was disposed of in Adelaide, Port Augusta, Petersburg, Hergott Springs and Broken Hill, but the venture did not prove a success. Attempts were made to make use of the coal for the Government railway locomotives; but, after being tested, the coal was judged to be unsatisfactory for the purpose.

A third bore was drilled at a later date through the coal-measures to a depth of 1,079 feet, at which depth bed-rock was reached, and for another 47 feet through the bed-rock itself.

The core from this bore shows that the superficial deposits and upper shales of the Coal-Measures extend from the surface to a depth of 608 feet. The next 38 feet 9 inches consist of coal material of variable quality and a number of smaller seams of similar material are distributed through the next 333 feet. Below a depth of 980 feet no coal was met.

Quality of the Coal

The chief drawback to the successful use of the coal has been its tendency to disintegrate on exposure to the atmosphere. Hitherto no exhaustive experimental work has been carried out with a view to the manufacture of briquettes from the coal.

Analyses made of the coal from the first two bores mentioned above show that there is some variation in composition, especially in the content of the moisture. The average composition of the coal from the first bore (based on four analyses) is:

Volatile Hydrocarbons	33.88%
Fixed Carbon	38.48
Ash	8.69
Water at 212°	18.55
	99.60

The average composition of the bed of coal 47 feet 10 inches thick, traversed by the second bore, is:

Volatile Hydrocarbons	26.9%
Fixed Carbon	41.4
Ash	14.2
Water at 212°	17.5
	100.0

The composition varies, the coal at the top of the bed being the richest in volatile hydrocarbons and containing over 20% of water, but being comparatively free from ash.

Some of the coal is compact in character and samples of the core have been kept for years without disintegration.

2—THE COAL OF LOWER CRETACEOUS AGE

In addition to the Jurassic coal of Leigh's creek there are a great number of small seams of brown-coal in the Lower Cretaceous beds of the main Australian artesian water basin. The presence of these has been proved by the bores sunk in search of water and fragmentary samples only have been obtained. None has been considered of sufficient bulk or importance to justify prospecting as a source of coal.

3—THE TERTIARY LIGNITES

Of still later geological age are the lignites which occur at several places in the southern portion of South Australia, viz., in the Adelaide Plains, Noarlunga, etc.

These beds of lignite are found widely distributed in the Tertiary basins of sedimentation, wherein they occupy the lower horizons. No attempts have been made to exploit them.

REPORT ON COAL-MEASURES OF TASMANIA

BY

W. H. TWELVETREES

Government Geologist

(*With one map in the text*)

COAL is found in Tasmania in beds or seams occurring in strata which belong to the following geological periods:

III—Tertiary	Brown coal and lignitic deposits.
II—Mesozoic	Upper Coal-Measures.
I—Permo-Carboniferous .	Lower Coal-Measures.

I—PERMO-CARBONIFEROUS

The lower Coal-Measures consist of land and fresh-water beds intercalated between marine mudstones, limestone and conglomerate. The overlying strata are called the Upper Marines and the underlying series the Lower Marines; but the coal-bearing beds may be regarded as representing an incidental, terrestrial and fresh-water phase in the marine beds of the Permo-Carboniferous system. Most of the fossil remains of the marine beds are common to both the upper and lower divisions. The whole assemblage of marine and terrestial strata can be correlated with the middle term of what is known as the Anthracolithic system. The beds are, for the most part, gently inclined. They have not been deformed by folding, but have been greatly disturbed by block faulting and have been intruded by enormous sills of diabase.

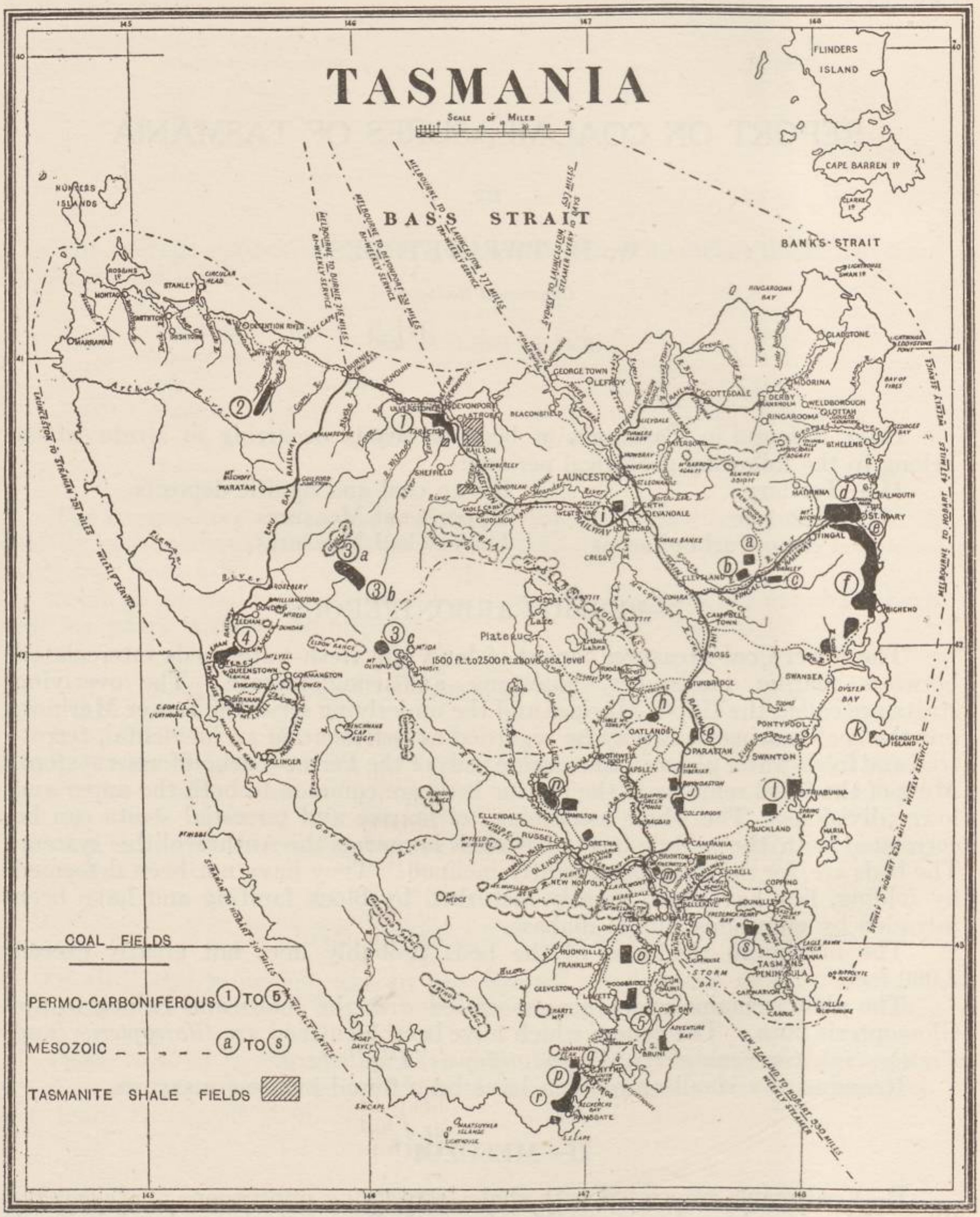
The maximum thickness of the beds probably does not greatly exceed 2,000 feet.

The plant remains which are associated with the coal-seams belong to the Glossopteris flora. The genera which have been identified are *Glossopteris* (and *Vertebraria*), *Gangamopteris*, *Nœggerathiopsis*, *Phyllotheca*.

Remains of a small amphibian have been found in these measures.

II—MESOZOIC

B—Coal-seams associated with shales containing impressions of *Zeugophyllites* (*Phœnicopsis*)—*elongatus* (Morris) and *Pecopteris lunensis* (Johnston) are only known in one locality in the south of the island (Ida bay). They are


TASMANIA
SCALE OF MILES
BASS STRAIT
BANKS STRAIT
FLINDERS ISLAND
CAPE BARREN I.
HUNTERS ISLANDS
MELBOURNE TO LAUNCESTON 277 MILES
SYDNEY TO LAUNCESTON 537 MILES
STANLEY
CIRCULAR HEAD
WARATAH
GEORGE TOWN
LEFROY
SCOTTSDALE
DERBY
GLADSTONE
ST. HELENS
ST. MARY
FINGAL
BICHENO
LAUNCESTON
PERTH
EVANDALE
DEVONPORT
ULVERSTONE
LATROBE
SHEFFIELD
RAILTON
BEACONSFIELD
ROSEBERY
ZEEHAN
QUEENSTOWN
MT. LYELL
STRAHAN
Plateau
1500 ft. to 2500 ft. above sea level
CAMPBELL TOWN
ROSS
TUNBRIDGE
SWANSEA
OYSTER BAY
OATLANDS
PARATTAH
TRIABUNNA
MARIA I.
SCHOUTEN ISLAND
ELLENDALE
HAMILTON
NEW NORFOLK
BRIGHTON
CAMPANIA
RICHMOND
SORELL
HOBART
HUONVILLE
FRANKLIN
GEEVESTON
STORM BAY
TASMAN PENINSULA
ADVENTURE BAY
S. BRUNI
RECHERCHE BAY
COAL FIELDS
PERMO-CARBONIFEROUS 1 TO 5
MESOZOIC a TO s
TASMANITE SHALE FIELDS

probably of Triasso-Rhætic age, or perhaps are on the same horizon as the Narrabeen-Hawkesbury series of New South Wales (Trias).

A—The upper Coal-Measures generally comprise beds of sandstone and shale with numerous, well developed seams of coal. Their most abundant plant remains are *Alethopteris australia* (Morris) (=*Cladophlebis denticulata* Brogn. var. *australis*) *Thinnfeldia odontopteroides, Zeugophyllites elongatus, Phyllotheca australis*, etc. These plants are characteristic members of the Rhætic flora. In Australian literature this coal is stated as being of Jurassic age.

III—TERTIARY

Clays and sands of Palæogene age, often covered with upper Tertiary basalt lava flows, are abundant all over the island and contain much brown coal, lignite and impure carbonaceous material. Leaves resembling those of Quercus, Ulmus, Betula, Cinnamomum and other trees and shrubs not now living in the island, are common in these deposits.

I—PERMO-CARBONIFEROUS COAL-AREAS

These include the following:—
1—The Mersey and Don Coal-Fields.
2—The Wynyard (Preolenna) Coal-Field.
3—The Western Highlands Coal-Field.
4—The Henty River Coal-Field.
5—The Mount Cygnet and Bruni Island Coal-Field.
These will now be briefly described.

1—The Mersey and Don Coal-Fields

The coal-seams of the basins of the rivers Mersey and Don are contained in beds of fresh-water sandstone lying below Upper Marine strata at shallow depths, and vary in size from 16 to 20 inches. They have been worked intermittently for over sixty years at different points between these rivers, but their small size is now realized as a bar to their exploitation on a large scale. The present output is confined to Allison's colliery at Tarleton and the Illamatha mine at Preyton, and does not exceed 2,000 tons per annum. The proximate analysis of the coal from these two mines is as follows:

	Fixed Carbon	Gas	Ash	Moisture
Allison's	36.5%	46.6%	4.0%	12.9%
Illamatha	36.6	41.2	9.8	12.4

The coal burns freely and is suited for domestic use and steam raising, but it contains an excess of sulphur. It has a ready sale in the local market.

2—The Wynyard (Preolenna) Coal-Field

The basal conglomerates of the Permo-Carboniferous system are exposed at sea-level at Wynyard, and continue inland southwards for twenty miles to the Arthur river concealed for some distance below Tertiary drift. At fifteen or sixteen miles from the coast, seams of coal outcrop The most important seam is a twenty-inch one, enclosed in sandstone beds, eighteen and three-quarter miles from Wynyard. The composition of the seam is as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Coke
Kerosene Shale, 6 inch....	21%	76.2%	2.3%	0.5%	Rather tender
Bright Coal, 9 inch......	51.46	42.45	4.82	1.27	
Splint Coal, 5 inch.......	50.61	43.40	5.07	0.92	

The upper part of this seam consists of a brown to black, slightly sectile, tough shale with pitchy lustre, conchoidal fracture, and the general physical properties of a first-class kerosene shale. The remaining fourteen inches of the seam consists of coal averaging 43% volatile hydrocarbons and 51% of fixed carbon. Other seams, one an eighteen-inch outcrop of good bituminous coal and another three-foot four-inch seam of somewhat dirty coal eight feet below it, occur a little farther south, besides a two-foot seam in this neighbourhood.

Analyses of the coal from the best of these seams are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Coke
19 Mile.............	52.5%	41.1%	5.5%	0.9%	Fairly firm
19 Mile.............	52.3	41.7	5.0	1.0	Tender
Fault Creek.........	45.7	43.4	9.7	1.2	Crumbly

Further seams at Camp creek measure eighteen, nine, and twenty inches, respectively, and are separated from one another by a few feet of sandstone. The assay results from these are:

Fixed Carbon	Volatile Matter	Ash	Moisture	Coke
44.4%	48.3%	6.6%	0.7%	Crumbly, tender
46.9	44.2	7.1	1.8	
42.2	47.9	8.8	1.1	

The Preolenna coal and shale are highly suitable for gas enrichment. The illuminating power of the gas obtained from the shale has been tested at the Launceston Gas Company's works and ascertained to be forty candle power per Gas Referee's burner. The coal from the fourteen-inch part of the principal seam yielded 12,030 cubic feet of gas per ton, and from the other seams 62.89% of good, clean, hard coke was obtained. The coal is superior to that of any other Tasmanian colliery, and when transport to the coast has been improved by tramway construction there is no doubt this coal-field will be worked.

3—The Western Highlands Coal-Field

(a)—BARN BLUFF

The plateau on the south side of Barn Bluff extends to the Pelion group and forms the dividing ridge between the Forth and the Bluff and Fury rivers. At the base of a spur which extends south-east from Barn Bluff transported fragments of cannel coal or kerosene shale are found scattered on the surface and imbedded in a morainal débris. Some of the coal is scored with ice striæ. Glossopteris and other plant remains are met with in a bed of black micaceous shale which underlies marine strata (Upper Marine). The seam has not been discovered.

The following proximate analyses have been made:

	1	2	3	4	5
Analyst	Sharpe	Ward	Newberry	Dixon	Average Analysis
Fixed Carbon	41.90%	44.3%	39.75%	43.69%	42.4%
Volatile Matter	55.0	51.1	54.20	50.86	52.8
Ash	2.8	4.2	6.05	4.12	4.3
Water	0.3	0.4	Trace	None	0.2
Sulphur	Trace	0.8	Not determined	1.33	0.7

Mr. W. F. Ward, the Government analyst for Tasmania, reports that the coke is firm and lustrous and that the gas would be of great value for enriching that of poorer coal. The specific gravity is 1.13. Tests for gas resulted in from 11,200 to 15,486 cubic feet per ton. Mr. Ward obtained ninety-two gallons of crude oil and tar per ton by very slow distillation. Mr. W. F. Petterd in his Catalogue of the Minerals of Tasmania suggests the name, "Pelionite," for this variety.

The general thickness of the loose blocks is from eight inches to twelve inches. The substance is tough, sectile, black, pitch like, with a conchoidal fracture, and burns freely on application of a light.

On the slopes of a ridge connecting Barn Bluff with Cradle Mountain a small seam of bright, clean coal, nearly a foot thick, occurs in black micaceous shale.

The area of probable coal-bearing ground round and under Barn Bluff was estimated by Mr. A. Montgomery, a former Government geologist, as 1,800 acres, and calculating the seam at eight inches thick and the quantity at 900 tons per acre, he considered this field might contain 1,620,000 tons of coal.

(*b*)—MOUNT PELION

Sandstones and conglomerates, mudstones and limestone with Permo-Carboniferous fossils (*Fenestella, Productus, Spirifera, Aviculopecten* and *Stenopora*) flank the Pelion group of mountains.

On the east slope of Mount Pelion West a horizontal seam of bright black coal seventeen inches thick occurs. The coal contains an undue proportion of iron sulphide. Its proximate analysis is as follows:

Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur
52%	19.6%	17.1%	0.8%	10.5%

At an elevation 900 feet above this is a seam outcropping on the north-west slope of Mount Pelion No. 3, two feet six inches thick, consisting of twenty-six inches of coal with a four-inch band of carbonaceous shale. About a quarter of a mile east of this point the seam is twenty-two inches thick, of uninterrupted coal. The floor is shale and the roof sandstone. The same seam continues round the slope of the mountain to the west side of Mount Pelion East. Here it is eighteen or twenty inches thick and about 3,400 feet above sea level (the same height as the seams at Barn Bluff).

(c)—COAL HILL

Near Lake Petrarch about six miles west of lake St. Clair is a two foot seam of coal. The lower portion of the seam, for a thickness of a foot to eighteen inches, is of good quality, while the upper part is somewhat earthy. The character of the coal is that of a cannel or kerosene shale. It burns freely on application of a lighted match.

The stratigraphy of the beds containing this seam is not well known, but from the nature of the coal they appear to belong to the Permo-Carboniferous.

4—The Henty River Coal-Field

This is an undeveloped field between Zeehan and Strahan on the west coast. Glossopteris shales exist at the Henty river lying below Upper Permo-Carboniferous sandstone, mudstone and limestone. The overlying beds contain remains of *Spirifera*, *Productus* and *Fenestella*, and the whole assemblage of beds is evidently on the horizon of those in the Mersey basin, but only insignificant seams of coal have been found.

5—The Mount Cygnet and Bruni Island Coal-Field

(a)—MOUNT CYGNET

The Coal-Measures form the western flank of the mountain range between D'Entrecasteaux Channel and the arm of the Huon river known as Port Cygnet. The Mount Cygnet mine is worked on the northern slope of a part of this range and is connected by a tramway with the township of Welsh at Gardner's bay, two miles and a half to the west.

The coal-seam, up to four feet thick, is enclosed in sandstone beds which overlie strata belonging to the Lower Marine division of the Permo-Carboniferous. The associated plant remains are those of *Vertebraria* and *Gangamopteris;* and the horizon is considered by Mr. R. M. Johnston to be that of the Adventure bay Coal-Measures and to be intermediate between that of the Mersey and that of the Newcastle Measures (N.S.W.).*

The crest of Mount Cygnet is diabase, which extends down the flanks of the mountain for about 300 feet, and this apparently rests upon a platform of Permo-Carboniferous sandstone beds 500 or 600 feet above sea-level.

The seam which is worked at the Mount Cygnet coal mine dips into the mountain in a south-south-east direction at an inclination of about 7°. Twenty-five feet below it is another seam with only from five inches to a foot of

* "Geology of Tasmania," 1888, p. 202.

coal. The mine is worked from an inclined adit giving access to the different roads, but the extension of the workings has been impeded by faulting and operations have been intermittent. The roof is hard, grey sandstone or sometimes conglomerate, and the floor clay rests on dark sandstone.

The coal is dense and dull, burning slowly without much flame, giving out a good heat and remaining alight for a long time without replenishing and burning quietly away to a soft ash.

Samples taken from the three-foot six-inch seam by the district inspector of mines and assayed by the Government analyst yielded the following result:

Fixed Carbon	Volatile Matter	Ash	Moisture
63.9%	13.2%	22%	0.9%

The coal has been used for steam purposes, but the steamers object to the residue. It commands, however, a ready market in Hobart as a household and forge coal.

The output, which extends over many years, has been limited, not exceeding 2,000 to 3,000 tons per annum.

The mine appears to be on the western edge of the coal basin. The outcrop of the seam can be traced for two miles, but it is hardly possible to estimate its superficial area. If uninterrupted, it would extend over 2,000 acres, but in view of prevalent faulting some deduction from this is necessary.

(*b*)—BRUNI ISLAND COAL-FIELD

In Adventure bay, South Bruni, Coal-Measures lie conformably on sandstone, fossiliferous conglomerate and mudstone of the Lower Marine stage, dipping to the south at angles from 10° to 15°. The basin is about two miles in length and the series of beds 700 feet or 800 feet thick.

At sixty to ninety feet from the surface small shafts have passed through a seam of coal two feet thick resting on sandstone and overlaid by shale and sandstone.

Some small leaves of *Glossopteris* and *Gangamopteris* occur in shale immediately above and below the seam of coal.

TASMANITE SHALE

A seam of an unique, combustible, brown shale occurs at various points in the basins of the Don and Mersey rivers. Its thickness varies from four to seven feet. It consists of sand and clay mixed with minute spore cases of some undefined plant which has been supposed to be allied to the lycopods. It burns readily with a smoky flame and unpleasant odour, and when submitted to destructive distillation it yields a variety of oils suitable for illuminating, lubricating and fuel purposes. Working tests have established that from forty to fifty gallons of crude oil per ton can be extracted from it, and it is believed that the deposits are of great value as a source for the supply of fuel oil for steamers.

The probable area of the seam is 2,000 acres and its contents are estimated at 12,000,000 metric tons of shale.

II—MESOZOIC COAL-AREAS

These comprise the following:

1—Northern and Eastern Fields

(*a*)—Mount Rex Field ⎫
(*b*)—Rigney's Coal-Seams ⎬ Avoca Field.
(*c*)—St. Paul's Seams ⎭
(*d*)—Mount Nicholas Range and Fingal Basin.
(*e*)—Thompson's Marshes.
(*f*)—Llandaff-Seymour Seams.
(*g*)—York Plains.
(*h*)—Mike Howe's Marsh.
(*i*)—Longford Coal-Field.
(*j*)—Colebrook Field.
(*k*)—Schouten Island.
(*l*)—Spring Bay and Prosser's Plains.

2—Southern and South-Eastern Fields

(*m*)—Compton and Old Beach.
(*n*)—Lawrenny-Langloh Coal-Field.
(*o*)—Sandfly Coal-Field.
(*p*)—Ida Bay Coal-Field.
(*q*)—Hastings and Southport.
(*r*)—Recherche Bay Coal-Field.
(*s*)—Tasman's Peninsula.

The following are brief descriptions of the respective fields:

Avoca Coal-Field

(*a*)—mount rex

The Mount Rex seams are five miles north-west of Avoca and three-quarters of a mile south and south-east of the Mount Rex tin mine. They are situate on a Crown land section of 160 acres. They occur in sandstone of Jurassic age flanking adjacent hills north and south which have crests of intrusive diabase. The highest seam is six or seven feet thick. One hundred feet lower a twelve-foot seam of good coal exists, dipping west at 10° from the horizontal, which has been opened up a little by a tunnel and shaft.

The assays made by the Government analyst are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur	
Upper part of seam..........	54.5%	35.0%	8.5%	1.2%	0.8%	Firm coke
Lower part of seam..........	55	28.2	15.1	1.7		Firm coke

The coal burns freely with a clean flame and gives out a good heat and is excellent for both steam and domestic purposes.

(*b*)—RIGNEY'S COAL-SEAMS

On Rigney's Freehold near Avoca a seam of good coal fringes the north side of the low diabase hills north of the railway. The seam is ten and a half feet thick and the coal burns freely with a bright flame. It cokes and gives out a good heat. Trials have been made with it on the Government railway, Launceston to Scottsdale, with satisfactory results, a good head of steam being maintained under all conditions of working. It belongs to the best class of Mesozoic coal. The analysis furnished by the owners is:

Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur	B.T.U.
62%	24%	12%	2%	.00127%	12062

Four and a half miles of railway would connect the mine with the Fingal-Conara line. Work has not yet been started.

(*c*)—ST. PAUL'S COAL-SEAMS

Seams of coal fringe the mountain near Avoca known as St. Paul's Dome. They have been opened on the mountain side above Brookstead.

(*d*)—MOUNT NICHOLAS RANGE

The largest collieries in the island are on the south flank of this range between the townships of Fingal and St. Mary's. Six or seven seams are known to exist, varying in thickness from three to ten feet and covering 200 to 1,500 acres each seam. Outcrops are also known on the north side of the range as well as on the south side of the valley, so that the possible reserves may be described as fairly extensive. A regular output has for a long time been produced by the Nicholas and Cornwall mines.

JUBILEE SEAM. This is being worked by the Enterprise Company on the south-east flank of the Nicholas range, 1,760 feet above sea-level and three miles north of the township of St. Mary's. The workable coal exposed in the mine workings is six feet thick. The coal is black and clean; lustre dull with shining bands, texture dense, fracture cubical; but ash fairly high. The Government analyst's assay is:

Fixed Carbon	Volatile Matter	Ash	Water	
45.6%	29.2%	18.9%	6.2%	Coke crumbly

It is suitable for household and steam purposes.

Fingal. The Nicholas Measures extend also to Fingal, where similar coal exists, but it has not been worked.

Government assays of the coal worked by the large companies on the Nicholas range are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur	
1	57.70%	26.30%	9.50%	6.50%		
2	58.36	26.14	8.02	7.48		
3	58.88	23.10	9.30	8.72		
4	57.50	28.40	9.28	4.28	0.54	No coherent
5	55.00	31.02	9.56	3.86	0.56	coke

(*e*)—THOMPSON'S MARSHES OR DALMAIN COAL-FIELD

This field may be regarded as a southern extension of the Mount Nicholas coal area or a northern extension of the Douglas river and Seymour field. It is from seven to eight miles south of St. Mary's and five miles north-west of Seymour on the east coast.

Several seams are known to exist; an upper one four feet thick; another four feet; one twelve feet thick with a band of clay four feet in thickness, which divides the seam into two equal portions.

This coal assays as follows: (Assay by J. D. Millen.)

Fixed Carbon	Volatile Matter	Ash	Moisture
55.4%	30.7%	13.1%	0.8%

Coke 68.5%. Coke fairly swollen with slight cauliflower excrescence, firm and fairly lustrous. Ash, fawn coloured and flocculent.

Another large seam outcrops along a creek or gully bed for about thirty feet in thickness including clay bands. Its roof is sandstone, its floor pipe-clay. Mr. J. D. Millen's analysis of coal from this is:

Fixed Carbon	Volatile Matter	Ash	Moisture
56.4%	33.4%	9.1%	1.1%

Coke 65.5%. Ash whitish grey, flocculent. Gas profuse. The coke obtained from this coal is excellent, being well swollen, with slight cauliflower-like excrescences, firm and lustrous.

The most northerly outcrop is that of a seam two feet six inches to three feet thick. The coal is dull, with shining laminæ and tabular to cubical fracture. Analyses show the following results:

	Fixed Carbon	Volatile Matter	Ash	Moisture
Government Analyst	56.5%	31.6%	7%	4.9%
J. D. Millen	58.8	30.8	9.2	1.2

Mr. Millen adds, "Coke well swollen with slight cauliflower-like excrescences, firm and lustrous. Ash, reddish tinge and flocculent."

In all 2,000 acres have been taken up for exploitation. What proportion of these is coal-bearing cannot yet be stated, but from appearances the seams extend over six hundred acres, with, to be safe, a probable aggregate thickness of eight feet.

Connection with Seymour would be by means of a tramway down hill for five miles, but a shipping jetty would have to be constructed.

(*f*)—THE LLANDAFF-SEYMOUR SEAMS

A strip of Mesozoic sandstone and shale from three to six miles in width is exposed along the east coast from Llandaff to Thompson's Marshes, lying at the foot of the coastal diabase tableland. At Llandaff several seams outcrop (about twelve in number), a few of which may be repetitions of the same seam caused by faulting. The usual thickness is from three feet to three feet six inches. The quality is variable, which is what might be expected in outcrops. Where the seam has been worked, coal of good quality has been raised. Assays are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur
Pike's Creek........	50.2%	34.7%	12%	2.40%	0.7%
Steep Creek A1.....	57.3	31.9	5.8	4.3	0.7
Fosbrooke's Gully...	55.5	33.75	8.5	2.25	

Farther north two seams have been worked about four miles from Bicheno on the Denison river; a four-foot seam at ninety-two feet from surface and a three-foot seven-inch seam at 165 feet. At the Lagoon near the sea a small seam (twenty inches) exists at ninety feet below the surface and a lower seam at 192 feet was worked between 1850 and 1860, the size of which has been stated at five and seven feet. The existence of seams has been proved by bores all over the flat, but as they were not worked it may be assumed that they were not of payable size.

Higher up the river are three seams exploited in 1898 and from 300 to 400 feet above sea-level. These are:

Seam B. 1—17 inches.
Seam B. 2—3 feet; 20 inches of which are workable.
Seam B. 3—2½ feet.

The assays of coal from these seams are:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur
B. 1................	55.15%	33.0%	6.85%	5.0%	
B. 2................	54	33.5	5.6	6.3	0.6%
B. 3................	53.1	28.9	13.1	4.9	

Douglas River. Two and a half miles north of the Denison, seams exist in the Douglas river basin. In the river bed 250 feet above sea-level, an eight-foot seam of coal outcrops with six feet of coal cut up by bands and partings in such a way as to make profitable working doubtful.

Half a mile farther up the river is an exposure of the same seam with four feet eleven inches of fair coal. The rest is apt to be stony. The assay of the good quality coal in the upper part of the seam is:

Fixed Carbon	Volatile Matter	Ash	Moisture
52%	27.1%	16.4%	4.5%

Two miles up the Douglas river in a creek flowing into it from the south, a seam containing two feet eight inches of good coal is exposed and has been opened by a short drive.

The assay is:

Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur
50.8	30.9	12.3%	5.5%	0.5%

The seams above referred to are distributed in faulted country and, having been sunk on or driven on at detached points, some of them may be portions of one and the same seam.

An approximate estimate of the area underlain by coal with an average thickness of three feet would be two square miles, in the country between Bicheno and Seymour; and about a square mile round Llandaff would have two to three feet. Two bars to profitable working are the moderate size of the seams and the absence of suitable harbours in the vicinity.

(*g*)—YORK PLAINS

The seam at Lord's Coal hill is four feet thick contained in beds of variegated sandstone. Some fifty or sixty feet below the seam that is being worked is a second seam two feet thick. The dip of the seams is to the north-east.

The analysis of the coal is:

Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur
67.4%	13%	16.2%	2.7%	0.7%

The coal is used in malting and other trades for which an anthracitic variety is suitable.

(*h*)—MIKE HOWE'S MARSH FIELD

A coal-seam occurs on Mr. Askin Morrison's land seven miles north-west of Oatlands and four miles south-east of the southern end of Lake Crescent. It is exposed in some workings a few hundred yards south-west of the road from Oatlands to Interlaken.

The roof of the seam consists of a soft yellowish sandstone, the floor of clay. The seam dips north-west at an angle of 20° and its size is from three feet six inches to four feet. It is free from bands, but the coal is somewhat clayey.

The Government analyst's assay is:

Fixed Carbon	Volatile Matter	Ash	Moisture	
62.4%	18.4%	10.8%	8.4%	No coke

There are indications which suggest that the area of the seam is limited.

(*i*)—LONGFORD COAL-FIELD

The Mesozoic Coal-Measures rise to the surface at Norwich from below the deposits of the Launceston Tertiary basin. The principal seam (twenty to seventy feet below the surface) has been worked to a limited extent only. It is from three to four feet thick and yields a coal which can be used for household purposes. It dips in a southerly direction. Its proximate analysis is:

Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur
47.10%	27.30%	12.60%	13%	0.55%

Coal has also been discovered near Deloraine.

(*j*)—COLEBROOK FIELD

At Colebrook (formerly Jerusalem) three seams are known, one three feet six inches, one three feet four inches, and the third three feet thick. The probable extent of the seam-bearing measures is 300 acres.

Government assays of the coal are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture
No. 1 Seam....................	43.1%	20.5%	27.6%	10.5%
No. 2 Seam....................	47.9	26.1	10.5	15.5

(*k*)—SCHOUTEN ISLAND

Many years ago coal was worked by the Imperial Government at Geographe Strait on the northern shore of Schouten Island. The seam that was worked is six feet thick containing bands of clay, and is anthracitic in its upper part with about four feet of workable household coal. This is a little above sea-level; about forty feet higher is another seam, stony in nature and practically of no value.

The dip is about 9° to the east. The sandstones and shales containing the seams of coal flank high hills of diabase which are bounded on the east by the Granite Range which occupies the greater part of the island.

Dr. Milligan estimated the workable area of seam as one mile by 500 feet, and calculated, with four feet of seam, a tonnage of 400,000 tons.

These seams occupy the eastern edge of a former coal-field of which the western edge still survives along the coast south of Swansea.

(*l*)—SPRING BAY OR TRIABUNNA COAL-FIELD

Seams of coal have been shown to exist on both sides of the head of Spring bay and coal has been raised from shafts in the township of Triabunna, but from what can be learned the quality is indifferent. One seam, five and a half feet thick, exists at 50 feet below sea-level, east of the estuary, and a five-foot seam, possibly the same, has been met with at a couple of hundred feet below sea-level on the west side.

The possible area of Coal-Measures here is, according to Mr. Selwyn, 300 acres, capable of yielding 900,000 tons of coal (on a three-foot basis).

(*l*)—PROSSER'S PLAINS, BLACK RIVER

Two seams of coal altogether four feet thick occur at Prosser's Plains on Back river, which is a branch of Prosser's river. They pass below a flat of 2,000 acres at angles from 35° to 50°, dipping to the south-west. The coal is somewhat slaty. The angle of dip is unusually high, but will probably be found to diminish in a south-west direction. On all other sides, the Coal-Measure sandstone beds are interrupted by hills of diabase. The coal appears to be of an anthracitic nature, analysis of an individual sample revealing 73.6% fixed carbon, and 15.1% volatile matter. The sandstone beds are reported to extend south to the back of Buckland.

(*m*)—COMPTON AND OLD BEACH

A seam of coal two feet thick occurs at sea-level a little north of Mount Direction on the east side of the Derwent, opposite Austin's Ferry, dipping westerly, and on the south side of a hill, the upper part of which consists of Mesozoic sandstone. It has been passed through in a shaft of forty feet from the surface. Bluish and grey shales overlie the seam and contain impressions of the usual Mesozoic plants (*Thinnfeldia, Pterophyllum, Zeugophyllites, Phyllotheca*).

(*n*)—LAWRENNY-LANGLOH COAL-FIELD

The Coal-Measure sandstone fringes the hills of diabase in the basins of the rivers Clyde and Ouse, where these empty into the Derwent near Hamilton and Ouse Bridge, respectively.

A seam of good coal was disclosed many years ago in a well, afterwards a shaft, near the homestead at Langloh Park on the Lawrenny estate near Hamilton. It has been variously reported as from three and a half to five feet in thickness and a small quantity of coal raised from it. A group of nine seams altogether was, by Government trials with the diamond drill in 1892, shown to exist within a vertical distance of 282 feet, aggregating from 7 feet 3½ inches to 13 feet 2½ inches coal, but only two seams attain a thickness of four feet and upwards; viz., No. 1, varying from 2 feet 1½ inches to 4 feet, and No. 2 from 2 feet 6 inches to 4 feet 7½ inches.

The strike of the beds is north and south and the dip west.

Mr. W. F. Ward's analyses of coal from seams 1 and 2 and from the shaft are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur	
No. 1......	52.95%	24.27%	15.80%	6.40%	0.58%	No true coke found
No. 2......	53.87	25.60	14.20	5.30	1.03	
Shaft.......	66.3	23.5	6.2	4.0	Residue slightly coherent	

The test for gas at the Launceston gas works gave 10,400 cubic feet per ton.

In 1891 this coal was tried on the Government railways on the express from Hobart to Launceston and the locomotive superintendent reported that it kept steam all through the journey. It is a strong dull coal, suitable for steam-raising and domestic purposes.

The proved area of the seams may be taken as about 200 acres, and they probably extend over three times this extent of ground, say 600 acres in all.

(o)—SANDFLY COAL-FIELD

This coal basin is situate between 1,400 and 1,500 feet above sea-level on the divide between the Huon and North-West Bay rivers. Several seams of coal crop out on the south side of the divide, striking N. 20° E. and dipping into the hill at 5° in a north-westerly direction.

The seam which has been principally worked consists of an upper part with five feet of coal and a lower part four feet thick, separated by four feet of fire clay.

Altogether upwards of a dozen outcrops are known, but faulting is so frequent that it is safe to assume that several of these pertain to one and the same seam. The repeated small faults met with underground have given so much trouble in working that the owners have recently ceased operations.

Analyses of standard samples from the main workings by Mr. W. F. Ward, Government analyst, are as follows:

	Fixed Carbon	Volatile Matter	Ash	Moisture	Sulphur	
Top of Seam......	46.5%	23.4%	28%	2.10%		Crumbly coke
" "	53.1	29.9	15.6	1.4		Firm coherent coke
" "	54.3	25.4	17.6	2.7		
Lower part.......	56	25.7	15	2.5	0.7	

The best quality should make an excellent steam coal, and is suitable also for domestic and industrial purposes From time to time, however, the proportion of ash varies and in parts of the seam increases to an objectionable extent; in the better class of coal, on the other hand, it decreases to 9%.

The mine is worked by adit and connected with its shipping port by a tramway eleven miles in length.

At the eastern end of the range the coal-seams tend to be anthracitic. Mr. Ward's analysis of a 3 foot 6 inch anthracite seam is:

Fixed Carbon	Volatile Matter	Ash	Moisture
80.8%	8%	9%	2.2%

This is a fine strong coal of its class.

(p)—IDA BAY COAL-FIELD

At Ida bay, an extension of Southport bay, beds of soft felspathic sandstone enclose two seams of somewhat soft coal four feet six inches and three feet in thickness, dipping to the south-west at about 7° towards the foot of the Sugar Loaf, a hill situate about a mile south-west of the bay. A little work was done here about twenty years ago, and operations have recently been resumed with a view of utilizing the coal in the manufacture of cement from the limestone which occurs near the property. Some of the coal has been used for household consumption.

The proximate assay of this coal is as follows:

Fixed Carbon	Volatile Matter	Ash	Moisture
58%	12.9%	25.3%	3.8%

In shales above the coal are impressions of the fossil plants, *Zeugophyllites* (*Phœnicopsis*) and *Pecopteris lunensis* (Johnston). The geological horizon of these beds is rather doubtful, but they probably belong to the lower Mesozoic, possibly succeeding the Knocklofty sandstone (Trias).

The coal-seams possibly extend over 2,000 acres.

(*q*)—HASTINGS AND SOUTHPORT

Mesozoic Coal-Measures exist here, but no active work is proceeding.

At Hastings coal of fair quality occurs, but much mixed with bands which require separating. No departmental information is available, but an analysis is recorded:

Fixed Carbon	Volatile Matter	Ash	Moisture
58%	30.8%	8.7%	2.5%

At Southport only a few inches of coal have been passed through in boring.

(*r*)—RECHERCHE BAY COAL-FIELD

Along the shore of Recherche bay Mesozoic Coal-Measures occur rising with the slopes of a diabase crowned range to the west. They occupy a strip of country about three miles in length by one in breadth, but expanding to a width of three miles in the basin of the Catamaran river.

In this field are the Moss Glen and the Catamaran mines. The seams and sandstone strata dip in a north-westerly direction.

In the northerly part of the area the Moss Glen seams have been tested at about 200 feet above sea-level with varying thickness of from $4\frac{1}{2}$ feet to $5\frac{1}{2}$ feet of coal. The angle of dip is about 20°. The quality is variable. Official samplings of the five and a half foot seam have yielded on analysis:

Fixed Carbon	Volatile Matter	Ash
54%	26.2%	19.8%

Coal has also been found at ninety feet above the water, and there is likewise a coal-seam on the east side of the bay.

An upper seam exists sixty or seventy feet above the principal one and has been shown by a shaft to contain four and a half feet of coal.

A very limited amount of work has been done on this property and it is at present idle.

Impressions of *Zeugophyllites* (*Phœnicopsis*) are frequent in the accompanying shale.

Catamaran Colliery. This is situate a couple of miles south of the above, a little north of the Catamaran river. Three seams are known on the property, one of which is being worked. The total thickness of the latter, together with various partings, is seven feet ten inches. Of this, five feet four inches comprise the bottom part and two feet six inches the top. The dip of the coal is 6° to the N.N.W. Another seam underlying the top seam is three feet three inches thick. The official analyses are:

	Fixed Carbon	Volatile Matter	Ash	Moisture
Upper Seam............	67.8%	24.5%	3.7%	4%
Lower Seam.............	65.6	27.7	3.9	2.8

From trials which have been made, this coal is a good steam fuel, besides being an excellent household coal. The seam has been prospected by various shafts half a mile west of the main workings and coal discovered three-quarters of a mile away.

The extent of the field over which the seams may be expected to exist is about 700 acres.

Farther south on the coast-line, various seams are exposed, from eighteen inches to four feet thick, in inaccessible positions and with coal stated to be of indifferent quality.

(*s*)—TASMAN'S PENINSULA

One or two seams of coal occur west of the Saltwater river in the northern part of the peninsula and were worked by the Imperial Government many years ago. The quality of the coal was inferior. Strzelecki states an ultimate analysis as:

Carbon	Hydrogen	Oxygen	Nitrogen
80%	8.8%	2%	9.2%

3—Lignite and Brown Coal

Deposits of lignite and brown coal are widely distributed in beds of Tertiary age, but at present their economic value is only potential. Localities are George Town, Rosevears, Muddy creek, Evandale, Kimberley, Sassafras, Howth, Blythe river, Detention, Magnet, Henty river, Macquarie Harbour, Glenora, Ouse Bridge, etc.

COAL RESOURCES OF TASMANIA

GROUP I

Including Seams of 1 Foot or over, to a Depth of 4,000 Feet

District	Coal-Seams			Probable Reserves (Approximate estimate)		Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	
Mesozoic Coal—						
Mount Rex	1	12 feet	40 acres	B_3	500,000	
Rigney's	1	10 "	140 "	B_3	1,500,000	
St. Paul's	1	....	....	B_3	....	Moderate
Mount Nicholas Range and Fingal	6	3 to 10 feet	200 to 1500 acres each seam	B_3	25,000,000	Large
Thompson's Marshes	4	Agg. 8 ft	600 "	B_3	5,000,000	
Llandaff Seymour	Several	Agg. 2 "	1,800 "	B_3	4,000,000	
York Plains	2	3 feet and 2 feet	200 "	....	500,000	
Mike Howe's Marsh	1	3½ feet	Unknown			
Longford and Deloraine	2	3 to 4 feet	Unknown			
Colebrook	3	3 "	300 "	B_3	2,000,000	
Schouten Island	1	4 "	100 "	B_3	400,000	
Spring Bay	1	5 "	250 "	B_3	900,000	
Prosser's Plains	2	4 "	?	....	....	Moderate
Compton	1	2 "	?			
Lawrenny-Langloh	2	3 to 4 feet	200 acres	B_3	1,000,000	Moderate
Sandfly	Several	9 feet	500 "	B_3	4,000,000	Considerable
Ida Bay	2	3 to 4½ feet	500 "	B_3	4,000,000	Considerable
Recherche and Catamaran	Several	Up to 7 feet	1,000 "	B_3	6,000,000	
Total Mesozoic Coal	....	....	....	....	54,800,000	Sp. gr. 1.3 B.T.U. 12,096
Permo-Carboniferous Coal—						
Preolenna	Several	20 in. to 3 ft.	600 "	B_2	3,000,000	
Barn Bluff	1	8 in. to 1 ft.	1,800 "	Cannel	1,500,000	
Mount Pelion	1	2 feet	600 "	B_2	1,500,000	
Mount Cygnet	1	3 "	1,200 "	B_2	3,000,000	Sp. gr. 1.35 B.T.U. 12,492
Bruni Island	1	2 "	500 "	B_2	1,000,000	
Mersey and Don	1	20 inches	600 "	B_2	1,000,000	
Total Permo-Carboniferous Coal	....	....	....	....	11,000,000	Unknown reserves fringing the Central Tiers
Total	....	....	....	....	65,800,000	

QUANTITY AND VALUE OF COAL RAISED IN TASMANIA

The following figures are taken from the annual reports of the Secretary for Mines:

Year	Quantity Long tons	Value £
1880	12,219	10,998
1881	11,163	10,047
1882	8,803	7,923
1883	8,872	7,985
1884	7,194	6,475
1885	6,654	5,989
1886	10,391	9,352
1887	27,633	24,870
1888	41,577	37,420
1889	36,700	33,030
1890	50,519	45,467
1891	43,256	38,930
1892	36,008	32,407
1893	34,693	27,754
1894	30,499	24,399
1895	32,698	26,159
1896	41,904	33,523
1897	42,196	33,757
1898	47,678	38,256
1899	42,609	38,349
1900	50,623	44,227
1901	45,438	38,451
1902	48,863½	41,533
1903	49,069	41,709
1904	61,109	51,942
1905	51,993	44,194
1906	52,895¾	44,962
1907	58,891	50,057
1908	61,067¾	51,907
1909	66,161¾	56,237
1910	82,445	48,609*
1911 (estimated)	60,000	26,600*
Total	1,261,832¾ =	1,033,518
Metric tons	1,413,252	

* Value at pit's mouth.

THE COAL MEASURES OF WESTERN AUSTRALIA

BY

HENRY P. WOODWARD

Assistant Government Geologist

(*With a map and section in the Atlas*)

THE COLLIE COAL-FIELD

Locality

Up to the present time only one area has been discovered in Western Australia in which marketable coal-seams have been proved to exist. This is situated upon the Collie river, about 100 miles south of Perth (the capital).

Means of Access

Collie is connected by railway line with the two principal south-western ports, Fremantle being 136 miles via Perth, and Bunbury, 41 miles.

Physical Features

The coal basin is situated in a depression at the back or to the eastward of the Darling range. It is 600 feet above the level of the sea, from which it is separated by a granitic ridge and the coastal plain.

Geological Characteristics

There are absolutely no indications of the presence of stratified rocks, the entire extent of the Coal-Measures being concealed beneath either sandy swamps or ferruginous laterite ridges, the whole basin being surrounded by gneissic granite. Attention was first directed to the existence of coal-seams many years ago by a shepherd who discovered an outcrop in the bed of the river during an exceptionally dry season, but it is only recently that mining operations were commenced.

Boring and shaft sinking prove the formation to consist of a series of sandstones, grits and micaceous shales, associated with a number of coal-seams, the largest of which is about seventeen feet in thickness.

Samples of these shales and sandstones have been described by Mr. Chapman as follows*:

* F. Chapman, Palæontologist to the National Museum, Melbourne, Victoria. Bull. 27, Geol. Survey, W.A., 1907, pp. 10 & 11.

"The Collection of plant remains from the Collie coal-field consists of *Glossopteris* leaves and stem fragments which occur on pieces of carbonaceous shale, and on the surfaces of a whitish sandstone with thin, black, carbonaceous partings, the sandstone specimens and some of the shales are from cores obtained by boring.

THE SHALES

"Some of the plant-bearing shales are earthy in texture, and show a fair sprinkling of mica folia on the split surfaces. The majority of the slabs bearing the finest leaves consist of a close-textured bituminous shale, which shows a bright surface where abraded.

"A microscope section of this bituminous shale proves it to consist of fine, amorphous, hydro-carbonaceous particles, and only in one case was anything like a spore detected. This had the appearance of a sub-elliptical cell, with a clear circular area situated near one side of the interior, and bore some resemblance to one of the cells of *Pila*, an organism whose remains constitute the bulk of the European bogheads.

THE SANDSTONE

"There are two specimens of sandstone, both being cores from a boring. One of these is a greyish rock with numerous papery carbonaceous layers averaging about 5 mm. in thickness, the intervening sandstone layers being about 2 mm. thick. This specimen is somewhat micaceous, both white and brown micas being present, the former preponderating. On one surface of the core a flattened stem-like fossil occurs, apparently of the nature of a plant stem or a rhizome. The rock shows distinct cross-bedding, pointing to the shallow water conditions prevailing when the deposit was laid down.

"The second sandstone specimen shows only one carbonaceous seam, although the core is 35 mm. thick. The stratification lines have a slight dip, and there are indications of current bedding. This specimen reveals some interesting structural features when submitted to a microscopic examination. The granules of which the rock consists are largely made up of quartz, some felspar and numerous garnets, with occasional mica. The rock is loosely compacted, the interstices being occupied by a white, powdery material, probably of the nature of kaolin. Of the mineral constituents of the rock, garnet is the most abundant; it is usually in fractured grains, but sometimes crystal faces are visible, and the colour varies from dark ruby to almost colourless. Quartz occurs next in abundance, usually in rounded, but not polished, grains; and sometimes shows included strings of cavities and acicular rutiles. The felspar is generally orthoclase, often showing zoning; occasionally there are fragments of microcline, with perthite structure. This material was probably derived from the garnetiferous granites or gneisses which are found in this locality.

"Amongst the finest powder of this rock, after crushing and washing, there occurred a few examples of foraminifera of unusually minute dimensions, and probably dwarfed on account of their brackish water habitat.

"On treating the powder of this sandstone with hydrochloric acid, a slight effervescence was noticed, due, no doubt, to the presence of a few remnants of foraminiferal tests."

Limestones are entirely absent, whilst the only palæontological evidence of the geological age of these beds is afforded by the fossil remains exposed in the shales after weathering. These consist of Plantæ: *Glossopteris browniana*, *G. indica*, *G. augustifolia* (?), *G. gangamopteroides*, rhizoma of *glossopteris* (vertebraria). Foraminifera; *Endothyra*, *Valvulina*, *Bulimina*, *Truncatutina* and *Pulvinulina*.

GEOLOGICAL AGE

Considerable divergence of opinion has existed in the past with regard to the age of this coal, for some palæontologists determined the plant remains as belonging to the Mesozoic series whilst others claimed that they were Permo-Carboniferous; they are now, however, unanimous in classing them under the latter head. My own leaning all along has been towards assigning to this coal an age either Mesozoic or intermediary between that and the Palæozoic, my reason being based entirely upon its chemical composition, which is almost identical with that of coals of that age in other parts of the world, and I consider that the composition of a coal, which is indicative of the character of the vegetation, is more conclusive than one or two associated plant leaves.

EXTENT OF MEASURES

As previously stated, the area lies in a granite basin, therefore the mapping of its extent is a matter of great simplicity, since the character of the soil and flora changes immediately the contact is crossed, even where no rock is exposed. This area we estimate at roughly ninety-five square miles. A considerable amount of boring has been done which has demonstrated the existence of a great number of seams, but with the exception of about four localities at which large seams have been worked, sufficient boring has not yet been done to determine the actual area over which the seams extend.

CHARACTER OF THE COAL

The coal is what would, thirty years ago, be described as a black lignite but now as a non-caking bituminous coal high in moisture. It is black, dirty to handle, partly of a splinty character and partly composed of bright layers, alternating with soft bands, which present the appearance of compressed, soft wood charcoal.

The splint coal is extremely tough to cut or break but rapidly develops cracks upon exposure to dry, warm air, which renders it unsatisfactory for long railway journeys or for storage at the gold-fields, since it rapidly slacks with the formation of smalls. It is highly hygroscopic, for even when dried in the laboratory it so rapidly absorbs moisture from the air that great care has to be exercised in weighing.

It does not kindle so rapidly as the coals from New South Wales, but it burns with the evolution of very little smoke and without the formation of cinders, until nothing but a bulky, light ash of a white or reddish colour is left. It neither fuses nor cokes and has a short flame.

CHEMICAL COMPOSITION

The following tables have been prepared from a number of tests made in the Departmental Laboratory by Mr. E. S. Simpson, B.E., F.C.S.:

Specific gravity	1.349
Proximate Analysis—	
Moisture	21.18%
Volatile hydrocarbons	28.99
Fixed Carbon	43.73
Ash	6.10
	100.00

ULTIMATE ANALYSIS

	Fresh Coal	After Deducting Moisture
Carbon	54.93	69.46%
Hydrogen	3.10	4.32
Oxygen	12.82	16.52
Nitrogen	1.04	1.32
Sulphur	.53	.68
Ash	6.10	7.70
Moisture	21.18	
	99.70	100.00
Calorific value, B.T.U	9,637	12,231

Ratio:

$\frac{\text{Volatile hydrocarbon}}{\text{Fixed Carbon}} = \frac{1}{1.55}$ $\frac{\text{Hydrogen}}{\text{Carbon}} = \frac{1}{16.3}$ $\frac{\text{Oxygen}}{\text{Carbon}} = \frac{1}{4.35}$

These samples were taken from the face in the mine and placed in air-tight tins, and tests were made with regard to the quantity of moisture given off upon exposure to dry, warm air which amounted to 7.66% in thirty-one days, after which no further change took place, therefore the average market coal is lower in moisture than these fresh samples and has a relatively higher calorific value.

The following are the results obtained at some locomotive trials in 1905 from a number of samples:

Calorific value, B.T.U	10,470
Moisture, per cent	13
Ash, per cent	6

It will be noticed from the above that the calorific value of the coal upon the market is about intermediate between that given by the samples containing mine water and the dried ones.

The following give the composition of three samples of ash:

Silica, SiO_2	35.29	61.18	28.29
Titanium Oxide, TiO_2	1.38	1.66	1.75
Phosphoric Oxide, P_2O_5	.16	trace	8.31
Vanadic Oxide, V_2O_5	.21	.10	.02
Sulphur Trioxide, SO_3	2.43	.58	3.30
Potash, K_2O	.18	.20	.32
Soda, Na_2O	.39	.72	.80
Lime, CaO	2.94	1.61	5.39
Magnesia, MgO	2.18	.51	3.99
Manganese Oxide, Mn_3O_4	1.35	.43	trace
Iron Peroxide, Fe_2O_3	36.57	5.67	23.38
Alumina, Al_2O_3	16.59	27.63	24.58

The greater part of the iron in the ash exists in the coal in the form of ferrous carbonate, the amount of pyrites being small, ranging from 0.5 to 1.1%.

MINING

There are only four companies operating in this field who work the whole or a portion of the largest seams by incline plane haulage, the height of the coal worked varying from six to ten feet, whilst the system adopted is the pillar and stall.

Owing to the light dip of the seams and the short period over which they have been worked, the greatest vertical depth yet attained is only 250 feet, but it is highly probable that a pair of vertical shafts will be shortly put down to a depth of 1,000 feet with the object of working a large seam which has been thrown down about 500 feet by a fault.

The coal is cut with electric band cutters and is bored for shooting by the same power, black powder being used as the explosive.

As the mines are absolutely free from gas naked lights are employed.

KIMBERLEY DIVISION

Although Collie is the only coal-field upon which active operations are being carried on, there are other districts in the State in which lignites and brown coals occur. No detailed geological surveys have yet been carried out such as would enable even an approximate estimate to be made of the area or the quantity of coal available.

Kimberley

In the Kimberley division, in the far north of Western Australia, a seam of hydrous, bituminous, non-caking coal, somewhat similar to that occurring at Collie, has recently been found in well sinking, on Lower Liveringa Station, some distance to the south of Derby in the valley of the Fitzroy river.

The seam, which proved to be twelve feet thick, was met with at a depth of fifty feet from the surface, in strata which there seems strong geological reasons for believing to be of Upper Carboniferous age.

An analysis of this coal, in the Geological Survey Laboratory, was as follows:

Moisture	8.87%
Volatile hydrocarbons	29.73
Fixed Carbon	33.99
Ash	27.41
	100.00

Calorific value, 7,722 B.T.U.

A sample of the above coal was received from the owners of Liveringa Station and was found to consist of grey shale and thin bands of coal, the thickest being about half an inch. An analysis was made of some of the clean coal and this yielded the following percentages:

Moisture	11.71%
Volatile hydrocarbons	37.81
Fixed Carbon	36.92
Ash	13.56
	100.00

Considering the very large area which these Carboniferous rocks occupy in Kimberley, there seem good reasons for believing that seams other than this exist.

COAL RESOURCES OF WESTERN AUSTRALIA

GROUP I

Including Seams of 1 Foot or over, to a Depth of 4,000 Feet

District	Coal-Seams		Actual Reserve, less Coal Extracted (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons
Collie...	24	3 ft. to 17 ft.	5,760 acres	D_1	153,331,200	61,440 acres	D_1	500,000,000

THE COAL RESOURCES OF NEW ZEALAND

BY

P. G. MORGAN

Director of the Geological Survey of New Zealand

(*With two maps in the text*)

GENERAL STATEMENT

Coal, varying in grade from anthracite to lignite, occurs in many parts of New Zealand. In proportion to the present yearly consumption of somewhat under 2,500,000 tons (about ten per cent. of which is imported) the supply may be considered relatively large, but in comparison with probable future needs, it is decidedly small. It is likely, indeed, that the known coal of the Dominion will be practically exhausted within one hundred years, and if the present wasteful methods of coal extraction continue, the end will be in sight much sooner.

Although, owing to fairly thorough exploration, the quantity of proved bituminous coal is over 37 per cent. of the total, there can be no doubt that the chief fuel reserve of the Dominion (excluding possible oil-fields) lies in its brown coal. (D_1 and D_2 of the standard classification* proposed by the Committee on Coal Resources.)

The areas over which coal-bearing rocks outcrop are considerable, and there are still larger areas covered by younger rocks under which Coal-Measures are probably present. It has to be pointed out, however, that there are several factors, each present to an unusual degree, which make it necessary heavily to discount any computation based only on area of Coal-Measures and thickness of known outcrops of coal.

The chief of these factors is the marginal or basin character of the coal deposits. In consequence, all the known coal-seams are decidedly lenticular, and a thick outcrop is no guarantee of great lateral extent. In places a seam completely thins out for no perceptible reason. As a rule coal has been deposited only in the lower part of the Coal-Measures, and if one were to calculate the amount of coal from the known extent of the upper beds, without giving full consideration to their overlap, which is commonly very great, a serious error would result.

In the second place, the coal-seams in many localities are sharply folded,

*The writer must not be regarded as endorsing this classification, which for several reasons he considers unsatisfactory. It appears to be quite unsuitable for New Zealand coals, and more especially for the bituminous ones, which in many places contain a higher percentage of volatile matter than that provided for in the classification.

crushed and faulted. Thus the amount of coal economically recoverable is greatly diminished.

Again, in some parts of the Dominion, for example in the Greymouth and Buller-Mokihinui coal-fields, denudation has removed immense quantities of fuel.

In places, dirt or stone bands detract seriously from the value of the coal-seams, but on the whole this drawback is not prominent, and New Zealand coals may be said to compare favourably in point of purity, with those from other parts of the world.

Owing to the reasons indicated, and to imperfect exploration, it is impossible to estimate exactly the amount of coal in New Zealand. For the purpose of this paper, however, an attempt must be made, and the writer therefore submits the figures on this and the following pages.

According to the classification usually followed in New Zealand, the quantity of coal may be stated as follows:

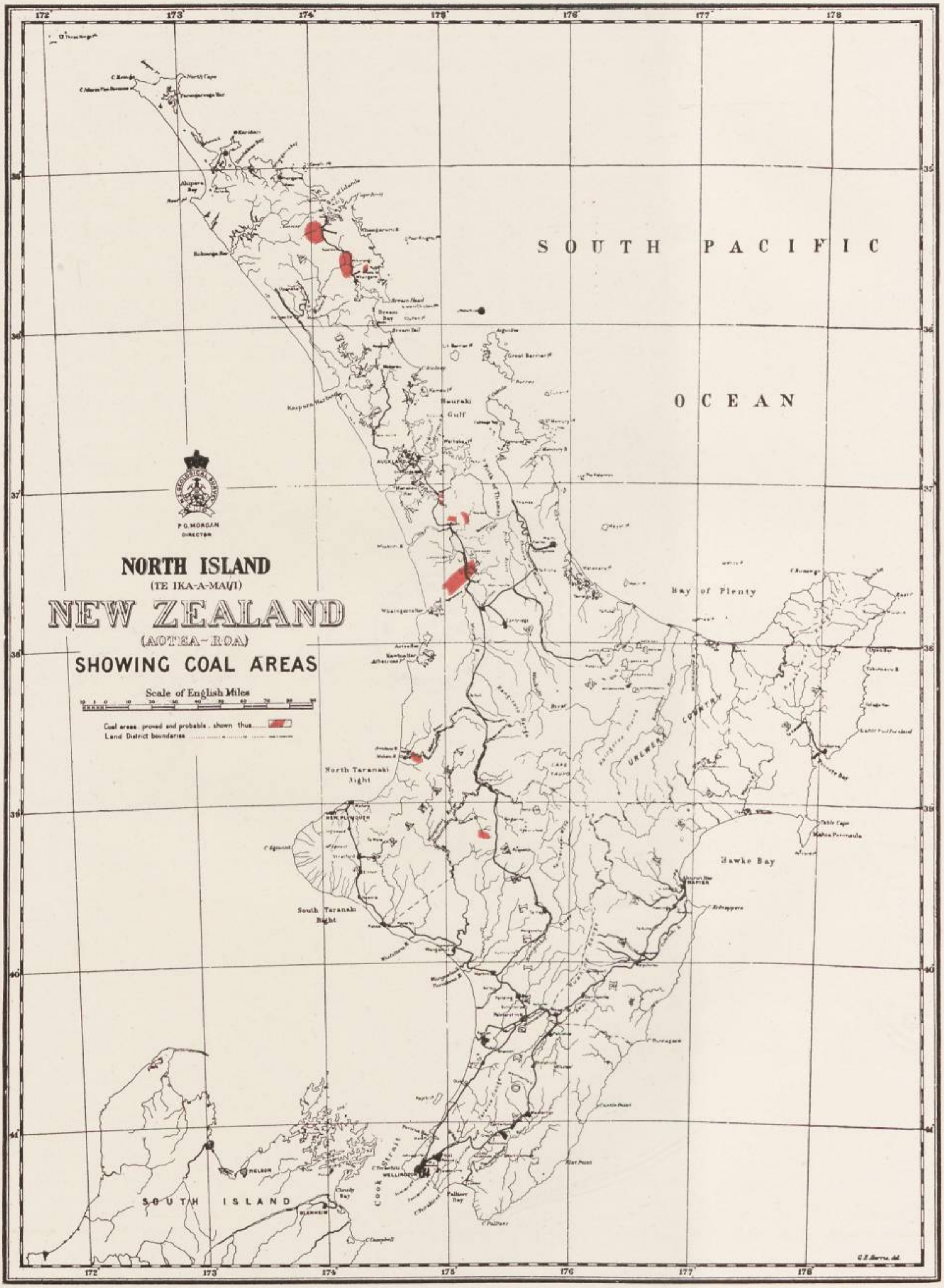
TABLE I

Class of Coal	Proved	Probable (including proved)	Possible
	Tons	Tons	
Anthracite	Very little	Very little	Small
Bituminous Coal, (including semi-anthracite)	374,000,000	851,000,000	Moderate
Glance or Pitch Coal	114,000,000	455,000,000	Small
Brown Coal, and Lignite	513,000,000	2,080,000,000	Large
Totals	1,001,000,000	3,386,000,000	Large

According to the proposed standard classification the quantities may be distributed somewhat as follows:

TABLE II

Class of Coal	Proved	Probable (including proved)	Possible
	Tons	Tons	
A_1	Very little	A little	Small
A_2	Very little	A little	Small
B_1	Under 1,000,000	5,000,000	Small
B_2	5,000,000	20,000,000	Small
B_3	20,000,000	100,000,000	Small
C	363,000,000	786,000,000	Moderate
D_1	333,500,000	1,350,500,000	Large
D_2	278,500,000	1,124,500,000	Large
Totals	1,001,000,000	3,386,000,000	Large


NORTH ISLAND
(TE IKA-A-MAUI)
NEW ZEALAND
(AOTEA-ROA)
SHOWING COAL AREAS
P. G. MORGAN
DIRECTOR
Scale of English Miles
Coal areas, proved and probable, shown thus
Land District boundaries
SOUTH PACIFIC
OCEAN
Bay of Plenty
Hawke Bay
North Taranaki Bight
South Taranaki Bight
Hauraki Gulf
UREWERA COUNTRY
AUCKLAND
NEW PLYMOUTH
NAPIER
WELLINGTON
NELSON
BLENHEIM
SOUTH ISLAND
Cook Strait
Palliser Bay
172
173
174
175
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177
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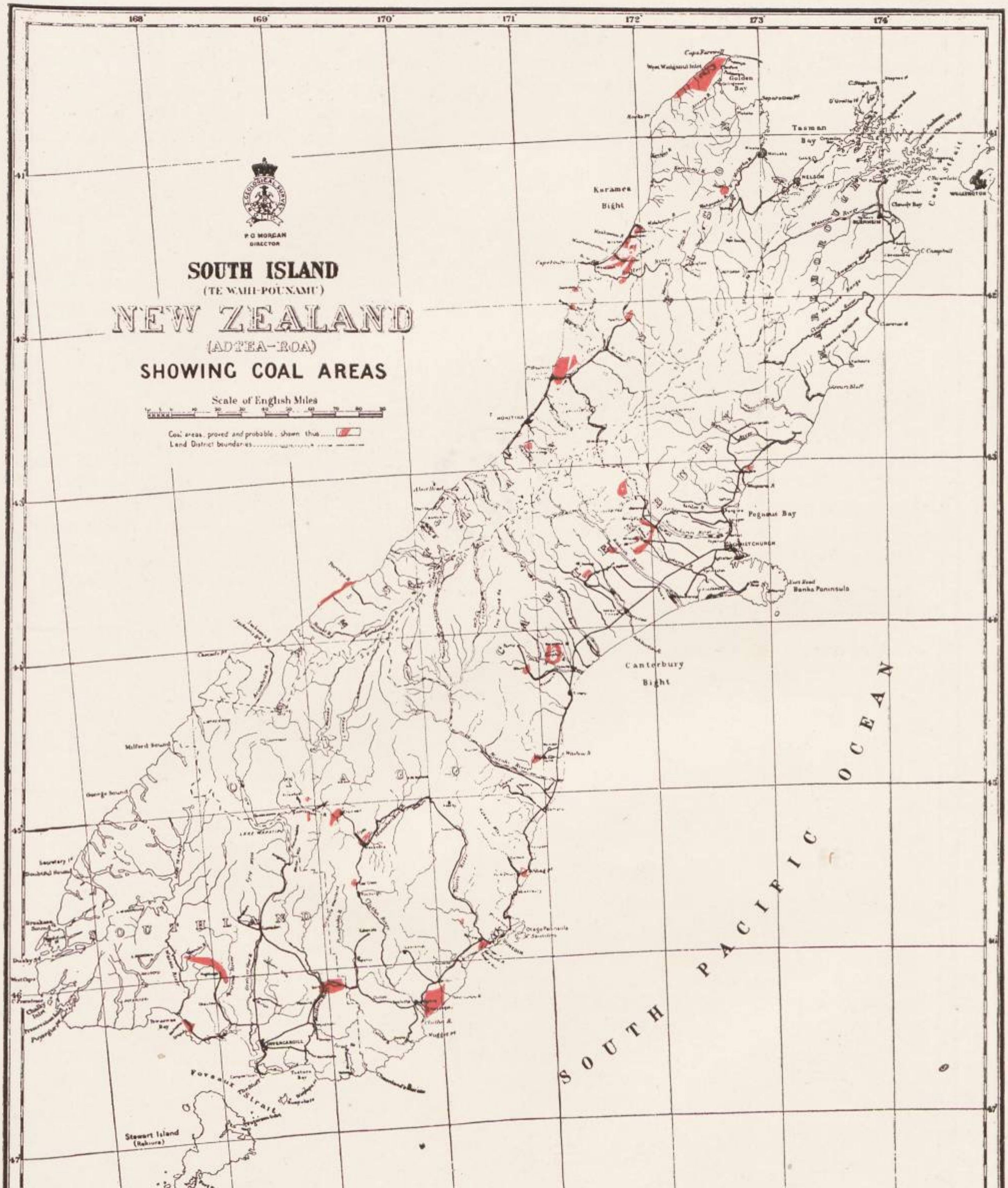
G. E. Harris, del.


P. G. MORGAN
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SOUTH ISLAND
(TE WAHI-POUNAMU)
NEW ZEALAND
(AOTEA-ROA)
SHOWING COAL AREAS
Scale of English Miles
Coal areas, proved and probable, shown thus
Land District boundaries
Karamea Bight
Tasman Bay
Golden Bay
Pegasus Bay
Banks Peninsula
Canterbury Bight
SOUTH PACIFIC OCEAN
Milford Sound
Foveaux Strait
Stewart Island (Rakiura)
NELSON
CHRISTCHURCH
INVERCARGILL
O T A G O
S O U T H L A N D

On account of the large limit of error, the tonnages in the above tables may be indifferently considered either as English or as metric tons. This statement applies to later figures also, except where the unit is expressly stated, and exactness implied, for example in the table showing production.

Detailed statistics in the form asked for by the Coal Committee will be found at the end of this paper.

Of the proved total of over a thousand million tons it is probable that not more than one-half is economically minable under conditions likely to prevail in the near future. Under present conditions it is doubtful if as much as one-third can be mined at a profit. It need hardly be stated that the coal-fields now being exploited in New Zealand contain the most cheaply worked and the best of our coals, and that future generations will probably have to be satisfied with a poorer class of fuel, won under greater difficulties.

OWNERSHIP

The Government of New Zealand has for many years consistently pursued the wise policy of reserving to the State the ownership of known mineral lands, and during the last fifteen or twenty years the ownership of possible mineral wealth has generally been reserved, even when the surface rights of public lands have been sold. It thus follows that most of the proved and probable coal-bearing areas belong to the State, which is always ready to lease coal-bearing land at a moderate royalty (generally 6*d* per ton), and under not very onerous labour conditions.

PRODUCTION

The following figures show the coal production of the Dominion in 1878, in 1880, and at intervals of five years since the latter date. The total production at the end of each period is also shown. It should be noted that the figures given do not show the total consumption of coal in the Dominion. At one time a large percentage of the coal used was imported, chiefly from Australia, but the importation is now less than one-tenth the total consumption.*

TABLE III†

Date	English Tons (2,240 lbs.)	Metric Tons (2,204.62 lbs.)	Total to Date	
			English Tons	Metric Tons
Prior to 1878	....	....	723,042	734,645
In year 1878	162,218	164,821	885,260	899,466
In year 1880	299,923	304,736	1,416,401	1,439,131
In year 1885	511,063	519,265	3,518,261	3,574,722
In year 1890	637,397	647,626	6,456,674	6,560,292
In year 1895	740,827	752,716	9,957,222	10,117,016
In year 1900	1,093,990	1,111,546	14,552,870	14,786,414
In year 1905	1,585,756	1,611,204	21,701,419	22,049,683
In year 1910	2,197,362	2,232,626	31,217,126	31,718,099

*The decrease in imported coal is only relative. The quantity varies considerably from year to year, but on the whole there is an increase in tonnage.

†There are small discrepancies between this table and the latest official records, due probably to omissions.

The 1910 production and the total production to date are classed in the official records of the Mines Department as follows:

TABLE IV

Class of Coal	1910 Production		Total Production	
	English Tons	Metric Tons	English Tons	Metric Tons
Bituminous and Semi-bituminous Coal......	1,495,709	1,519,727	18,550,088	18,847,780
Pitch Coal............................	6,068	6,165	1,982,671	2,014,489
Brown Coal............................	594,995	604,549	9,304,324	9,453,640
Lignite...............................	100,590	102,205	1,380,043	1,402,190
Totals..........................	2,197,362	2,232,646	31,217,126	31,718,099

Though accurate data, as might be expected, are wanting, the writer has endeavoured to reclassify the coal produced according to the proposed standard classification, with the following results:

TABLE V

Class of Coal	1910 Production		Total Production	
	English Tons	Metric Tons	English Tons	Metric Tons
A_1 and A_2....................	Nil	Nil	Nil	Nil
B_1 and B_2....................	36,569	37,156	43,795	44,498
B_3..............................	Nil	Nil	Nil	Nil
C*................................	1,164,537	1,183,237	16,218,589	16,478,865
D_1..............................	696,683	707,869	9,016,986	9,161,691
D_2..............................	299,573	304,384	5,937,756	6,033,045
Totals..........................	2,197,362	2,232,646	31,217,126	31,718,099

At the present time the total production of coal is more than doubling itself every ten years, and the production of bituminous coal is increasing at a greater rate than that of non-bituminous. It can, therefore, be easily shown that if the "natural increase" were maintained the whole of the proved bituminous coal will be exhausted in less than fifty years, and a very serious inroad made upon the probable reserves. Such a result, especially in view of the fact that New Zealand has considerable undeveloped iron resources, would be a

* All bituminous coal not naturally falling into any other class has been placed in C.

national calamity and it is one that quite likely will so far eventuate as to cause serious embarrassment long before the end of the present century.

AGE OF THE COAL-FIELDS

In south-east Otago (Waikawa, Catlins river) and in Southland (Hokonui hills) small seams of coal occur in Jurassic rocks, but in no case is a workable seam known to be present. The chief coal-bearing rocks of New Zealand are of early Tertiary age, but Upper Cretaceous coal-seams almost certainly occur, and there are considerable quantities of lignite of Miocene, Pliocene, and possibly even Pleistocene age. The difficulties in settling the relative ages of the New Zealand coal-fields are such that for many years the subject has been a controversial one, and probably no two geologists agree on all points. It would be useless to give in this paper a summary of the opinions held, and the reader is therefore referred to the writings of Hochstetter, Von Haast, Hector, Hutton, McKay, Park, Marshall, Speight and other geological workers in the New Zealand field.

A somewhat similar confusion as to the limits of Upper Cretaceous and early Tertiary strata, appears to have existed until recently, with respect to the sedimentary succession in many parts of western North America. With further knowledge, it is evident that a very interesting parallel between the Coal-Measures of New Zealand and those of Alaska, western Canada, and western United States can be drawn.

It may be said, however, that there are signs of a *rapprochement* among present workers in New Zealand, and as detailed field surveys are extended, and palæontological research made, it is probable that a fairly close agreement will be reached within the next decade.

CORRELATION OF THE COAL-MEASURES

In a general way the Coal-Measures of New Zealand may be correlated with those of various countries on the borders of the Pacific, for example with the coal-deposits of Borneo, Japan, British Columbia and Alaska. There is no coal-field corresponding in age with the Permo-Carboniferous Coal-Measures of Australia, though doubtless some of the New Zealand lignites are strictly contemporaneous with the Miocene lignites of south-eastern Australia (Victoria). Again, there is no parallel to be drawn between the Coal-Measures of New Zealand and those of China, which have been reported as of Carboniferous age.

MODES OF FORMATION, AND CONDITIONS OF DEPOSITION OF COAL

Practically all New Zealand geologists are agreed that, as already stated, the coal-seams are marginal or basin deposits of a lenticular character. It is probable that they have been formed in more than one way. Some may represent buried swamp or peat-bog vegetation, some are formed of drifted vegetable matter, whilst others again may represent accumulations both of vegetation that grew *in situ* and of drifted material.

Almost all our coals have been formed under fresh-water conditions. In one or two places marine beds form the roof of the coal, and in one instance a workable seam occurs wholly enclosed in marine strata.

MODES OF ALTERATION

The writer is not in a position to discuss (even if it were advisable) the possible bacterial alteration of the original vegetable matter of the coal-seams, but the available evidence points to a similarity of composition in the chief coal-deposits when first buried beneath the earth's surface. Subsequent alteration consists mainly in the loss of volatile matter, principally water. Exceptionally the loss of hydrocarbons has been high. In some cases the coal appears to have acquired a notable percentage of sulphur, though it must be observed that, on the whole, this objectionable constituent is low.

The varying composition of the bituminous coals in the north-western part of the South Island is evidently due mainly to differences in pressure and heat, conditioned by the amount of original cover, and in pressure (with accompanying heat) due to earth movements. The maximum cover appears to have varied from 5,000 feet to 10,000 feet. The anthracite of the Fox river is due to involvement of bituminous coal in faulting movements.

The brown coals of the Malvern Hills district, Canterbury, at a number of places has been considerably altered by the intrusion of igneous rocks into the strata. The altered coal now contains from 50 to 90 per cent. of fixed carbon, 0 to 37 per cent. of volatile matter, 1 to 9 per cent. of water, 2 to 14 per cent. of ash, and 2 to 4 per cent. of sulphur. Some of it thus has the composition of anthracite.

EXTENT AND THICKNESS OF COAL-SEAMS

From what has been said the reader will be prepared for the statement that no individual coal-seam has, as yet, been traced for more than a few miles in any direction. The variations in thickness are extraordinary. There are many instances of seams ten to twenty feet in thickness thinning to one or two feet in distances of a quarter of a mile or less. As regards maximum thicknesses the following instances may be mentioned:

In the Waikato district (Auckland), 50 to 60 feet brown coal (D_1).

In the Buller-Mokihinui district, 53 feet of bituminous coal (C).

In the Kaitangata district, 30 feet or more brown coal (D_1).

At Coal-creek, near Roxburgh, Central Otago, 80 feet (or according to Professor Park 100 feet) of lignite (D_2).

At Nightcaps (Southland), 36 feet of brown coal (D_2 but near D_1) in three bands.

It is obvious that if thicknesses such as those cited were maintained over even moderate areas, the amount of coal would be large, but unfortunately this is not the case. Moreover, in these thick seams it is extremely difficult to maintain freedom from accidents, and at the same time to secure a high percentage of extraction, and thus the amount of recoverable coal is diminished.

COMPOSITION

The following proximate analyses, all of which have been made by Dr. MacLaurin, Dominion analyst, and his staff, have been selected as typical of New Zealand coals.

TABLE VI—PROXIMATE ANALYSES

Locality	Fixed Carbon	Volatile Hydro-carbon	Water	Ash	Total Sulphur	Calories	Class in Proposed Standard	Ordinary New Zealand Classification
Fox River (south of Westport)...........	90.9	5.1	0.8*	3.2	....	....	A_1	Anthracite
Fox River (south of Westport)...........	82.42	11.07	0.23*	6.28	0.35	....	A_2	Anthracite or semi-anthracite
Paparoa Mine, near Greymouth..........	78.90	16.93	0.40*	3.77	0.37	8,439	B_1	Semi-anthracite or bituminous
*Paparoa Mine........	77.67	16.68	0.70	4.95	0.30	8,286	B_1	Semi-anthracite or bituminous
Paparoa Range........	62.90	33.53	0.67*	2.90	0.33	8,443	B_2 or C	Bituminous
Ironbridge Mine, Denniston...............	57.67	41.14	0.91	0.28	4.62	8,227	C or B_2	Bituminous
*Brunner Mine, near Greymouth, St. Kilda Section............	57.16	36.93	0.34*	5.57	2.35	8,025	C or B_2	Bituminous
Coalbrookdale, Denniston..................	55.73	40.08	2.37	1.82	0.55	7,923	C or B_2	Bituminous
*State Coal Mine No. 2, near Greymouth.....	54.24	42.36	1.27	2.13	0.23	8,275	C or B_2	Bituminous
Puponga, N.W. Nelson.	50.95	39.99	6.05	3.01	0.50	6,865	C	Semi-bituminous or Glance
*State Coal Mine No. 1, near Greymouth.....	49.71	41.50	8.22	0.57	0.45	7,118	D_1 near C	Semi-bituminous or Glance
Kawakawa, N. Auckland.................	45.93	46.46	4.17	3.44	5.67	6,948	D_1 or C	Glance
Kiripaka, N. Auckland.	43.08	44.79	4.65	7.48	1.03	6,581	D_1 near C	Glance
Taupiri Extd. Coal Mine, Waikato......	43.73	42.12	11.72	2.43	0.32	6,129	D_1	Brown
Mangapapa Mine, Mokau................	38.65	43.29	11.34	6.72	2.71	5,897	D_1	Brown
Kaitangata, Otago.....	38.00	39.96	18.22	3.82	0.40	5,553	D_1	Brown
Springfield, Canterbury.	34.74	35.13	23.88	6.25	0.45	5,205	D_2	Brown
Nightcaps............	31.04	39.24	24.80	4.92	0.23	4,767	D_2	Brown
Gore, Southland.......	25.34	40.42	30.92	3.32	0.45	4,195	D_2	Lignite
Bannockburn, Central Otago.............	23.75	43.83	26.12	6.30	0.32	4,291	D_2	Lignite

* Ultimate analyses of these coals are also given (Table VII).

All the samples except those with the water percentage marked (*) are representative samples taken in the mine, placed in air-tight tins, and then forwarded to the analyst. The water-percentage is therefore that of the freshly mined material, except in five cases, in none of which is the loss of moisture through air-drying believed to exceed 0.5 per cent. It may be mentioned that the Brunner Mine coal is almost anhydrous, and normally contains under 0.5 per cent. of moisture at 100° C.

Attention ought to be drawn to the fact that the volatile hydrocarbons are usually somewhat high in New Zealand coals. Thus, nearly all are free kindling and fast burning.

Very few ultimate analyses of New Zealand coals have been published. The following, by Dr. J. S. MacLaurin and staff, are representative of the coals of the Greymouth district:

TABLE VII—ULTIMATE ANALYSES

Locality	Carbon	Hydrogen	Nitrogen	Oxygen by difference	Sulphur	Ash	Total
1—Paparoa Mine..........	83.89	4.46	0.70	5.70	0.30	4.95	100.00
2—State Coal Mine, No. 2..	78.92	5.61	1.57	11.54	0.23	2.13	100.00
3—Brunner Mine (St. Kilda Section)...............	78.41	4.94	0.87	7.86	2.35	5.57	100.00
4—State Coal Mine, No. 2..	77.34	4.98	1.59	14.44	0.41	1.24	100.00
5—State Coal Mine, No. 2..	76.73	5.01	1.38	12.87	1.04	2.97	100.00
6—State Coal Mine, No. 1..	70.19	5.51	1.09	22.19	0.45	0.57	100.00

Proximate analyses of 1, 2, 3, and 6 are given in Table VI.

PHYSICAL CHARACTERISTICS

The lignites and brown coals, when in the solid, are usually soft and easily mined, but in a few cases are so tough as to involve some difficulty in breaking down. All, of course, when exposed to the atmosphere, lose moisture and begin to disintegrate. The specific gravity of the brown coals is generally about 1.25 but with a high ash may reach 1.37.

The bituminous coals as a class are friable or "soft," a characteristic which depends largely upon their freedom from ash, and to some extent also upon their comparatively young geological age. The amount of fine coal or slack produced in exploitation is increased beyond that necessary by the methods of mining and transport in use. The specific gravity of the bituminous coals is generally between 1.24 and 1.33, but exceptionally, where there is a high percentage of ash, it may reach 1.41.

VALUE AS FUEL

Under the conditions prevailing in New Zealand the calorific equivalent of a coal does not determine its value as a fuel. Much of the higher grade bituminous coal, as already stated, is friable, and therefore will not sell in the open market at a price covering the cost of production and transport. Coking has been practised to a limited extent, and is now coming into more extended use, but in all cases the volatile constituents are entirely wasted. Briquetting, which has been tried only with the slack coal (Class C) from the Seddonville State coal mine, is so far an economic failure, the cost of manufacture (including pitch) and of transport exceeding the selling price. Mechanical stokers are installed in a few commercial enterprises, particularly electrical power plants, and allow the consumption of a certain amount of friable coal. The main problem, however, as to how friable coal is to be utilized, has not been commercially solved.

In mining and transporting the brown coals a large percentage of slack is produced, and though a small amount of this, mixed with lump or unscreened coal, is used under stationary boilers, the greater part is wasted.

The market value of coal in New Zealand is very high. The State coal mines receive about £1 per (English) ton from the Railway Department for lump coal (close to the border line between C and D_1). The same class of coal is retailed for household use in Wellington at about £1,9,0 per ton, whilst the somewhat higher grade bituminous coal from the Westport Company's mine sells for several more shillings per ton. The brown coal from Kaitangata (D_1) after a railway haul of about fifty-five miles, is retailed in Dunedin at £1,8,0 per ton. The still lower grade Green Island coal, though carried only six or seven miles by rail, fetches considerably over £1 per ton in the same town.

SPECIAL AREAS

1—North Auckland

The peninsula that lies to the north of Auckland contains a number of detached coal-bearing areas. Further exploration may extend the known areas of these, and prove that some are connected. The coal (C, D_1) is of the class generally known in New Zealand as glance or pitch coal. In recent official reports it is termed semi-bituminous. By proximate analysis it contains from 40 to 56 per cent. of fixed carbon, 36 to 48 per cent. of volatile matter, 4 to 6 per cent. of water, 1 to 15 per cent. of ash. Sulphur varies from 1 to 6 per cent., and the calorific value from 6,600 to 7,000 calories. The chief collieries at the present time are situated in the Whangarei district at Hikurangi and Kiripaka. The Kawakawa mine, once the largest in New Zealand, is now almost exhausted.

2—Waikato

South of Auckland, principally in the lower Waikato valley, is a large area over which coal is found. Coal is supposed to underlie almost the whole valley, and, if so, the amount present is many hundred millions of tons. The coal (D_1) is a useful brown coal having, as mined, approximately 36 to 44 per cent. fixed carbon, 41 to 46 per cent. volatile matter, 12 to 15 per cent. water, 2 to 3 per cent. ash and under $\frac{1}{2}$ per cent. sulphur. The calorific value is from 5,400 to 6,100 calories. The largest collieries in the district are those of the Taupiri Coal Company.

3—Raglan

The Waikato Coal-Measures extend westward and southward into the Raglan and Kawhia districts. Practically nothing is known as to the amount of coal available in these localities.

4—Mokau—Upper Wanganui

This coal-field, which may be considered as the southern extension of the Waikato and Raglan fields, is almost unexplored. The chief outcrops are in the Mokau and Retaruke (Upper Wanganui) districts. Ultimately the coal will probably be found over a large area, but if one judges from the present scanty data, the seams are thinner and dirtier than those in the Waikato district. The only coal mine now at work is the Mangapapa, situated on the Mokau river some twenty-two miles above its mouth. An analysis of the coal is given in Table VI.

5—North-West Nelson

There is a considerable extent of Coal-Measures in the north-west part of Nelson, but the seams are in many places somewhat thin for working under present New Zealand conditions, and are much split up by dirt bands. The coal (C, D_1) occurs in two horizons and varies from brown to bituminous. It contains from 42 to 57 per cent. fixed carbon, 33 to 49 per cent. volatile matter, 2 to 20 per cent. water, 3 to 12 per cent. ash, and sulphur from under $\frac{1}{2}$ per cent. to 3 to 4 per cent. The calorific value is from 5,700 or less to 7,300 calories. The collieries now at work are situated at Puponga and Seaford.

6—Central Nelson

Under this heading are included the Coal-Measures in the Tadmor, Hope, Baton, Sherry, Wangapeka, Owen and Murchison districts. Very little is known as to the amount of coal in these localities, although Sir James Hector and others have made some estimates. The coal (C, D_1, D_2) is in general bituminous or sub-bituminous in character, but there is also some brown coal. The better coals contain from 41 to 56 per cent. fixed carbon, 36 to 54 per cent. volatile matter, 1 to 6 per cent. water, 2 to 7 per cent. ash, and 1 to 5 per cent. sulphur.

7—Reefton

The proved coal of the Reefton district is contained in a number of isolated patches. There is, however, a large possible extension underneath the surface-beds of the Inangahua valley. As worked in several small mines the coal (mainly D_1 but partly C) has the following composition: 42 to 51 per cent. fixed carbon, 40 to 41 per cent. volatile matter, 5 to 10 per cent. water, 1 to 5 per cent. ash, and $\frac{1}{2}$ to 6 per cent. sulphur. The calorific value is from 6,800 to 7,200 calories.

8—Buller-Mokihinui

The Buller-Mokihinui coal-field contains the largest coal mines in New Zealand. These are exploiting a bituminous coal of high calorific value. Partly owing to denudation and partly to original deposition, the coal is in isolated patches of relatively small area as compared with that of the whole field. Outcrops being numerous, it is possible to arrive at a fairly close approximation to the amount of coal. The portion between the Ngakawau and Buller rivers, (the Orikaka valley excluded), was carefully surveyed under Sir James Hector's direction, with the result that the coal-bearing area was found to be 10,642 acres, or 16.628 square miles, containing an average thickness of 13.406 feet of coal. There was, therefore, about 214,000,000 English tons (217,434,272 metric tons) of coal originally present in this area. Sir James Hector used a factor of safety of 2, and thus reduced his estimate to somewhat over 100,000,000 tons. In the table at the end of this report the writer endeavours to give the actual quantity of coal in the ground, and thus, by adding the proved coal north of the Ngakawau river (Mokihinui district) and subtracting the coal actually won, a final estimate of 221,000,000 tons is reached.

The Mackley or Orikaka valley, in the south-east part of the coal-field, is as yet unexplored. It is believed to contain a considerable amount of coal, some of which is of the D_1 grade only.

In no New Zealand coal-field are the effects of marginal thinning of coal-seams and of denudation more apparent than in the Buller-Mokihinui district. Owing to these causes the workable area is not more than one-tenth of that originally occupied by the Coal-Measures. Again, owing to the thickness of the seams, and other causes, a very large amount of coal is left in the ground, and it is doubtful whether the extraction reaches thirty-three per cent.

The Buller-Mokihinui coal (classed as C in list, but in ultimate composition approaching B_2) contains as worked from 51 to 61 per cent. of fixed carbon, 34 to 42 per cent. volatile matter, 1 to 5 per cent. of water, $\frac{1}{4}$ to 4 per cent. of ash, and $\frac{1}{2}$ to 5 per cent. of sulphur. The calorific value varies from 7,100 to 8,200 calories. Fixed carbon decreases from south to north, whilst hydrocarbons, water and sulphur tend to increase.

The chief collieries are those of the Westport Coal Company near Denniston and Millerton, of the Westport-Stockton Coal Company near Ngakawau, and of the State at Seddonville.

9—Charleston-Brighton

The coals south of Westport near Charleston and Brighton are brown coals or lignites of Miocene age with from 29 to 34 per cent. fixed carbon, 45 to 49 per cent. volatile matter, 17 to 19 per cent. water, 3 to 5 per cent. ash, and 5 to

6 per cent. sulphur. They appear to be intermediate between D_1 and D_2 in composition.

A few miles inland from Brighton are the anthracite outcrops of the Fox river. The larger seams are said to be from seven to twenty-six feet thick but are in general much crushed, and dip at high angles, owing to involvement in a faulted band of country. Some of the coal in this neighbourhood, however, is bituminous, with a high percentage of volatile matter.

10—Greymouth

The coal of the Greymouth district occurs in several distinct horizons, but these belong to one geological formation of early Tertiary age. It is in general bituminous, but varies in grade from a fuel approaching semi-anthracite (probably much the same as the "semi-bituminous" coal of the United States markets) to coal very high in hydrocarbons and containing an appreciable amount of water.

Thus fixed carbon varies from 29 to 80 per cent., volatile matter from 15 to 53 per cent., water from less than ½ to 10 per cent., ash from 1 to 19 per cent., and sulphur from almost nil to 7 per cent. The heat value is from 6,000 to 8,450 calories. The coal therefore belongs to classes B_1, B_2, C and D_1, but is mainly C.

The chief collieries of the Greymouth district are the Paparoa, Blackball, Brunner and State (two in number).

11—Canterbury

Coal occurs in a large number of places in the hilly or mountainous country west of the Canterbury Plains, but no large field has yet been proved. It is probable that the coal extends synclinally under the Pleistocene and recent deposits of the Canterbury Plains, possibly at depths well under 4,000 feet. Confirmation of this view is given by the fact that at several points off the eastern coast of Canterbury large pieces of brown coal have been obtained by trawling at depths of from thirty to forty fathoms.* Such an extension of the Coal-Measures would imply that the fuel reserves are very large.

The Canterbury coals are probably not all of one age. The Malvern hills coal is believed to be of Upper Cretaceous age, whilst the coal from southern Canterbury is Tertiary.

The principal localities at which coal has been mined are Broken river, the Malvern hills, Glentunnel, Mount Somers, Kakahu, and Waihao Forks. At several places in the Malvern hills the original brown coal, as previously mentioned, has been altered by igneous intrusions to a high grade coal, or even to anthracite. When unaltered the coal generally belongs to class D_2 (some approaches D_1) of the standard classification, and as a rule has from 25 to 35 per cent. of fixed carbon, 40 to 44 per cent. volatile matter, 23 to 29 per cent. of water, 2½ to 12½ per cent. of ash, and from less than ½ to over 3 per cent. of sulphur. The heat value is from 4,400 to 5,200 calories.

*R. Speight: *Transactions of the New Zealand Institute*, Vol. 43, 1911, pp. 421-422.

The lignite mined at Albury from a twenty-two foot seam has the following composition: Fixed carbon, 15.38 per cent.; volatile matter, 44.75 per cent.; water, 35.72 per cent.; ash, 4.15 per cent.; sulphur, 0.49 per cent. The heat value is 3,694 calories.

12—North-east Otago

The coal of north-east Otago occurs in isolated patches, for example at Ngapara and Papakaio. It is a brown coal or lignite (D_2) with practically the same composition as the Canterbury coal. Fixed carbon varies from 25 to 31 per cent.; volatile matter from 38 to 43 per cent.; water from 26 to 27 per cent.; ash from 4 to 5 per cent.; sulphur from under $\frac{1}{2}$ to 4 per cent. The heat value is from 4,100 to 4,600 calories.

13—Shag Point

This is a small coal-field about fifty miles north of Dunedin. The coal (D_1) is probably of Cretaceous age. The output of the Allendale coal mine, now the principal colliery, has the following composition: Fixed carbon, 40 to 43 per cent.; volatile matter, 34 to 35 per cent.; water, 16 to 17 per cent.; ash, 6 to 9 per cent.; sulphur, 2 to 4 per cent. The heat value is about 5,500 calories.

14—Green Island

The coal at Green Island and Saddle Hill is a brown coal or lignite of moderate quality (D_2), but being near a centre of population (Dunedin) is very useful as a household and stationary boiler fuel. Its composition as mined is as follows: Fixed carbon, 25 to 29 per cent.; volatile matter, 35 to 41 per cent.; water, 31 to 33 per cent.; ash, 1 to 3 per cent.; sulphur, 1 to 3 per cent. The heat value is from 4,500 to 4,700 calories. The principal collieries of the district are the Abbotsroyd (Freeman's) and the Jubilee.

15—Milton-Kaitangata

This, the most important of the Otago coal-fields, produces brown coal varying from D_1 to D_2 in quality, but very useful as household and stationary boiler fuel. The coal contains from 22 to 38 per cent. fixed carbon, 39 to 49 per cent. volatile matter, 16 to 30 per cent. water, 4 to 7 per cent. ash, and 2 to 7 per cent. of sulphur. The heat value is from 4,600 to 5,550 calories. The largest producer of the field is the Kaitangata mine.

A lignite of late Tertiary age, mined from a thirty foot seam at Benhar, near Stirling, has the following composition: Fixed carbon, 17.70 per cent.; volatile matter, 48.49 per cent.; water, 30.41 per cent.; ash, 3.40 per cent.; sulphur, 0.44 per cent. The heat value is 3,694 calories.

16—Nightcaps

The Nightcaps coal-field (Southland) is said to have a length of eighteen miles, with a maximum width of three miles. In places more than one seam is present. The coal (partly D_1, but mainly D_2) contains from 31 to 41 per cent. fixed carbon, 38 to 39 per cent. volatile matter, 17 to 25 per cent. water, 2 to 5 per cent. ash, and under $\frac{1}{2}$ per cent. of sulphur. The heat value is from 4,800 to 5,700 calories.

17—Orepuki

This small coal-field is situated south of the district last described. Its coal (D_2) is similar to that of the Nightcaps field, but is somewhat lower grade. The following analysis represents its composition: Fixed carbon, 30.03 per cent.; volatile matter, 38.98 per cent.; water, 25.02 per cent.; ash, 5.97 per cent.; sulphur, 4.20 per cent. The heat value is 4,689 calories.

18—Central Otago

Lignites of moderate quality (D_2) but often very useful for fuel purposes in this treeless district, occur as isolated patches in many parts of central Otago. The chief localities are Coal creek near Roxburgh (seam at least 80 feet thick), Alexandra, Clyde, Cromwell, Bannockburn, Gibbston, Idaburn, St. Bathans, etc. These lignites are very low in fixed carbon, which varies from under 15 to 25 per cent. Volatile matter ranges from 43 to 50 per cent.; water from 23 to 33 per cent.; ash from 4 to 9 per cent. Sulphur is always, or nearly always, well under 1 per cent. The heat value is from 3,750 to 4,500 calories.

19—Gore-Pukerau

Lignite of post-Miocene age occurs over an extensive area near Gore and Pukerau (Southland and Otago land districts). There is very little cover on the lignite, which is therefore mined from open pits. The composition of the freshly mined fuel is: fixed carbon, 18 to 25 per cent.; volatile matter, 36 to 41 per cent.; water, 36 to 39 per cent.; ash, 3 to 5 per cent.; sulphur, under $\frac{1}{2}$ per cent. The heat value is from 3,600 to 4,200 calories.

A shale mined near Waikaia, apparently for fuel purposes, has the following composition: fixed carbon, 12 per cent; volatile matter, 60.25 per cent.; water, 18.25 per cent.; ash, 9.50 per cent.; sulphur, 2.16 per cent. The heat value is not less than 5,917 calories, and therefore considerably exceeds that of the best brown coal mined in Otago.

20—Miscellaneous Localities

Among the localities not hitherto mentioned in which small areas of coal occur are Enner Glyn near Nelson, Takaka (Nelson), Clarence valley (Marlborough), Waipara (Northern Canterbury), Paringa river (Westland), Forest hill (South-east Otago), and Preservation inlet (South-west Otago).

MAPS

The two maps accompanying this summary of New Zealand coal resources show all coal-fields of which the boundaries are approximately known. Other localities at or near which coal-seams occur are also shown on the maps, but boundaries are not indicated.

The coal-bearing areas as coloured on the maps are intended to show the probable as well as the proved areas, but are not everywhere accurately delineated, and on account of the small scale blanks and minor denuded areas cannot well be shown.

SCHEDULE OF COAL RESOURCES

In the following table the tonnage and other figures given must be understood as somewhat rough estimates in many cases. It is of course, no easy task to make really reliable estimates of buried minerals, but in connection with the New Zealand coal-fields the difficulty of doing so is much greater than in countries fortunate enough to possess regular Coal-Measures.

Since all New Zealand coal mines are shallow, and deep ground is unprospected in any way, no bituminous coal over 2,000 feet, or lower grade coal over 1,000 feet, in depth has been included in the table. The lenticular and patchy nature of the coal deposits renders extreme caution in estimating undeveloped coal very necessary.

In several cases the classification of the coal is very rough. Proximate analyses are generally available, but ultimate analyses are scarce, and difficulty has arisen to some extent through the apparent unsuitability of the proposed standard classification for New Zealand coals.

Since the deepest coal mine in New Zealand is only a few hundred feet in depth, and no workable coal has been proved by bores at depths over 1,500 feet, no estimates can be given. There is reason for believing that the amount of workable coal at depths over 4,000 feet is not large.

COAL RESOURCES OF NEW ZEALAND

GROUP I

Including Seams of 1 Foot or over, to a Depth of 4,000 Feet

District	Coal-Seams		Actual Reserve, less Coal Extracted (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
1 North Auckland	1	1 ft. to 20 ft., average 6 ft.	Under 4 sq.m.	C D_1	Under 10,000,000 Over 10,000,000				
" "	2	Average workable agg., say 6 ft.	...	...	...	16 sq.m.	C D_1	45,000,000 50,000,000	Moderate
2 Waikato	1	2 to 60 ft., average 10 ft.	15 sq.m.	Mainly D_1	141,000,000				
"	2	Average agg. say 10 ft.	...	...	...	45 sq.m.	Mainly D_1	432,000,000	Large
3 Raglan	1	Unknown	...	...	...	...	...	...	Moderate
4 Mokau—Upper Wanganui	1	2 to 16 ft., average say 4 ft.	Under 4 sq.m.	D_1	Under 15,000,000				
Mokau	1	Average say 4 ft.	...	...	...	23 sq.m.	D_1	244,000,000	Moderate
5 North-West Nelson	2	1 to 7 ft., average agg. say 6 ft.	Under 4 sq.m.	C D_1	8,000,000 15,000,000				
" "	2 to 6	Average agg. say 6 ft	...	...	...	32 sq.m.	C D_1 D_2	4,000,000 180,000,000	Small
6 Central Nelson (Group of Districts)	1 to 2	Average agg. say 4 ft.	...	...	...	20 sq.m.	C. D_1 D_2	10,000,000 60,000,000 7,000,000	Moderate

COAL RESOURCES OF NEW ZEALAND—(*Continued*)

District	Coal-Seams		Actual Reserve, less Coal Extracted (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
7 Reefton..........	2	1 to 10 ft. 2 to 40 ft. Average agg. say 6 ft.	Under 1 sq.m.	Mainly D_1	Under 5,000,000	....	....	....	Large
8 Buller-Mokihinui....	1	1 to 53 ft., average 13.4 ft..........	18 sq.m.......	Mainly C	221,000,000				
" " ...	2	Average agg. say 10 ft..............	....	....	....	4 sq.m.......	Mainly C	38,000,000	Moderate
9 Charleston-Brighton..	1	2 to 20 ft., average say 8 ft..........	Under 1 sq.m.	D_2	7,000,000	Unknown ...	....	....	Moderate
10 Greymouth.........	1 to 20	Average agg. 20 ft.	12 sq.m.......	B_1 B_2 B_3 C D_1	1,000,000 5,000,000 20,000,000 124,000,000 74,000,000				
"	Over 20	Average agg. say 20 ft..............	....	....	....	38 sq.m......	B_1 B_2 B_3 C D_1	4,000,000 15,000,000 80,000,000 326,000,000 51,000,000	Moderate
11 Canterbury (Group of Districts)........	1	2 to 30 ft., average say 6 ft..........	5 sq.m........	Mainly D_2	28,000,000				
Canterbury (Group of Districts)......	2	Average agg. say 6 ft	....	....	....	23 sq.m......	D_2	104,000,000	Large
12 North-east Otago (Group of Districts)..........	1	4 to 40 ft., average say 10 ft.........	1 sq.m........	D_2	9,000,000	Unknown....	....	....	Moderate

COAL RESOURCES OF NEW ZEALAND—(*Continued*)

District	Coal-Seams		Actual Reserve, less Coal Extracted (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
13 Shag Point..........	3	1 to 11 ft., average say 10 ft.........	½ sq.m........	Mainly D_1	3,500,000	Unknown....	....	....	Small
14 Green Island........	1	4 to 30 ft., average 10 ft.............	8 sq.m........	D_2	75,500,000				
" "	2	Average agg. say 12 ft...............	....	....	....	Unknown....	....	....	Moderate
15 Milton-Kaltangata...	1 to 2	2 to 35 ft., average agg. say 15 ft....	10 sq.m.......	D_1 D_2	70,000,000 71,000,000				
" "	1 to 4	Average agg. say 15 ft...............	....	....	....	10 sq.m......	Mainly D_2	144,000,000	Large
16 Nightcaps...........	1	2 to 36 ft., average say 10 ft.........	5 sq.m........	Mainly D_2	47,000,000				
"	2	Average agg. say 10 ft...............	....	....	....	15 sq.m......	Mainly D_2	192,000,000	Moderate
17 Orepuki............	1	1 to 15 ft., average 6 ft.............	½ sq.m........	D_2	Under 3,000,000				
"	2	Average agg. say 6ft	....	....	....	Under 1 sq.m.	D_2	5,000,000	Small
18 Central Otago.......	1	4 to 80 ft., average say 10 ft.........	Under 2 sq.m.	D_2	19,000,000				
" "	1	Average say 10 ft...	....	....	....	19 sq.m......	D_2	173,000,000	Moderate
19 Gore-Pukeran.......	1	6 to 23 ft., average say 10 ft.........	2 sq.m........	D_2	19,000,000				
" "	1	Average say 10 ft...	....	....	....	23 sq.m......	D_2	221,000,000	Large
20 Miscellaneous.......	......	....	....	....	....	....	....	....	Moderate

THE COAL RESOURCES OF BRITISH TERRITORY IN NORTH BORNEO

COMPILED BY

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COAL is widely distributed in Borneo, occurring in most cases in localities at no great distance from the coast. It is of later age than that of most other countries, being, so far as known, in every case of Tertiary age, for the supposed discovery of plants of Gondwana types has not been substantiated. The oldest coal-bearing deposits, and those which have been most worked, including probably all or nearly all those that are here referred to, are of Eocene age, while others have been referred to the Oligocene, Miocene, Pleistocene and Recent.

In the west of the State of Sarawak, Eocene coal has been worked since 1881 near the confluence of the Simunjan river with the Sadong (110° 40′ E. longitude). The coal-bearing formation consists mainly of shales, sandstones and conglomerates, and contains excellent coal suitable for steam-raising purposes. Two seams have been developed which outcrop in the hills 200 feet above the surrounding country, and strike in a south-west and north-east direction parallel to the coast for about fifty miles from Insigni hill through Ngili hill, where the colliery is situated, to Sebattik. The dip, which is to the south-east, that is to say towards the interior, does not exceed 5°, but the field is still unexplored in this direction, the total area prospected being only forty-five square miles, and even a rough estimate of its resources cannot be arrived at.

The seams are two feet six inches and three feet in average thickness, respectively. The former consists throughout of clean coal, but the latter is interrupted by a shale band with an average thickness of four inches. The faults are unimportant and the strata are otherwise little disturbed. The workings have not yet reached the level of the water in another mine previously sunk in the same neighbourhood. There has therefore been no trouble with water nor is any serious difficulty expected from this source in the future.

The site of the colliery is three and a half miles from the wharves on the Sadong river, with which it is connected by a railway. The wharves are eighteen miles from the mouth of the river. The coal is transported in lighters and steamers, and vessels with a draft of eighteen feet can ascend when the tide is full. These particulars were supplied by Mr. J. W. Evans, the manager of the colliery.

The mines are worked underground by Chinese coolies and on the surface by native labour.

Another large coal-field is in course of development at Selantik (111° 30′ E. longitude, 1° 5′ N. latitude) lying along the Kelingkang range. It occurs eighteen miles up the Linga river on the left bank of the Batang Lupar, to the east of Sadong.

Good coal also occurs farther north at Pegasus, or Pelagus, on the Rejang river (111° 20′ E. longitude, 2° 45′ N. latitude), which enters the sea near Cape Sirik, but is at present too inaccessible to be of commercial importance.

Other localities are on the Mukah (112° 8′ E. longitude) and Bintulu rivers (113° E. longitude) farther to the east, and their tributaries.

In the territories of the Sultan of Brunei, which are now administered by the British Government, valuable seams of coal also occur on the Baram (114°-114° 30′ E. longitude) and Limbang rivers (115° E. longitude), and on the Madalam, a tributary on the left bank of the latter. These have been leased to the Sarawak Government. Other places in this district from which coal has been reported are Mount Dulit (114° 15′ E. longitude and 3° 10′ N. latitude), Tutau on the tributary of the Baram of the same name and Similajan.

Beyond Brunei is another tract, belonging to the State of Sarawak, in which considerable desposits of coal occur at Brooketon or Muara, which lies on the south-west side of Brunei bay, opposite to the island of Labuan. There are five seams, with a thickness of 28 feet, 26 feet, 29 feet, 5 feet, and 2 feet, in a succession of sandstones and fine clays. Both the 28-feet and 26-feet seams are worked. The dip of the seams varies between 45° and 80°. Stiff bluish clays are found immediately above the coal-seams and sandstones below; the strata are, accordingly, believed to be inverted. At a distance of two miles the dip is only 15°, and it is possible that here the strata may occur in their true order.

Two faults occur; one has only a very small throw, while the extent of the other has not yet been proved.

The coal is a bright-looking lignite with a shaly fracture, and is easily broken. It burns with a luminous flame, is non-coking, leaves a white ash and is somewhat liable to spontaneous combustion. The following analysis of the coal from the 28-foot seam has been supplied by Mr. Thomas Lewis, manager of the colliery:

Volatile matter (exclusive of sulphur)	40.24%
Fixed carbon	46.70
Water	11.48
Ash	1.58
Sulphur	0.36
Calorific value, small calories	6,667

Water is pumped out from the mine at the rate of 150,000 gallons a day. The workmen employed consist of Chinese and Malays in equal numbers. The mine is only two miles from the wharf and is connected with it by a short line of railway.

Coal is also worked on a small scale at Buang Tawar, about six miles south of Brooketon. There are three seams measuring five feet, two feet, and one foot six inches in thickness. The strata are very disturbed, being faulted and folded in an irregular manner, so that there are several outcrops of each seam.

The five-foot seam, which is mostly worked, can be followed in places, with a dip of only 10°, for a distance of forty yards, and then suddenly dips absolutely vertically. The outcrops appear at heights of 380, 270 and 200 feet above the sea in different places, and are almost at right angles to one another.

The coal is only worked for use in local launches, and the output in 1909, 1910 and 1911 amounted to only 1,200, 1,500 and 1,300 tons, respectively.

The Brooketon coal-field appears to extend under the sea as far as the north of the island of Labuan, where the coal outcrops in two ranges of hills about 300 feet high. These hills consist mainly of sandstone and extend for about three and a quarter miles obliquely across the island in a north-east by east direction from Merinding, near Luke's point on the west through Belangow to Coal point and Kubong bluff. Outcrops also occur at Banting about half a mile south of Belangow, and two or three other points. At Kubong bluff seams one foot two inches, one foot seven inches, eleven inches and five inches are stated to occur in a series of 275 feet of sandstones, shales and clays, while in the principal workings which lie farther to the south-west, there are four seams measuring four feet six inches, one foot six inches, three feet nine inches, and nine feet, respectively. At Kubong bluff the dip is only 24° to the north-north-west; in the mines it is 35°, while in the extreme south-west it is as much as 70°. The workings extended from a fault at Belangow north-eastward to Coal point, but operations have now been abandoned. A depth of 800 feet along the dip below sea-level was reached, and it was expected that 1,500,000 tons could be won without going deeper.

The coal is of good quality, hard, compact, with conchoidal fracture, and contains a yellow transparent resin. An ultimate analysis by John Percy showed that there was present 72.27 per cent. of carbon, 5.20 of hydrogen, 14.28 of oxygen and nitrogen, 0.30 of sulphur, 1.85 of ash and 6.10 of hygroscopic water.

The sandstone rock is very porous, and contains much water which flowed into the seams at the rate of 600 to 700 gallons per minute. A line of railway twelve miles long connects the mines with the coaling pier at Victoria on the south-east coast of the island.

Coal also occurs in a number of localities in Sabah, the territory of the British North Borneo Chartered Company. It is met with immediately to the south-east of Labuan in Padas or Batu-Batu bay in the eastern portion of Brunei bay near the mouth of the Lenkongan or Linkongan river, 115° 40′ E. longitude, and 5° 11′ N. latitude. It is also found on the north coast in Gaya island (116° E. longitude, 6° N. latitude), on the Sequati and Kurina streams (116° 41′ E. longitude, and 6° 51′ N. latitude), and the Benkoka river (117° 3′ E. longitude and 6° 50′ N. latitude), on the east side of Marudu bay in the extreme north of Borneo; and in Sandakan bay on the east coast (118° E. longitude and 5° 50′ N. latitude), where a coaling station has been established. It is believed to occur in the interior to the south-west of the lofty summit of Kinabalu (116° E. longitude and 6° N. latitude), as well as at Penungah (about

117° 5′ E. longitude and 5° 20′ N. latitude), on the Kinabatangan river, and on the Quarmote, a tributary on the right bank of the same river.

Of much greater importance, however, is the Silimpopon coal-field,* on the river of the same name, which enters Cowie harbour in Sibuko or St. Lucia bay in the south-east of the company's territory. It is situated in longitude 117° 26′ E. and latitude 4° 18′ N. twelve miles from the coast, but vessels of moderate tonnage can ascend to within eight and a half miles of the mine.

The dip at the mine is about 6¾° to the south, and the coal appears to lie in a synclinal basin, where the dip is everywhere low or the strata are actually horizontal.

The coal is dull and compact, bituminous and slightly resinous in appearance with occasional small isolated patches of pure resin. Ultimate analysis shows it to contain, when dried, 70.64 per cent. of carbon, 5.62 per cent. of hydrogen, 8.80 per cent. of oxygen, 0.85 per cent. of nitrogen, 2.47 per cent. of sulphur (mainly as sulphate) and 11.62 per cent. of ash. The calorific value is 7,416 small calories, or 13.348 B.T.U.

The only seam which is worked is known as the "Queen" seam. It is usually five feet ten inches thick, and is included in a series consisting of sandstones and shale, mainly the former. Immediately over the seam is a layer of shale averaging five feet in thickness. At a point two feet from the floor is a band of shale four inches to five inches thick, which is suitable for holing. The highest nine inches contains stringers of shale and is consequently of somewhat inferior quality.

The coal is worked by an incline at an angle of about 14½° and therefore greater than the dip of the coal. When this reaches the seam, it is continued in four parallel roads in the seam in the direction of the dip; one of these is an engine way, one a man way, and two are return air ways. The coal is taken up the incline in trucks and carried over a railway for three and three-quarter miles to the river wharf, and thence in lighters to the ships in Cowie harbour or to the storage ground at Sebattik island, fifteen and a half miles from the wharf.

Fire-damp has only been noticed in small quantities, and naked lights are employed. The water in the mine contains sulphuric acid in solution, presumably from the oxidation of pyrites, and corrodes pipes and other metallic objects. Wooden pipes have, accordingly, been substituted, and the water ends of the pumps are protected by lead or cement linings.

There is stated to be an "actual reserve" of 5,600,000 metric tons and a "probable reserve" of 70,000,000 metric tons.

The labour employed consists mainly of Chinese coolies with some Malays and Javanese.

Taken as a whole, the coal deposits of British territories in Borneo, including all the divisions which have been described, must be of very considerable extent and importance. Much, however, remains to be done in the way of prospecting and proving them, and there is almost an entire absence of analyses. From their age they would naturally be placed among the brown coals or lignites.

*The information regarding the Silimpopon coal-field was furnished by Godfrey E. Morgans, B.A., for T. & W. Morgans, consulting engineers to the Cowie Harbour Coal Company, Limited.

They contain a considerable amount of resin, which occurs in patches and has been employed by the natives for illuminating purposes. There appears to be no satisfactory evidence as to the percentage of moisture in the Labuan coal when mined, though this is obviously a matter of considerable importance, but it would seem to be less than in most lignites.

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THE COAL RESOURCES OF THE NETHERLANDS-INDIA

BY

E. A. DOUGLAS

(*Translation*)

(*With two maps in the Atlas*)

A GREAT deal of coal is found in the Indian Archipelago; it is impossible, however, to make an even approximately accurate estimate of the available coal supply, because many districts are at present hard to reach, and therefore comparatively unknown. Moreover, most of the coal deposits occur in the more recent formations—the majority are later than the Eocene—and in the present undeveloped state of industrial enterprise in the Indies their examination at high cost would not be justified by the profit which could be derived from them.

Few deep borings have been put down within the coal-bearing areas, so that only in a few districts has the existence of coal-seams under the surface been definitely established. The bore-holes that have been put down are generally not more than from 300 to 400 metres in depth.

Among the most thoroughly explored coal deposits are those of the Lower Tertiary areas in Sumatra, Java and Borneo; also the younger coal formations in the eastern and north-eastern part of Borneo.

In the following notes these coal occurrences are briefly described; for more comprehensive descriptions the reader is referred to the accounts of examinations of these areas by different mining engineers, which are contained in the "Jaarboek van het Mijnwezen." *

The more important of these treatises are given below, in chronological order:

1. R. D. M. Verbeek. Geologische beschrijring der districten Riam Kiwa en Kanan in de Zuideren Ooster-afdeeling van Borneo. Jbm. 1875 decl I blz. 3-130.

2. R. D. M. Verbeek. Het Ombilinkolenveld in de Padangsche Bovenlanden. Sumatra's Westkust. Jbm. 1875 decl II blz. 3-121.

3. R. Fennema. Verslag van een onderzoek van het kolenterrein rondom den Boekit Soenoer in de Ommelanden van Benkoelen. Jbm. 1885. Technisch en administratief gedeelte blz. 6-66.

4. J. A. Hooze. Onderzoek naar kolen in de Berausche landen ter O. kust van Borneo. Jbm. 1886. Technisch en Administratief gedeelte blz. 5-105.

* In subsequent references the abbreviation Jbm. will be used for this publication.

5. J. A. Hooze. Onderzoek naar kolen in her Rijk van Koetei ter Oostkust van Borneo. Jbm. 1887. Technisch en Administratief gedeelte blz. 5-95.

6. J. A. Hooze. Nadere gegevens betreffende enkele kolenterreinen in Koetei en onderzoek eener aardoliebron. Jbm. 1888. Technisch en administratief 2de gedeelte blz. 315-337.

7. J. A. Hooze. Onderzoek naar kolen in de Straat Laut en aangrenzende landstreken. Jbm. 1888. Technisch en administratief 2de gedeelte blz. 337-431.

8. J. A. Hooze. Kolen aan de Oostkust van Borneo van de Sint Lucia baai tot de Pamoekan baai. Jbm. 1888. Technisch en administratief gedeelte, 2de gedeelte blz. 431-471.

9. J. A. Hooze. Topografische, Geologische, Mineralogische en Mijnbouwkundige beschrijving van een gedeelte der afdeeling Martapoera in de Resdientie Zuider-en Osterafdeeling van Borneo. Jbm. 1893. Technisch en administratief en Wetenschappelijk gedeelte blz. 161-263 en 282-314.

10. Dr. R. D. M. Verbeek en R. Fennema Het Bajah kolenveld in: Geologische Beschrijving van Java en Madoera 1896 Deel II blz. 782-816.

A large number of minor references to coal in the Netherlands-India may be found in the Jaarboek van het Mijnwezen.

THE GEOLOGY OF THE COAL DEPOSITS

No coal-beds older than Tertiary have been found except a few thin Carboniferous beds of little economic value, which occur near the Merangin river in Djambi. All the subdivisions of the Tertiary in the Dutch Indies are coal-bearing. The best coals and the most important Tertiary coal basins occur principally in the uppermost stage of the Eocene.

The Eocene in Netherlands-India was originally divided stratigraphically into four stages. This subdivison was based upon studies of the Tertiary in Sumatra. From later geological investigations in the other islands, however, it appeared that the two upper stages of the Eocene should be placed with the Miocene; and the Eocene arranged in but two subdivisions as follows:

1. The lower, called the Breccia stage, consisting of breccias, conglomerates, sandstones and marl slates.

2. The upper, known as the Sandstone stage, containing coal-bearing quartz sandstones.

Coal is seldom found in the lower stage, only one such occurrence having been so far discovered. On the other hand, the upper stage in the various islands contains important coal-beds. The two largest Eocene coal-basins now known in the Indies are the Ombilin coal-field in Sumatra and the Eocene coal occurrence in the eastern part of the Zuider Residency "South and East Division of Borneo and surrounding Islands."

The Oligocene seems to occur but seldom in the Indies. Up to this time two areas of that age are known in Java, of which the one at Nanggoelan (Residency Djokjakarta) alone contains a small amount of rather poor coal.

On the other hand, the Neocene is of widespread occurrence, and contains important coal-beds. In nearly all the large islands of the archipelago, and probably in New Guinea also, coal is found in large quantities. Because of their large water content these coals are not suited for use as bunker-coal on shipboard and are therefore at present only used locally as fuel in the various growing industries of the Dutch Indies.

There is no reason to doubt that these deposits will with the progress of industrial enterprise gradually become of great value.

PROPERTIES OF THE COALS

The contemporary coals on the various islands have, more or less, the same general characteristics and may conveniently be treated together.

The Eocene coals, which in appearance greatly resemble hard pitch, are often called pitch coals. They are of a glistening black colour, are hard, have a conchoidal fracture and yield practically no dust. The specific gravity runs from 1.23 to 1.25. The average calorific value is 7,000 calories. Under a good draught they burn easily with a long white flame and make good steam coals. The Eocene coals of Borneo contain a large amount of ash, averaging 8%.

They generally contain very thin clay partings. These are hard to see in the fresh coal, but appear as bluish grey bands when the coals are exposed to the air.

The water content runs from 3% to 6% and the amount of resin about 2%; the streak is black to brownish black, but changes to a light yellow if the coal is boiled in a strong alkaline solution.

The younger Miocene coal exhibits woody and earthy textures; it flakes upon drying and falls to pieces. Boiling in an alkaline solution colours the coal brown to black.

The water content is greater in the younger coals.

Eocene coals contain, as was stated above, from 3% to 6% of moisture; Miocene 9% to 20%, and Pliocene more than 20%. In certain deposits the quality of the Miocene coals has been locally improved by contact metamorphism; this is the case, for instance, in the Lower Miocene coals in the neighbourhood of Boekit Soenoer, in Benkoelen, also in the Lematang coals in Palembang. They have been brought into contact with younger eruptive rocks, which break through them. This has lowered the original water content quite considerably and the calorific value has been raised. On an average, the calorific value of the Neocene coals runs from 4,000 to 5,000 calories; by the operation of metamorphism, however, it has been raised to from 7,000 to 8,000 calories.

For the chemical composition of the coals the reader is referred to the table at the end of this paper.

The following is a list of the most important coal deposits, arranged by islands and according to age. For the sake of completeness we have indicated upon the accompanying map all the localities where coal has been found, even those of lesser importance.

SUMATRA

Eocene Coals

1. A bowl-shaped basin more than 30 square km. in area is found on the Sepoetih river, south-west of Segalamidar in the Lampong districts of South Sumatra. The coal-bearing beds belonging to the Breccia stage of the Eocene lie directly upon granite and include two coal-seams, respectively 1.70 metres (.50 metres of which is shale) and .70 metres thick. This is the only known occurrence of coal in the lower stage of the Eocene in Netherlands-India.

2. In the Ombilin field, which lies in the division Tanah Datar, of the Residency "Padangsche Bovenlanden," the coals are somewhat younger. (See map in the Atlas). A comprehensive description of this field is given by the Government mining engineer, R. D. M. Verbeek, in Jbm. 1875, part II, under the heading "Het Ombilinkolenveld in the Padangsche Bovenlanden."

The area lies on both sides of the Ombilin river and extends for 10 km. in a north-south by 9 km. in an east-west direction. The Ombilin field can be separated into three divisions both from a topographic and geologic standpoint.

(*a*) The Parambahan division, named after the Soengei Parambahan which forms its southern boundary, contains from four to ten rather thin seams and three or four thicker ones. A few of the larger seams attain a thickness of 10 metres. This area covers 3 square km. and contains 40,000,000 tons of coal.

(*b*) The Sigaloet division is about 25.5 square km. in area and contains 118,000,000 tons of coal. It lies to the south of the Parambahan division and in it seven well defined seams occur, four of which have an aggregate thickness of 5 m. The coal-seams crop out in an east-west direction and dip 27° to 45° to the south at the surface. All the coal-seams crop out on Sigaloet mountain.

(*c*) The Soengei Doerian division lies to the south of the Ombilin river and is the most southerly of the three. It has an area of at least 16 sq. km. and contains about 144,000,000 tons of coal. This division may be divided into three parts:

1. The area west of the Loera Gedang.
2. The Soengei-Doerian field proper, which is the area upon which the Ombilin mines were opened.
3. The Soegar area.

After a thorough examination it was decided in 1892 to develop the central part of this field, and in succeeding years the following quantities of coal were produced:

1892	1,758 tons
1893	46,075 "
1894	72,452 "
1895	107,942 "
1896	126,284 "
1897	142,850 "
1898	149,433 "

1899	181,325 tons
1900	196,207 "
1901	198,074 "
1902	180,702 "
1903	201,292 "
1904	207,280 "
1905	221,416 "
1906	277,097 "
1907	300,999 "
1908	314,065 "
1909	339,694 "
1910	387,522 "
1911	406,508 "

Oligocene coals have not been found in Sumatra up to the present time.

Miocene Coals

Lower Miocene coals are found in the Ommelanden of Benkoelen around Boekit Soenoer. They contain 14 to 20% of water and have a high ash content. The beds are broken up in an irregular manner and are widespread in their occurrence. The thickness of the seams varies from 0.20 metres to 4.50 metres. In several localities the coals have been altered to cokes by an intrusion of basalt.

Other coal-seams, varying from 1 to 1.5 metres, occur within a distance of 60 kilometers, in the Lais and Benkoelen divisions of the Residency Benkoelen. The number of seams cannot be stated definitely; they occur in soft Miocene clay-shales and in loose clayey sandstones. The coals have a high content of ash and water.

Later Miocene and Pliocene coals have a wide distribution in Sumatra. The deposits are especially well developed in the eastern part of the island, in synclines in the petroleum areas, in the residencies of Palembang and Djambi. The Lematong coal-beds, referred to above, occur in the Residency Palembang, south of Moeara Enim; they have been locally improved in quality by the contact metamorphism of younger eruptives. The calorific value of the unaltered coal runs from 4,000 to 5,000 calories while that of the improved or altered coal varies from 7,000 to 8,000 calories.

JAVA

A—*Eocene Coals.* On the south coast of Bantam and west of Wijnkoops bay six Eocene areas are found, of which the Bajah field is the most important, owing to the occurrence in it of seams of workable size. A detailed examination of this field showed it to be much disturbed and strongly folded. Several coal-seams occur, two of which average one metre in thickness. Of much less extent is the area at Karang Tengah in Goenoeng Walat, to the west of Soekaboemi, where two coal-beds appear in the ridge of the mountain.

B—*Oligocene coals* are only found near Nanggoelan in the Residency Djokjakarta, where a coal-seam averaging one metre in thickness occurs over a small area; the coal is of poor quality.

C—*Miocene coals* occur at Sindangwangi, in Bantam, in a Lower Miocene area covering twenty square kilometres of surface. The thickness of the coal-seams varies from 0.35 to 0.5 m. The water content of the coals amounts to 17.68%.

Younger coal is found at Bodjong Manik in the same residency and in the division Lebak. Two seams were discovered by boring, the lower of which is two metres thick. Several coal-seams, running from 0.60 to 0.70 metre in thickness, are found at Sedan and Ngandang in the Residency Rembang.

BORNEO

Regarding West and Central Borneo too little is known to permit one to judge of their available coal supply. The region embracing the eastern and south-eastern part is better known, chiefly because of the explorations of Mr. Hooze, the Government mining engineer whose investigations have shown that this district contains vast quantities of coal.

A—*Eocene Coals.* At Selimbau, in the western division of Borneo, coal-seams occur with a thickness of from 0.6 to 0.9 metre.

In South and East Borneo Eocene coals occur, especially in the south-eastern part. There, in the division Martapoera, the coal-area between Riam Kiwa and the Java sea is the best known, both because of geological examinations which have been made there, and through actual mining operations. Coal is found in several hilly ridges over a distance of 45 km. The number of seams varies from six to eleven, of which from two to three and occasionally six seams are thick enough to mine.

A few small Eocene areas occur on the Borneo shore at Pamoekan bay and on the islands in Kloempang bay.

The Eocene area of South-eastern Borneo is apparently connected with the Eocene coal-area in the northern part of Poeloe Laut. The underground structure of this island has been ascertained by deep borings. In approximately 100 m. thickness of sandstones and shales, five coal-seams are found, of which the lowest is a bituminous shale rather than a coal. The others have thicknesses of 0.6–2.68–.50–2.18 metres and dip to the north-west. The Eocene at this place is underlain by diabase or serpentine.

The coal which is now mined at the Barito, about 2 kilometres north of Moeara Teweh is probably also of Eocene age. The thickness of the coal-seams in one part of these areas varies from 1.80 to 3 meters, in another section from .80 to 1.60 metres. Tests made upon these coals have shown that they resemble the Ombilin coals.

B—*Oligocene Coals.* No coals of Oligocene age are known in Borneo.

C—*Miocene Coals.* Along the lower course of the Koetei or Mahakkam river, coal-seams occur in a number of hilly ridges, on both sides of the stream, and between the delta of this river and the capital, Tengarong. From eight to fifteen workable seams, dipping from 30° to 40° to the east, contain an aggregate of 10 to 21 metres of coal.*

In the Berausche Landen, made up of the territories of Sambalioeng and Goenoeng Taboer, an enormous quantity of coal is found between the Segah and Kaleh rivers and also at Goenoeng Sawar, on the right bank of the latter river. Eleven workable seams, with more than 20 metres of coal, have been found there. In composition they correspond to the Lower Miocene coals of Koetei.†

Upper Miocene coals occur in Sint Lucia bay, Boeloengaan, the islands Tarakan and Sebetik, along the coast of Koetei, Pasir, the Tanah Boemboelanden and along the southern coast of Borneo. Some of these form important deposits.

Another area along the Berau river opposite Poeloe Sepingen, twenty miles downstream from the junction of the Segah and Kaleh rivers, is even richer in coal than the Miocene just mentioned and that at Goenoeng Sawar. These are the so-called Ridjang and Kaman coals, which contain 30% of water and which, when air dried, crumble to a granular mass. Twenty-one seams are found there, with about 31 metres of workable coal.‡

On the island of Celebes, Eocene and Miocene coals are found in several places in the mountain regencies of the division Maros, while Miocene coal deposits also occur in Middle Celebes. Further details regarding these deposits are lacking.

Occurrences of coal are also reported from New Guinea. The information needed for a more detailed description of these is, however, not at hand.

*For maps of this area the reader is referred to "Jbm. 1887. Technisch en Administratief, gedeelte I."

†Maps of this area are to be found in the "Jbm. 1886. Technisch en Administratief gedeelte."

‡For maps see "Jbm. 1886. Technisch en Administratief gedeelte."

COAL RESOURCES OF NETHERLANDS-INDIA

GROUP I

Including Seams of 1 Foot or Over, to a Depth of 4,000 Feet

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)		Probable Reserves (Approximate estimate)	Possible Reserve
	No.	Thickness in Metres	Area in Sq. Km.	Class of Coal	Metric Tons	
Sumatra						
1. Government Atjeh and dependencies—						
Peureula	....	....	....	....	....	Unknown
Tamiang	....	....	....	....	....	Unknown
2. Res. Tapanoeli—Nias	1	0.5	....	....	....	Small
3. Government West Coast of Sumatra—						
A. Res. Bovenlanden of Padang:						
(*a*) Ombilin field:						
(1) Parombohan	4	1.5–1–2–10	3	C	40,000,000	
(2) Sigaloet	3	2.3–1.2–1.5	25.5	C	110,000,000	
(3) Soengei Doerian	3	6–2–2	14	C	140,000,000	
(4) West of Loera Gedang	3	2–1.5–2	2	C	4,000,000	
(*b*) Kota Baroe	....	....	....	....	....	Unknown
B. Res. Benedenlanden of Padang—						
(*a*) Painan:						
Concession Boekit Poelai	1	0.60	....	....	....	Unknown
" Boekit Doerian	1	0.60	....	....	....	Unknown
b. Tapan	....	....	....	....	....	Unknown
4. Res. Benkoelen—Boekit Soenoer	3	0.20 to 4.5	1	C	3,000,000	
Division Lais	?	1 to 1.5	....	D_1 & D_2	....	Unknown
5. Res. Districts of Lampong—Segala Midar	2	1.20 & 0.70	....	C	....	Unknown
6. Res. Palembang—						
a. Division Benedenlanden of Palembang	....	....	....	D_1 & D_2	....	Very large
b. Division Bovenlanden of Palembang						
(1) Concession Behangan	1	4	0.1	D_1	400,000	
(2) Area south of Moearo Enim	....	2 to 10	....	D_1	....	Very large

COAL RESOURCES OF NETHERLANDS-INDIA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)		Probable Reserves (Approximate estimate)	Possible Reserve
	No.	Thickness in Metres	Area in Sq. Km.	Class of Coal	Metric Tons	
7. Res. Djambi—						
Division Djambi	....	....	....	D_1	....	Very large
Division Tembesi	....	....	....	D_1	....	Very large
Toengkal	....	....	....	D_1	....	Very large
Boengo Coal-field	....	....	....	D_1	....	Unknown
8. Indragiri—						
Concession Retch	....	....	....	D_1	....	Unknown
" Tjenoko	....	....	....	....	....	Unknown
" Tjerenti	....	....	....	....	....	Unknown
9. Res. East Coast of Sumatra—						
Goenoeng Sakilan	....	....	....	....	....	Unknown
Concession Loeboek Bendoro Arang Batoe Kwaloe	1	3	....	D_1	250,000	
Bohorok, Division Langkat	....	....	....	....	....	Unknown
Java						
1. Res. Bantam—Bajah	1	1	5	C	3,000,000	
Sindang Wangi	....	0.35–0.50	....	D_1	....	Unknown
Bodjong Manik	1	2	1.2	D_1	3,000,000	
2. Res. Batavia—Bolong	....	....	....	....	....	Small
3. Res. Pr. Regentschappen—Tanasari	....	....	....	C	....	Small
4. Res. Djokjacarta—Nanggoelan	1	1	1	D_1	1,000,000	
5. Res. Rembang—Sedan and Ngandang	1	0.7	1	D_1	700,000	

COAL RESOURCES OF NETHERLANDS-INDIA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

DISTRICT	COAL-SEAMS		ACTUAL RESERVE (Calculation based on actual thickness and extent)			PROBABLE RESERVES (Approximate estimate)		POSSIBLE RESERVE
	No.	Thickness in Metres	Area in Sq. Km.	Class of Coal	Metric Tons	Class of Coal	Metric Tons	
Borneo								
1. Res. West Borneo—								
Selimbau..........	....	....	....	......	....	......	....	Unknown
Sekadau...........	....	....	....	......	....	......	....	Unknown
2. Res. East Borneo—								
a. Division Martapoera:								
Goenoeng Lowak.....	....	....	....	......	....	......	....	Unknown
Pengaron...........	3	7.50	....	......	....	......	....	Very large
Concession Goenoeng Koepang I........	5	1.20-0.75-0.85-0.65–0.80	7.75	D_1	31,800,000			
Concession Goenoeng Koepang II.......	2	0.90–1.40	7.99	......	....	......	....	Unknown
Concession Goenoeng Koepang III......	2	0.80–1.10	5.03	......	....	......	....	Unknown
b. Tanah Boemboelanden Poeloe Laoet......	4	5.94	98		300,000,000			
Seboekoe...........	....	....	....	......	....	......	....	Unknown
Kloempangbaai......	....	....	....	C	....	......	....	Small
Pamoekanbaai	....	....	....	C	....	......	....	Small
c. Pasir-Adangbaai.......	....	....	....	......	....	......	....	Unknown
d. Koetei—								
Rauten-Batoe Panggal	9	11.50	70	D_1	300,000,000	D_2	300,000,000	
Pelarang............	8	10.30	4.5	D_1	46,000,000	D_2	10,000,000	
Perdjiwa di Koeloe....	4	6.50	20	C	40,000,000	C		
Goenoeng Damar.....	9	10.20	6	D_1	57,000,000	D_2	27,000,000	
Concession Mathilde..	....	....	....	D_1	....	......	....	Very large
" Louise	....	....	....	D_1	....	......	....	Very large
" Nonug	....	....	....	D_1	....	......	....	Very large
" Moeara......	1	3	....	D_1	....	......	....	Very large
" Poeloe Miang	....	....	....	D_1	....	......	....	Very large
" Moeara Pahoe	....	....	....	D_1	....	......	....	Unknown

COAL RESOURCES OF NETHERLANDS-INDIA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)		Probable Reserves (Approximate estimate)	Possible Reserve
	No.	Thickness in Metres	Area in Sq. Km.	Class of Coal	Metric Tons	
e. Doeson Landen—						
Batoe Poeti						Unknown
North of Moeara Teweh		0.80–3		C		Unknown
f. Berausche Landen Goenoeng Sawar	11	30.5		D_1		Very large
Near Poeloe Sepingan				D_1		Unknown
Concession Aanoragen				D_1		Very large
Parapattan				D_1		Very large
Mary				D_1		Very large
Rautan Pandjang				D_1		Very large
Progress				D_1		Very large
Florence				D_1		Very large
Inaran I				D_1		Very large
Inaran II				D_1		Very large
g. Tidoengsche Landen—						
Tarakan				D_1		Unknown
Sebetik				D_1		Unknown
Celebes						
Bergregentschappen				C & D		Unknown
Enrekang				D_1		Unknown
Moluccas						
Ceram						
Boela						Small
New Guinea						
Kararaboe				D_2		Unknown
Sègèt				D_2		Unknown
Sebjar						Unknown
Mamberamo				D_1		Unknown
Denambring				D_1		Unknown
Noord River						Unknown

COMPOSITION OF THE COALS OF NETHERLANDS-INDIA

Localities	C.	H.	O.+N.	O.	N.	S.	H_2O.	Ash	Coke	Calories
	%	%	%	%	%	%	%	%	%	
1. Ombilin, Sumatra	72.57	5.31	15.09	.....	.....	0.20	5.96	0.87	55.11	7,081
2. Retch, Indragiri, Sumatra	.....	.....	.....	.....	.....	4.48	11.75	4.03	50.00	
3. Palembang	.....	.....	.....	.....	.....	.....	13.82	0.54	45.26	5,600
4. Palembang (metamorphosed coal)	.....	.....	.....	.....	.....	.....	0.46	1.64	70.53	7,700
5. Bodjong Manik, Java	51.55	4.17	17.19	.....	.....	0.40	23.72	2.97	42.54	
6. Sedan, Ngandang, Java	.....	.....	.....	.....	.....	.....	11.00	2.75	55.27	
7. Pengaron, Borneo	66.03	5.35	.....	13.21	1.45	0.35	4.25	9.36		
8. Poeloe Laoet, Borneo (coal from Kota Baroe)	59.36	5.70	.....	.....	.....	0.61	5.79	16.70	66.06	
9. Poeloe Laoet, Borneo (coal from Djlapat)	65.03	5.73	.....	.....	.....	0.61	6.07	10.53	63.40	
10. Batoe Panggal, Kotei, Borneo	60.01	4.40	.....	17.19	1.73	1.70	10.40	4.00	52.90	
11. Pelarang, Kotei, Borneo	.....	.....	.....	.....	.....	0.50	14.40	1.60	55.40	
12. Goenoeng Damar, Kotei, Borneo.	.....	.....	.....	.....	.....	1.96	13.21	2.42	56.20	
13. Goenoeng Sawar, Kotei, Borneo	56.54	3.76	.....	18.05	2.07	0.32	17.76	1.51		
14. Kararaboe, New Guinea	.....	.....	.....	.....	.....	1.10	22.25	4.84	40.18	4,500
15. Denambring, New Guinea	.....	.....	.....	.....	.....	0.53	17.81	12.44	45.10	4,730

THE COAL RESOURCES OF THE PHILIPPINE ISLANDS

DATA COMPILED BY

F. A. DALBURG

Under the direction of Warren D. Smith, Chief, Div. of Mines

(*With four figures in the text*)

CONTENTS

INTRODUCTION

The coal resources of the Philippine Islands have only been investigated to a very limited extent. Coal has been reported from nearly every island in the archipelago and the most important fields have been visited and samples taken for analysis. Geological surveys and investigations have been made in several fields, but these, for the most part, have been of a preliminary nature, and, while they have yielded important facts regarding the occurrence and distribution of the coal deposits, they do not furnish the minute knowledge essential for quantitative determination.

This article is intended to present a concise report on the geologic occurrence of coal in the Philippines, the extent of the coal-areas, the amount, location and distribution of the reserves, so far as these are known, together with such chemical and physical qualities of the coals as are determinative of their technical utilization.

HISTORICAL SUMMARY

The first discoveries of coal date back to the year 1827, and were made on the island of Cebu. From that date to the present time locations may be said to have been continuous. Following the discovery in Cebu, after a lapse of

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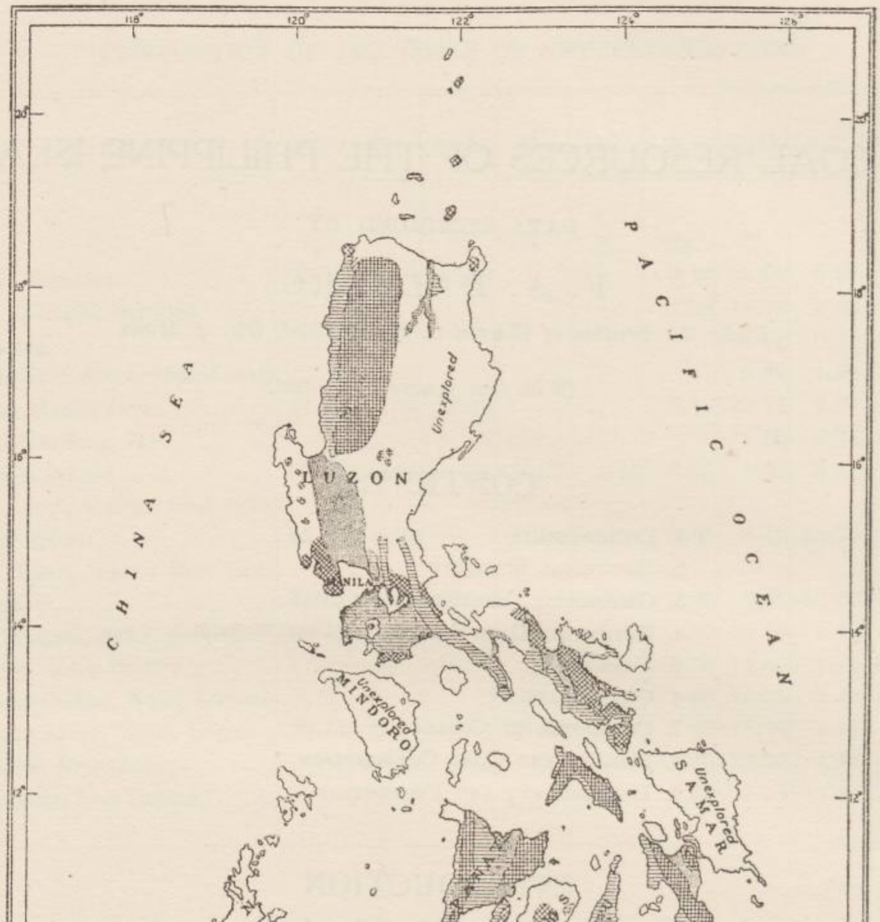


FIG. 1. GEOLOGICAL MAP OF THE PHILIPPINES

time during which no importance was placed on the coal resources of the archipelago, owing to the fact that there were no steamships visiting the islands, coal was reported from the island of Batan in 1842. These two localities, besides being the first in which coal was discovered, also play the most important part in the later history and development of the Coal-Measures in the Philippines.

Desultory mining development was carried on on the island of Cebu from 1853 to 1898, the most extensive work being done in the Uling, Danao, and Compostela districts. In 1875 to 1877 the deposits at Sugud, Albay Province, were worked to some extent, but were finally abandoned. From 1898 to the present time several fields have been exploited; but only two are at present being worked, on Batan Island and in Danao district, Cebu Island.

GEOLOGICAL OCCURRENCE OF COAL

The geological age and sequence of the several coal-bearing formations have not been very definitely determined. Detailed surveys have been made in two fields only, and the structure is so complex that the results are far from conclusive. It seems to be established, however, that all the coal-seams of commercial importance are of Tertiary age and, for the most part, belong to the Miocene. A very characteristic zone fossil, *Vicarya callosa*, Jenk, has been found in most of the formations in the roof of the coal-beds. Marine fossils, intermingled with plant remains, have been found to some extent.

The coal-fields are of small area, but are widely distributed. The coals generally grade from lignite to bituminous. Many of the beds are of considerable thickness, but as a rule are accompanied by irregularity in the geological structure to such an extent as to be unfavourable to mining conditions.

The coal-bearing rocks are made up of sandstones and shales, locally, with a large percentage of conglomerate. A coralline limestone lies in patches over the Coal-Measures and contains foraminifera and algæ which mark the Middle Miocene epoch.

Figure 1 shows the distribution of the geological formations in general.

The stratigraphic succession of formations in the Philippines, as determined provisionally by Dr. Warren D. Smith, Chief, Division of Mines, is given in Table I below:

TABLE I—PROVISIONAL TABLE OF PHILIPPINE STRATIGRAPHY

Period	Formation	Type Locality	Distribution	Economic Deposits	Characteristic Fossil
Recent.......	Piedmont deposits including fluviatile............	Cagayan Mindanao...........	Throughout the archipelago....	Bench placers	
	Solfataras........	Laguna Province.	....	Kaolin and sulphur	
	Talus............	....	Throughout the archipelago		
	Spring deposits...	Mountain Province..........	....	Gold, building sand	

TABLE I—PROVISIONAL TABLE OF PHILIPPINE STRATIGRAPHY—(*Continued*)

Period	Formation	Type Locality	Distribution	Economic Deposits	Characteristic Fossil
Recent	Coral reefs	Cebu	Along much of the Philippine coast line	Building stone and lime	
	Littoral deposits	Sangley Point	....	Sand	
	Volcanic tuff	Vicinity of Manila	Southern Luzon Ilocos Norte	"Guadalupe" stone for building.	Leaves, probably belong to *Euphorbiaceae*
	Basalt and andesite flows	Mount Arayat and Mount Apo			
Unconformity					
Pleistocene and Pliocene	Raised coral reefs.	Cebu, west coast.	Cebu, N.W. Luzon		
	Marls	Ilocos Norte	Samar, Agusan River	....	*Hindsia dijki* Mart
	Eruptives	Mount Mariveles.	Mindanao, Luzon, etc.		
Unconformity					
Miocene	Limestone, upper.	Cebu	....	Burned for lime, very pure	Shells very similar to recent forms; chiefly coral reefs
Unconformity	Andesite flows	Cebu	Cebu, Masbate, etc.	Gold, silver, manganese, lead	
Miocene	Limestone, middle	Cebu	Cebu, central Luzon, S.W. Luzon, north Mindanao, east Mindanao, Romblon	Romblon marble, Montalbon limestone	*Lepidocyclina insulæ-natalis* Chap; *Lithothamnium ramossimum* Reuss
	Sandstone	Batan Island	....	Oil in Tayabas and Cebu	*Cycloclypeus communis; Orbitolites,* etc.
	Shale	Batan Island	....	Coal deposits, Cebu, Batan, Polillo, Masbate, Mindanao, Luzon, etc.	*Arcas, Callianassa dijki* Mart; *Vicarya callosa* Jenk

TABLE I—PROVISIONAL TABLE OF PHILIPPINE STRATIGRAPHY—(*Continued*)

PERIOD	FORMATION	TYPE LOCALITY	DISTRIBUTION	ECONOMIC DEPOSITS	CHARACTERISTIC FOSSIL
Oligocene.....	Limestone, lower.	Cebu, Batan Island..........	....	....	*Nummulites niasi* Verb.
	Cherts...........	Ilocos Norte	....	....	Radiolorian tests.
Age uncertain, probably Tertiary....	Crystalline Schists, granite, gneiss.........	Camarines.......	Camarines, Ilocos Norte, Cebu, Zamboanga Peninsula, Romblon Island.....	Gold, mica, talc, apatite, hematite, magnetite.	
	Iron Formation..	Bulacan			
Unconformity (?)					
Pre-Tertiary..	Quartz porphyry.	Lepanto.........	Central and northern Luzon....	Copper ores	
	Diorites.........	Benguet.........	Northern Luzon, Leyte, Panay	Gold, tellurium, silver.	
	Gabbros.........	Leyte...........	Leyte, Mindanao, etc.		
	Pyroxenite.......	Ilocos Norte.....	Ilocos Norte, Zambales Mountains, Batan Island..........	Serpentine and asbestos	
	Peridotite........	Near Olongapo			

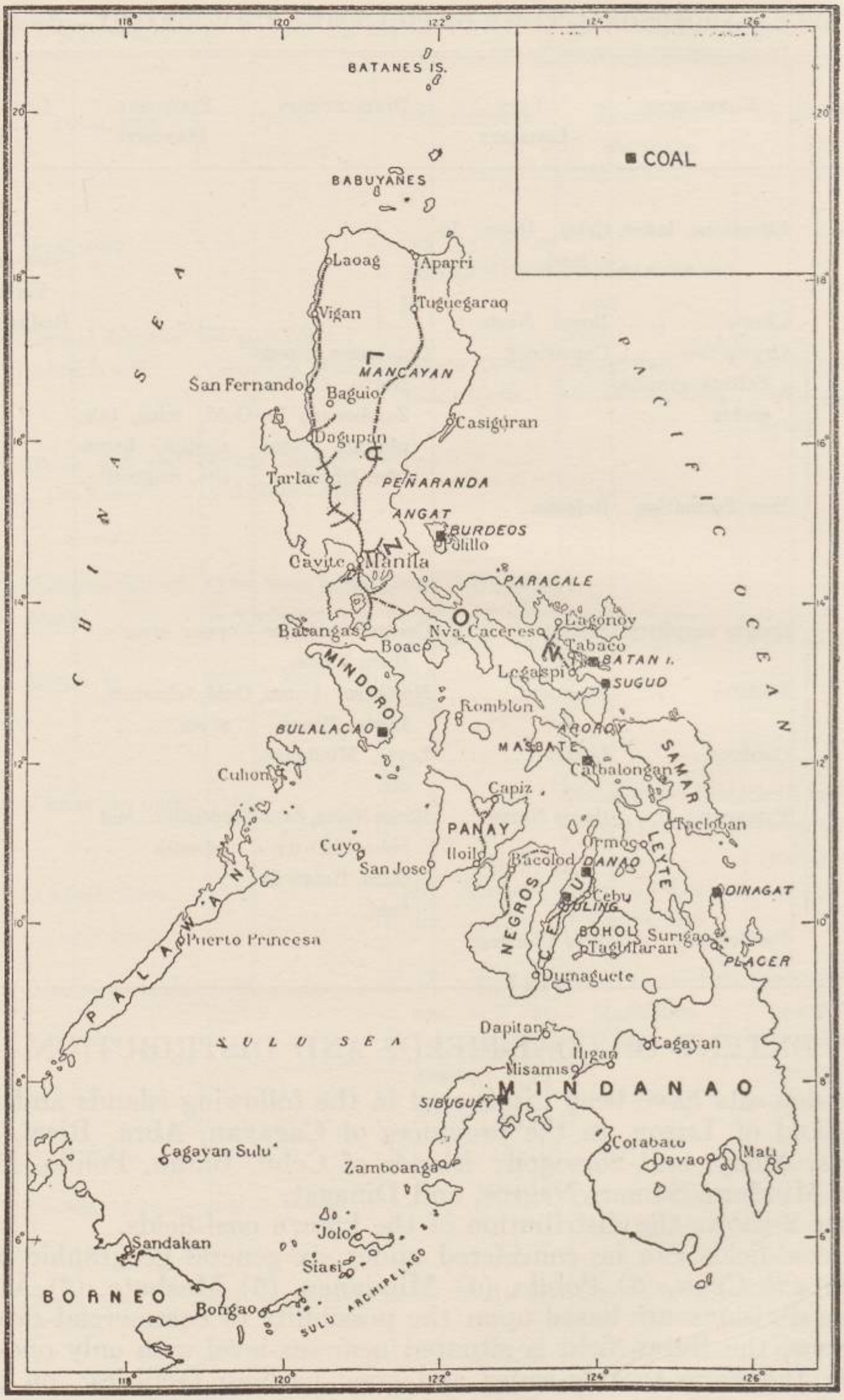
EXTENT OF COAL-FIELDS AND DISTRIBUTION

Coal deposits have been discovered in the following islands and localities: on the island of Luzon, in the provinces of Cagayan, Abra, Rizal, Tayabas, Camarines, Albay, and Sorsogon; islands of Cebu, Batan, Polillo, Mindanao, Masbate, Mindoro, Samar, Negros, and Dinagat.

Figure 2 shows the distribution of the known coal-fields.

The coal-fields can be considered under six general geographic provinces: (1) Batan, (2) Cebu, (3) Polillo, (4) Mindanao, (5) Masbate, (6) Mindoro.

These divisions are based upon the possibility of commercial exploitation. For instance, the Batan field is situated near sea-level with only one-half mile haul from the mine to tide-water and good harbour facilities; on the other hand, to bring coal from the Cebu field would necessitate the construction of a railroad from eight to fifteen miles long. Then, again, the Polillo coal, although of a good quality, is off the main travelled route of steamers and has



PHILIPPINE ISLANDS

FIG. 2. OUTLINE MAP SHOWING COAL DISTRICTS

a difficult harbour entrance. The remaining fields also have difficult transportation facilities.

As only a small portion of the several coal-fields has been surveyed geologically, it is evident that any estimate of the area serves only as a minimum area. The total known coal-fields contain an area of about 53 square miles. Future surveys will no doubt show that the coal area is much greater. An estimate covering the actually known coal lands—those which are known to be underlain by coal of a quality, thickness and depth that makes mining practicable, gives an area of less than 7 square miles.

In the above classification, only quality, quantity, and depth of coal are taken into consideration. It is evident that so far as development is concerned the accessibility of the coal and possibility of marketing it are just as important as the factors mentioned above.

Table II gives principal localities in the archipelago. The figures given in Table III show approximately the areas of the Philippine coal-fields.

TABLE II

Location of Principal Coal-Fields in the Philippines

District	Location	Province	Island
East Batan	Batan Island	Albay	
Liguan	Batan Island	Albay	
Calanaga	Batan Island	Albay	
Camujumayan (Lantauan)	Near Danao	Cebu	Cebu
Camansi	Near Danao	Cebu	Cebu
Mt. Licos	Near Compostela	Cebu	Cebu
Uling	Near Naga	Cebu	Cebu
Burdeus	Polillo Island	Tayabas	
Alat River	Sibuguey Bay	Moro	Mindanao
Nabangig	Cataingan	Sorsogon	Masbate
Dimas Alang	Cataingan	Sorsogon	Masbate
Cawacat River	Bulalacao	Mindoro	Mindoro
Gatbo	Sugud Bay	Sorsogon	Luzon

TONNAGE

Any estimate of the coal resources expressed in tonnage, will necessarily indicate the minimum quantity and cannot show the ultimate coal resources of the archipelago. Even where surveys have been made, a large factor of uncertainty still exists, as the coal-seams dip at all angles up to 90° and the seams are folded and faulted. Numerous seams have been known to thin out and disappear, and there is great lack of knowledge regarding the sequence of the strata. The areas used in making the estimates are small and may possibly be greatly extended in the light of subsequent information.

TABLE III

Estimate of Areas and Tonnage, Philippine Coal-Fields

	Class of Coal	Coal Seams		Tonnage			Coal Lands (areas actually containing marketable coal)	Coal Lands (areas possibly containing coal)	Coal-Fields (areas possibly containing coal)
		No.	Thickness	Actual	Probable	Possible			
East Batan	Lignite (black) D_2	2	5′—3½′	3,340,000	20,096,000	Moderate	¾ sq. mile	2 sq. miles	6 sq. miles
Liguan	Subbituminous D_1	8	Aggregate 35′	61,600	216,000	Small	1/80 sq. mile	¼ sq. mile	2 sq. miles
Calanaga	Lignite (black) D_2	4	Aggregate 16′		2,560,000	Moderate		½ sq. mile	5 sq. miles
Camujumayan	Subbituminous D_1	4	Aggregate 29′		14,592,000	Small		1 sq. mile	2 sq. miles
Camansi	Subbituminous D_1	4	Aggregate 16′		4,505,600	Small		½ sq. mile	6 sq. miles
Mt. Licos	Subbituminous D_1	4	Aggregate 15′		5,352,000	Small		½ sq. mile	9 sq. miles
Uling	Subbituminous D_1	3	Aggregate 26′	800,000	4,992,000	Small	1/80 sq. mile	½ sq. mile	5 sq. miles
Burdeus	Bituminous D_1	2	6′—3½′		1,331,200	Small		1/10 sq. mile	7 sq. miles
Cataingan	Subbituminous D_1	3	4′—3′—3′		612,000	Small		1/20 sq. mile	2 sq. miles
Sibuguey	Bituminous D_1	2	5′—8′		3,628,000	Small		¼ sq. mile	2 sq. miles
Bulalacao	Lignite (black) D_2	6	Aggregate 40′		4,096,000	Small		1/10 sq. mile	3 sq. miles
Sugud	Subbituminous D_1	3	Aggregate 17′	154,000			1/120 sq. mile	2 sq. miles	4 sq. miles

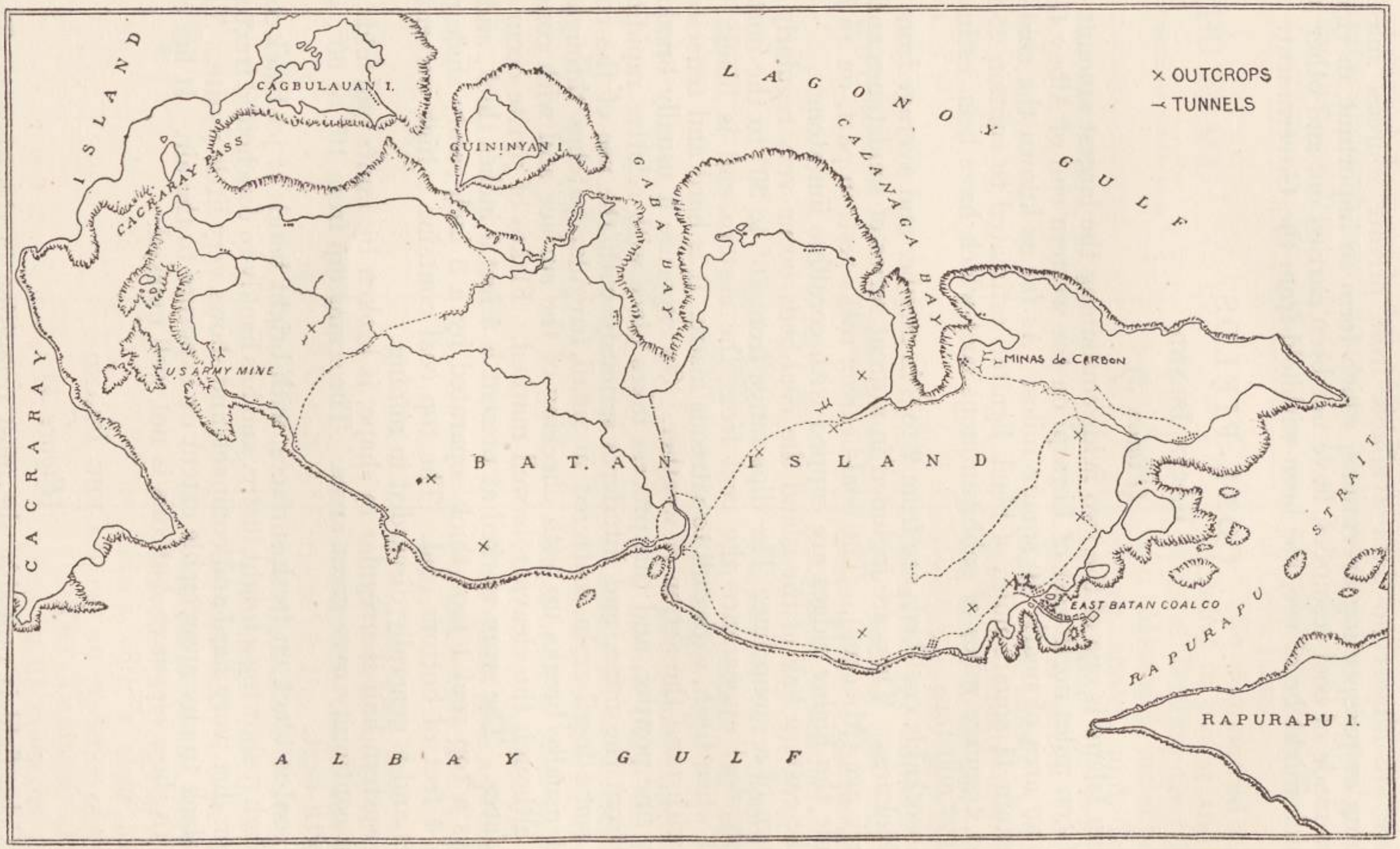


FIG. 3. MAP OF BATAN ISLAND

There are almost no data available from private sources, since extensive mining or prospecting operations, which form so important an element in estimates made of coal resources, have not been carried on, and other information, which might be of use, has been withheld from the Government.

COAL-FIELDS

Batan Island

(*Figure 3*)

Batan Island is one of the two fields containing the largest amount of coal. It lies fifteen miles north-east of Legaspi on the western end of Albay Gulf and contains an area of nearly 40 square miles. As far as known the coal-bearing areas contain 11 square miles of black lignite; estimated to contain 25,996,000 tons, and 2 square miles of subbituminous coal which have been estimated to contain 277,600 tons.

The workable coal-beds are from 2 to 8 in number and average from 3 to 12 feet in thickness. They are included in a great series of sandstones and shales of Tertiary age (Miocene). The coal-bearing rocks rest, in part, on an igneous base, while the higher ridges are capped with coralline limestone.

In the eastern half of the island the coal-beds occur very regularly and lie in the form of a monocline. The dips range from 10° to 30° to the northward.

In physical appearance the coal from the eastern end is black, usually glassy jet when fresh, with dull to vitreous lustre. It is hard and tenacious, but will not withstand the action of weather. On exposure it usually breaks down to a very fine powder, and this process takes place with relative rapidity after removal from the mine, and interferes seriously with the use of the coal. It contains some fossil resin scattered in small, irregular patches throughout its mass. It usually breaks up with checking of the surface and with conchoidal fracture, although the cleavage is well marked. Flakes of pyrite occur on the cleavage faces. The seam worked at present is 5 feet 3 inches thick, and in section shows a top coal 1 foot thick separated by a 3 inch sandy shale parting from the 4 feet of bottom coal. The top coal contains a high percentage of impurities and is generally discarded in mining.

The western half is irregular in shape, is broken by faults and folds, and is lacking in continuity over great areas. The seams dip from 10° to 60°, slightly to the north-west.

The coal is black on fresh surfaces, with bright bands of jet-black coal running through it showing a bright lustre, and has hackly to conchoidal fracture. It is free from dirt, very hard and compact, and shows very little pyrite. The coal does not slack to any appreciable extent on exposure to the air. It has a slight tendency to show cleavage, but this is not well marked.

Cebu Island

(*Figure 4*)

The Cebu field is probably the most promising in the islands. The field is situated on the eastern side of the Cordillera, which traverses the central portion of Cebu. It extends from Mt. Lantauan on the north to Mt. Alpaco on the south, and embraces an area of coal-bearing rocks of nearly 80 square miles. The distance from tide-water is from 8 to 15 miles. Fig. 4 shows the distribution of the Tertiary areas of Cebu Island.

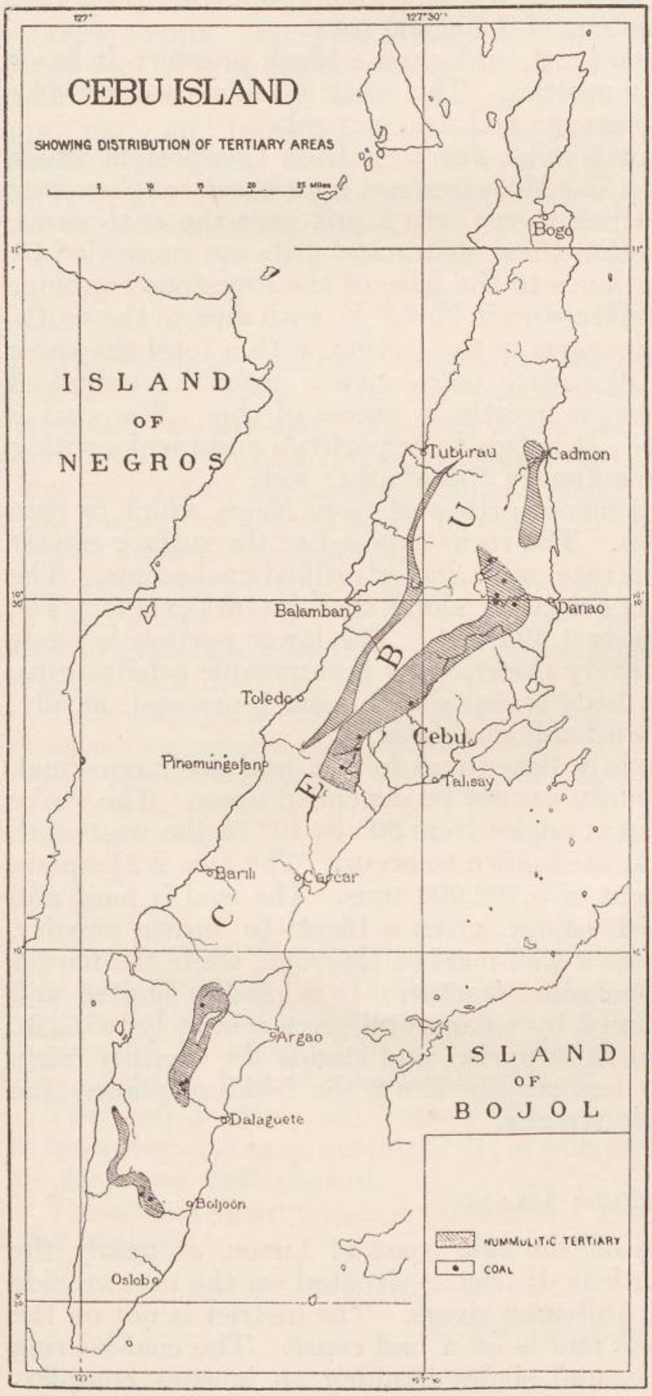


Fig. 4

The commercial coals are included in folded and faulted rocks of Tertiary age (Oligocene and Miocene) including sandstones, shales, and, locally, a large amount of conglomerate, the whole series being over 2,000 feet thick. Coal-bearing rocks are widely distributed in the Cebu field and very little correlation has been undertaken between the different fields. The coals of this field are sub-bituminous. The largest areas and those which have been most extensively prospected and worked are: (1) Camujumayan, (2) Camansi, (3) Mt. Licos, (4) Uling.

The Camujumayan district is a narrow basin with a strike of nearly N. 45° E., and 35° dip. Its area is estimated at 3 square miles with a total thickness of 29 feet of coal in the section. This would give a probable coal content for the area of 14,592,000 tons.

The coal has a brilliant black colour on fresh fracture; it is usually quite hard in portions of the seam and gives a brownish black powder. It has a rather dull, vitreous lustre with fine coatings of iron pyrite on some surfaces and shows blocky cleavage but irregular cleats. It burns with a clear flame and shows no evidence of coking.

The Camansi district is situated six miles due west from Danao. The region is very hilly and presents a sharp relief. The rocks are shales, sandstone, and limestone, touching an igneous formation to the west. The field is monoclinal with some minor folds. Several faults were encountered in earlier exploration work. The coal-seams are four in number and have an aggregate thickness of 16 feet. The total coal-area available is not over $6\frac{1}{2}$ square miles with a content of 4,505,600 tons.

The coal is black, very firm and hard, and gives a black powder; it has a brilliant lustre and is free from impurities. This coal is comparatively free from partings. It has no regular cleavage and does not coke.

The Mt. Licos district is about 6 miles due west from Compostela which is situated on the sea coast. The Coal-Measures rest on a basal conglomerate and are composed of gray shales which merge into a grit near the coal-seams. Higher, stratigraphically, in the section these shales and grits are succeeded by a coarse gray sandstone, which continues to the base of the limestone capping.

The general strike of the Coal-Measures is N. 25° E. with dips to the south-east from 30° to 90°. There are four seams in the section, with a total thickness of 16 feet. The probable area is $9\frac{1}{2}$ square miles with a probable content of 5,352,000 tons, and the possible area is greatly in excess of this The coal is black and compact with dull lustre. It is free from partings and breaks with a conchoidal fracture. It resists the action of the weather well.

The Uling district is situated 8 miles north-west from Naga, which in turn is 12 miles south of the city of Cebu. The rocks exposed at the surface consist of shales, sandstones, and conglomerate, with interstratified coal-seams. The beds change in thickness as well as character along their lateral extent. The thickness of the whole series is nearly 1,500 feet. The lower portion is made up of a massive bluish shale cut in every direction by innumerable calcite veins. The upper portion consists of thin beds of red shales, sandstones and, locally, a conglomerate, and contains the workable coal-beds.

The coal-bearing rocks are slightly flexed and folded, and are monoclinal. The conditions are such that continuity cannot be depended upon. The strike is nearly N. 15° E. and the beds dip at angles from 30° to 40° to the westward. Three seams, from 2 to 15 feet thick, are known to occur. The area is $5\frac{1}{2}$ square miles, and has a possible coal content of 5,792,000 tons. The coal is hard and strong, with a jet-black to brownish colour, gives a black to brown powder, and shows a dull lustre. It possesses a well-marked cleavage, while the harder and blacker coal breaks with a conchoidal fracture; it is readily ignited and burns with a yellow flame accompanied by coking and gives a light brown ash. It contains very few impurities and little pyrite, and stands the weather fairly well. The coal separates more or less readily along the bedding planes, the surfaces of which exhibit small shale streaks.

Polillo Island

Polillo Island lies fifteen miles off the east coast of Luzon, at nearly the same latitude as Manila. The Burdeus district is situated on the eastern side of the island between Burdeus and Anibauan rivers. The district is not on the route of any regular line of steamers and is on a bad coast. The coal-bearing rocks are conglomerates, sandstone, and shales flanking an igneous complex, and are of Tertiary age. The strata are somewhat folded owing to the effect of an east-west, lateral thrust. There is one well-marked anticline and syncline, with two monoclines. The general strike is N. 20° W, with local variations.

The best outcrops have been found on Guinibauan creek, and vary in thickness from a few inches to 7 feet. So far as known, only 2 seams occur within workable depth. The area is estimated at 7 square miles with a thickness of 9½ feet of coal. The probable content is 1,331,200 tons of bituminous coal. The coal is hard and firm in the lower portion of the seam; of shiny black colour in the upper part, and brownish black in the lower part, with shiny angular particles cemented in a coal matrix. It has a bright to dull lustre and gives a black powder. No well-defined cleats appear, but it shows "slickensides" or shearing. It does not coke nor air slack.

Mindanao Island

The Sibuguey district is north-east of Zamboanga about 90 miles and 12 miles from tide-water. The coal-seams occur in shales, sandstones, and agglomerates of Tertiary age. The axis of the field is apparently parallel to the main cleats, N. 18° W., and the dip of the coal is S. 20° W. There are two seams, 5 feet and 8 feet thick, of bituminous coal. The coal is of black colour with bright lustre and gives a black powder. It is very firm and does not air slack. It forms a hard, coherent coke.

A coal from Dumanquilas bay shows an analysis of 48 per cent. fixed carbon, but the outcrop is only 1½ feet thick and the only one known, as yet. Subsequent information may show a greater extension in this district. Exploration work has been limited.

It is impossible to make an exact estimate of the total amount of coal, but assuming an area of 2 square miles with one-quarter square mile underlain by coal, the content would be 3,628,000 tons; the possible area is great.

Masbate

This field is situated in the south-eastern part of Masbate, nearly nine miles distant from Cataingan bay. The rocks consist of a series of shales and sandstones, and are of Tertiary age (Upper Oligocene or Miocene). The rocks are flexed and folded into anticlines and synclines with a N.W. strike and dip from 45° to almost 90°. Three distinct seams occur, having a thickness of from 3 to 4½ feet of subbituminous coal.

The coal is black and gives a black powder, shows a satiny lustre and is free from clay and sand partings. It is firm and hard, and shows no air slacking. The cleats are well marked.

The area is about 2 square miles and is estimated to have a probable content of 612,000 tons.

Mindoro Island

The Bulalacao district is situated in the southern part of the island of Mindoro, six miles from tide-water. The rocks are composed of shales, sandstones, and conglomerates. The strike is north-east-south-west, with dips from 20° to 40° to the east.

Six seams are reported from 3 to 12 feet thick, covering an area of nearly 3 square miles. The coal is a lignite and the content of the field is 4,096,000 tons. It is brownish black with a dull lustre, not very hard and brittle and does not withstand weathering. Cleats are fairly well defined and the coal breaks with conchoidal fracture.

Sugud

Sugud district (Gatbo) is situated in the south-eastern part of Luzon Island on Sugud bay. The rocks are composed of shales, sandstones, and conglomerates of Tertiary age. The coal-seams are nearly vertical, with a N. 20° W., S. 20° E. strike. The seams are from 10 to 27 feet thick.

The coal is firm and hard, black in colour, and gives a brownish black powder, generally with a dull lustre. The cleavage is fairly well-defined on one face, and the coal breaks into large lumps, with conchoidal fracture. It burns with a long white flame and gives a white ash without coking; contains very little sulphur; shows a slickensided appearance in some parts of the seam and does not slack on exposure to air.

The area is approximately 6 square miles of coal-bearing rocks, but the seams are nearly vertical and broken. The coal content is estimated at 154,000 tons of coal.

Tonnage Estimates

	Metric Tons
Bituminous:	
Burdeus	1,331,200
Sibuguey	3,628,000
Subbituminous:	
Liguan	277,600
Camujumayan	14,592,000
Camansi	4,505,600
Mt. Licos	5,352,000
Uling	5,792,000
Sugud	154,000
Masbate	612,000
Lignite (Black):	
East Batan	23,436,000
Calanaga	2,560,000
Bulalacao	4,096,000
	66,336,400

Summary

Bituminous	4,959,200
Subbituminous	31,285,200
Lignite (Black)	30,092,000
	66,336,400

CHARACTER OF COALS

The coal-fields of the Philippine Islands contain lignite, subbituminous, and bituminous coals. This classification is based, primarily, on their difference in physical character with regard to the colour, manner of weathering, and adaptability to a particular use. The lignite coal is generally black and very seldom shows a woody appearance or brown colour.

The coals that slack or crumble on exposure to the air break with an irregular fracture which, as a rule, does not conform to the bedding planes or cleats.

The lignites are found where the rocks are little disturbed and at a distance from the lines of uplift. The subbituminous and bituminous coals occur near the bases of the mountains, or where the lateral disturbance and pressure which folded the formations have made great changes in the character of the coal. All the coals so far as known are non-coking, although a few samples have shown an incipient to semi-coking tendency.

The coal will generally stow about 48 cubic feet to the ton. It is friable, and a large percentage is small or broken. Unless carefully fired, a portion only is consumed, and the rest goes away with the ashes. In some cases the ashes may be fired twice, and still contain a considerable amount of combustible matter. The coal is very gaseous and it is almost impossible to insure complete combustion in an ordinary type of boiler furnace. Firing lightly and almost continuously insures the best results, and it is important that the grate bars should be properly spaced—not over three-quarters of an inch apart.

Recent tests in a German gas producer have shown the coal to be suitable for this purpose.

Considerable difficulty is experienced in storing the lignite coals owing to the danger of spontaneous combustion.

The fuel value of the best Philippine coals is from two-thirds to three-fourths that of the best Cardiff coals, is very little short of that of Australian coals, and equal to that of many of the Borneo and Japanese coals.

The subjoined table gives the analyses of representative Philippine coals. These analyses were made by the "smoking off" method, by which the coal is subjected to a low heat so as to expel the volatile matter with a very small flame, and finally heated for seven minutes over a Bunsen burner.

The sampling was done according to the U.S.G.S. method. The results are given on an air-dried basis, at temperature of laboratory (30°C.).

ANALYSES OF PHILIPPINE COALS *

Source		East Batan	Liguan	Calanaga	Camujumayan	Camansi	Mt. Licos	Uling	Bulalacao	Sibuguey	Cataingan	Polillo
Air-Dried Basis												
Proximate Analysis.	Moisture......	18.32	5.81	13.28	12.49	7.49	8.10	14.90	17.57	5.32	4.87	3.76
	Volatile Matter	36.53	39.39	39.10	41.63	44.18	40.73	38.63	42.43	46.17	46.50	43.58
	Fixed Carbon.	36.60	49.71	39.13	42.41	43.90	48.21	41.91	31.49	46.65	44.18	48.60
	Ash..........	8.55	5.09	8.49	3.47	4.43	2.96	4.56	8.51	1.86	4.45	4.06
	Sulphur.......	1.02	0.12	1.93	0.65	2.40	0.42	0.35	2.54	0.43	......	0.32
Ultimate Analysis.	Hydrogen.....	5.32	5.08	......	......	5.11	5.72	......	5.87	5.44	......	5.54
	Carbon.......	51.55	68.14	......	......	66.18	66.46	......	52.60	70.20	......	70.47
	Nitrogen......	0.92	1.11	......	1.64	1.72	2.10	......	0.96	1.73	......	1.59
	Oxygen.......	32.64	20.56	......	......	20.16	22.34	......	29.52	20.34	......	18.02
Calorific value determined.	Calories......	4,618	6,358	5,221	5,761	6,249	6,424	......	4,959	6,751	......	6,775
	B.T.U........	8,312	11,444	9,398	10,370	11,284	11,563	......	8,926	12,152	......	12,195
Calorific value computed from U.H.	Calories......	4,603	6,386	5,266	......	6,294	6,389	......	5,058	6,681	......	6,840
	B.T.U........	8,285	11,495	9,479	......	11,329	11,500	......	9,104	12,026	......	12,312

* Analyses from General, Inorganic and Physical Chemistry Laboratory, Bureau of Science, Philippines.

MARKET AND COAL CONSUMPTION

The possible market for Philippine coal is within the islands. Over 500,000 tons are used annually by the inter-island steamers, railroads, Unites States Army and Navy, and by industrial plants. Most of the coal used at present is imported from Japan and Australia.

The prices which coal commands in the islands vary from $4.50 to $7.00 per ton. Coal in Australia is mined for $0.98 at the mine, and these mines are situated close to tide-water and can deliver coal on board ship at $1.78 to $2.67 per ton, while in Japan coal is sold at the ship for $2.60 to $4.80 per ton.

DEVELOPMENT AND PRODUCTION

Although coal has been known to exist in the islands for more than eighty years the amount of actual mining has been insignificant. The total production since 1906 is shown in the following table. Some coal was mined during the Spanish régime but was mostly for tests, or for use on small vessels.

Production of Coal in Philippines, 1842-1911

Year	*Metric Tons*	*Value*
1852-1906	30,000*	$45,000
1907	4,123	26,800
1908	10,035	77,166
1909	30,336	197,184
1910	27,969	209,738
1911	32,000*	208,000

* Estimated.

Since the American occupation, extensive developments have been made on the Island of Batan. The United States Army explored the western part and mined some coal. The seams were folded and faulted, and since January, 1910, no work has been done. The most extensive developments have been made on the eastern end of Batan Island by the East Batan Coal Co. The seam is very regular and practically all the coal mined now comes from this mine. The average output is 100 tons per day.

THE ANTARCTIC COAL-FIELDS

BY

T. W. EDGEWORTH DAVID

Professor of Geology, University of Sydney

THE coal-fields of the Ross Quadrant (or Australian Sector) of Antarctica are of great, but as yet unknown, extent, and probably reach from the South Pole to fully 73° S. latitude = 17° of latitude. The strata of the coal-fields have been proved to be actually coal-bearing at two localities, viz.: Mount Buckley, at the head of the Beardmore glacier in latitude 85° 5′ S., longititude 164° E., and at the Mackay glacier, a short distance inland from Granite Harbour, on the west side of Ross Sea, in latitude 75° S., longitude 162° E., a distance of 605 geographical miles.

The series of sandstones, shales and thin limestones to which the coal-seams belong, have been termed by Mr. H. T. Ferrar, geologist to Captain R. F. Scott's expedition in the *Discovery*, the Beacon Sandstone. Beacon Sandstone caps Mount Nansen, 8,000 feet above sea-level, near latitude 74° 30′ S., and it is fairly evident from the photographs of Roald Amundsen that similar sandstones cap Mount Fritjof Nansen, perhaps 15,000 feet high, near latitude 86° S., and somewhere near longitude 160° W. It may safely be assumed that this Beacon Sandstone formation extends from latitude 86° S., at least, probably as far as latitude 74°., i.e., 12° or 720 geographical miles.

The structure of this coal-field is that of an immense long and narrow "horst," with a nearly S.E. to N.W. trend near the South Pole, and swinging into a more meridional trend to the north of the Beardmore glacier.

This "horst" is bounded eastwards by faults having an aggregate throw of many thousand feet (perhaps 6,000–7,000) and westwards by faults with smaller throws, aggregating perhaps about 2,000 feet. Its width varies from fifty miles to one hundred miles. For considerable areas the Beacon Sandstone has been removed from the "horst" by erosion. Even if it be assumed that three-quarters of the portion of the coal-bearing strata on this "horst" have been denuded, there would remain at least 12,000 square miles probably coal-bearing. There would also probably be a far vaster area in the down-faulted block to the west of the great "horst" (the "Antarctic Andes" of Roald Amundsen).

One can but hazard an opinion as to the area of concealed coal-field under the vast area of inland plateau west of the "horst." It might reasonably be assumed that the coal-field there, added to what survives on the "horst," would have an area of not less than 100,000 square miles. The rough section of the measures obtained by Frank Wild, of the Shackleton expedition in December, 1908, is as follows, in descending order:

500 feet sandstone.
300 feet sandstone, with bands of shale alternating with laminæ of bright coal and with occasional coal-seams, occurring in approximately the following order:
1 foot to $1\frac{1}{2}$ foot coal-seam.
strata.
7 foot coal-seam with gray shale bands.
strata.
5 foot coal-seam, apparently clean coal.
strata.
3 foot (about) coal-seam.
strata.
3 foot (about) coal-seam.
strata.
3 foot (about) coal-seam.
700 feet sandstone, with, in places, water-worn quartz-pebbles.

1,500 feet—total.

A small sample of coal, apparently from the lowest seam, obtained by Mr. Wild was analyzed in Sydney by Mr. J. C. H. Mingaze, F.G.S., with the following result:

Hygroscopic moisture	3.16%
Volatile hydrocarbons	14.57
Fixed carbon	68.84
Ash	13.43
	100.00

Although a little high in ash the coal is evidently of economic value.

No true coke was formed. The sulphur in the coal was 0.274%.

If about 15 feet in thickness of the coal be exploitable, this coal-field would contain a gross quantity of about 20,000 tons per acre. So that the supply of coal in this untouched field may be very vast. It must, however, be distinctly understood that, so far, it is not certain whether a single one of the seams is really workable.

Captain Scott's expedition when it returns in 1913 should throw important light on this matter.

As regards geological age, the Shackleton expedition found some wood, probably pine wood, in the Beacon Sandstone. What appears to be resin cells have recently been detected at the university here in this fossil wood.

Mr. T. Griffith Taylor, B.S., B.Sc., B.A., senior geologist of the Scott expedition, discovered plates of a large crustacean (?) in the Beacon Sandstone at Granite Harbour.

The age of the Coal-Measures, in my opinion, is probably Upper Gondwana (Permian).

ASIA

THE COAL RESOURCES OF CHINA

BY

NOAH FIELDS DRAKE

Professor of Geology and Mining, University of Arkansas

(*With a map and four figures in the text*)

WITH our present knowledge of the coal-fields of China, it is impossible to make an accurate quantitative estimate of the coal resources. However, the amount of coal in a few of the smaller fields is well known, and we have an approximate knowledge of the coal in the most important of the larger fields; so an estimate will, at least, be accurate in some details and give a fair idea of the resources as a whole. In the estimates offered an attempt has been made to be conservative and present the data upon which the estimates have been based.

Coal is widely distributed over China. It is found to some extent in every province, and is abundant in most of them; the provinces of Kiangsu, Anhui, Chekiang and Hupei have very little coal. The map on page 131 shows the distribution of the coal-bearing areas over China proper. Two of these areas are very large, the one in the northern part of China overlies most of southern Shansi and adjacent parts of Chihli and Honan, while the large area in the south extends from south central Kiangsi over southern Hunan, central Kueichou, central and southern Szechuan, eastern Yunnan, and western Kuangsi. While the larger part of the coal of China lies within these two areas, many small fields of great importance lie outside of them.

The extent of the coal-fields as shown in these areas, is not to be taken as strictly accurate; some barren areas are doubtless included in the parts mapped as coal-bearing, and some coal-bearing areas on the borders of China are not shown, as well as many small coal-fields in the interior. On the whole, the areas as mapped, somewhat exaggerate the continuity and extent of the coal-fields, but since they represent the better known coal-fields and since many small coal-fields exist that are not shown on the map, the areas shown may be taken to fairly well represent the actual acreage of the coal-fields in China.

The coal and its associated beds naturally vary much over such an extensive country, but there are a few remarkably uniform characteristics. The most marked uniform feature is the floor, or beds, over which the lowest coal-beds were deposited. This floor consists of limestones varying in thickness from a few hundred feet to about three thousand feet and is usually about two thousand feet in thickness. The limestone is known to extend from southern Kuang-tung to northern Chihli, a distance of about 1,500 miles, and from eastern Chekiang to western Szechuan, a distance of 1,300 or 1,400 miles. It is known as Sinian and according to Willis* belongs to the Ordovician.

Deposited in apparent conformity on the eroded surface of the Sinian limestones are beds of shales, sandstones, conglomerates and coal. In the lower coal-beds and associated carbonaceous clay-shale, there is also a marked uniformity, or at least a similarity, over a large area of China. The lowest coal-bed usually lies from one to three hundred feet above the Sinian limestone, the intervening strata being usually carbonaceous clay-shale with some sandstone and conglomerate. In places, thin limestone beds are interstratified with the shale, coal, sandstone and conglomerates that lie immediately above the Sinian limestone. It appears that the earth-crust movements that took place from near the close of the Carboniferous to near the close of the Jurassic period were oscillatory, with slight gains in elevation, and the final culmination of these movements resulted in producing land areas during Jurassic and Triassic times. Another subsidence took place during Tertiary times, when most, if not all, of China was again under water. During Tertiary times oscillatory movements also took place and coal-beds were deposited, especially over Manchuria, Mongolia, and the north part of Chihli. The coal occurs in every period, with the possible exception of the Cretaceous, from the Pennsylvanian to the Tertiary, inclusive, but it is found most abundantly in beds that may be termed Permo-Carboniferous. The fossils, especially plant remains, that are found associated with the lowest coal-beds, present such a mingling of Pennsylvanian and Permian forms that it is difficult to separate them, and there is a tendency now to call these beds Permo-Carboniferous.

In variety, the coal ranges from hard, dry anthracites to lignites with woody structure. There are extensive deposits of each kind. The following discussion is mainly confined to coal-fields of the eighteen provinces of China proper, though a few references to coal in Mongolia are made.

MONGOLIA

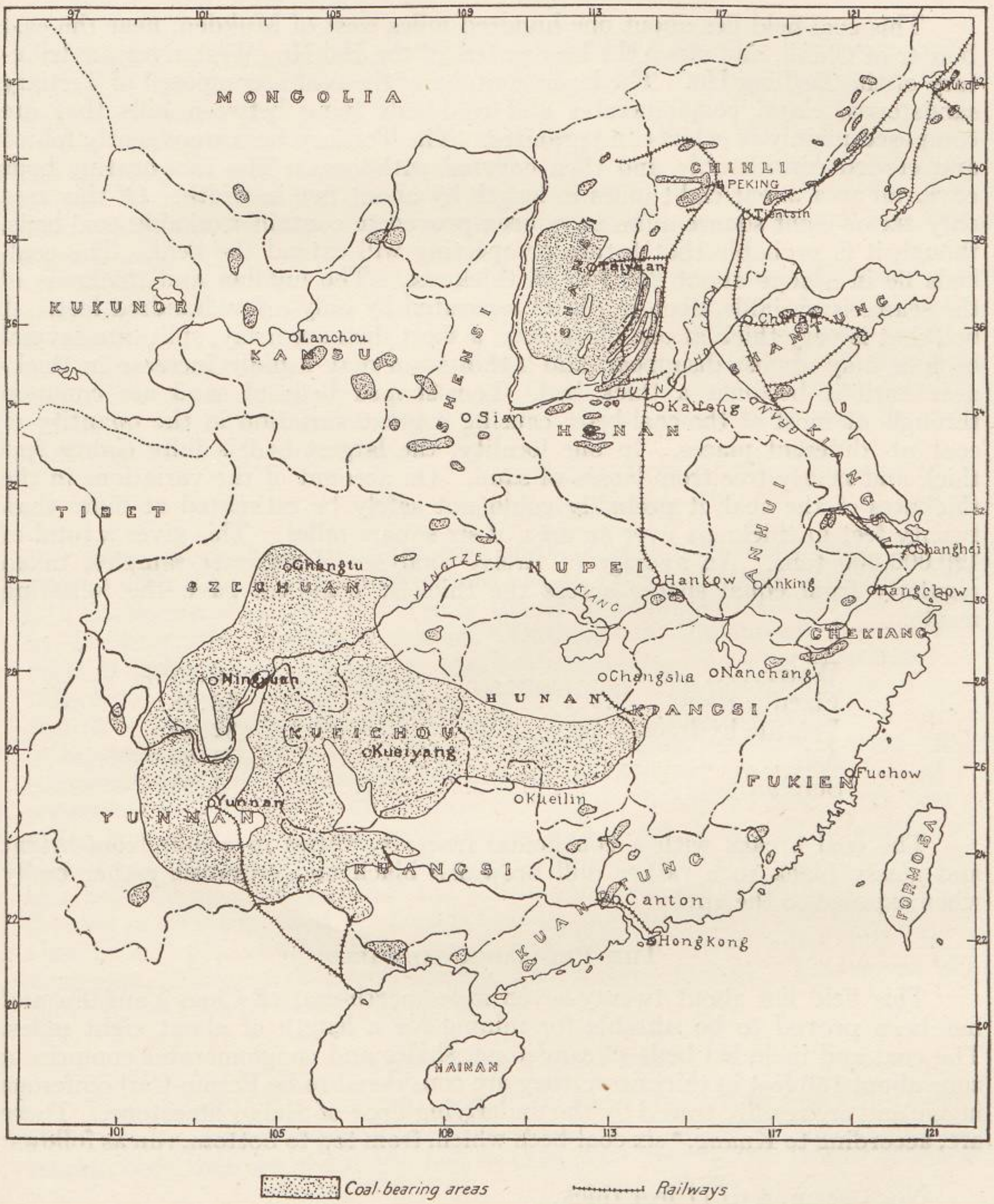
Coal is known to occur in many places in Mongolia, but there is very little published information about the deposits there. Bituminous coal and lignite both appear to be somewhat more common than anthracite. The following estimate is given, but the tonnage is, probably, much too small:

Lignite	500,000,000 tons.
Bituminous coal	500,000,000 "
Anthracite	200,000,000 "

CHIHLI

This province, excepting the coastal plains portion, is well supplied with coal, and in many places the seams dip under parts of the coastal plain also.

* *Economic Geology*, Vol. III, p. 8.



The Coal-bearing Areas of China

Hsin Chiu Coal-Field

This coal-field lies about one hundred miles west of Mukden, near the east border of Chihli, and along the headwaters of the Hsi Ho (West river), a tributary of the Ta Ling Ho. The basin containing the coal is composed of Tertiary sandstones, clays, conglomerates and coal-beds lying between hills that are composed mainly of schists and granites. The Tertiary beds were gently folded and eroded considerably and then covered with loess. The coal-bearing beds cover an area about eight miles in length by about five in width. Of this area only six or eight square miles have been proved to contain workable coal-beds, though it is probable that future prospecting will extend the field. The coal-beds lie in a zone about 250 feet in thickness. The number and thickness of the seams is variable, even in places separated by only a few hundred feet. A bed that is very thick at one place may, a short distance away, split into several beds or may almost disappear, and a thin seam may rapidly increase in thickness until it becomes a thick bed. Lens-shaped beds of sand are common throughout most of the coal-beds, causing a great variation in the quantity of coal at different places. In one locality, the largest bed is fully eighty feet thick and nearly free from lenses of sand. On account of the variations in the thickness of the coal, it probably could not safely be estimated at more than twenty feet in thickness over an area of six square miles. This gives a total of 120,000,000 tons. An average of twelve analyses of separate samples, taken regularly from equal spaces across the thickest coal-bed, gave the following result:

Water	9.97%
Fixed carbon	45.78
Volatile hydrocarbons	32.41
Ash	11.84
Sulphur	1.91

The coal breaks with a conchoidal fracture, varies in colour from bright and glassy black to a rather dull brownish black and crumbles rather badly when exposed to the air.

The Pei-piao Coal-Field

This field lies about twenty-seven miles north-east of Chao Yang Fu and has been proved to be suitable for mining for a length of about eight miles. The coal and included beds of sandstone, shales and conglomerates comprise a zone about 150 feet in thickness; they are considered to be Permo-Carboniferous in age and are readily traced by the underlying floor of Sinian limestone. There are, according to Kuang,* six coal-beds which, from top to bottom, run as follows:

No. 1 seam, 4 to 17 feet thick.
No. 2 seam, 3 to 5 feet thick.
No. 3 seam, 5 feet thick.

* Private communication.

No. 4 seam, 5 feet thick.
No. 5 seam, 4 feet thick.
No. 6 seam, 3 feet thick.

Moller* gives a section of these beds as containing five coal-seams aggregating 25 feet in thickness, but as seams 1 and 2 run together in places, his section evidently was made where the two seams were united. The coal dips to the north-west at angles varying usually from 40° to 60°. For estimating the quantity of coal we may assume the dip to be 50°, the beds to aggregate 20 feet in thickness and the field to be eight miles long. This would give 164,000,000 tons of coal. This is a fair quality of bituminous coal and makes a good coke.

Farther to the south-west, beyond an igneous intrusion, the coal-bearing group again outcrops for a distance of about three miles and the coal there is anthracite, in rather thin beds, and is little worked. About six miles farther to the south-west, beyond a belt of schists, the Sinian limestone again outcrops and is overlaid by Tertiary deposits that contain coal-beds, one to ten feet thick, extending for a distance of about twelve miles. This coal is poor in quality and only worked for local use.

Nan Piao Coal-Field

This coal-field lies along the east border of Chihli, about twenty-five miles west of Chin Cho Fu, Manchuria, and has an extent of about twenty-five miles in a north-east-south-west direction, though it is broken in a number of places by faulting and igneous intrusions. Outcrops of the underlying limestones make it fairly easy to locate the coal-bearing strata, which are over 200 feet in thickness. The dip of the coal is very irregular, varying usually between 30° and 70°. The coal is classed as Permo-Carboniferous and varies from anthracite to bituminous. In places the same bed changes from one to the other kind in comparatively short distances. According to Moller † over fifty feet of coal occurs in the central part of the field and about twenty-six feet in the east end of the field. The coal is, in many places, high in ash, though it is fairly good in some localities and in some of the beds. For estimating the amount of coal in this field we may assume that the bituminous coal and anthracite are equally divided in quantity, that the field is twenty miles in length, that the area workable, to a depth of 4,000 feet, would equal twenty square miles and that the aggregate thickness of the workable coal is four metres. This gives about 150,000,000 tons of each kind of coal.

P'ing Kow Coal-Field

This coal-field lies at and around P'ing Kow, about fifty miles north-east of Chun Ho So. The coal is of Tertiary age and is included in shale and conglomerate beds that are about 150 feet in thickness. At the north end of the field

* Moller, The Coal-fields between Shan Hai Kuan and Mukden, North China. *Trans. Inst. Min. Eng.*, Vol. XXXIII., p. 469. Newcastle-upon-Tyne, 1910.

† *Ibid.*, p. 8.

there is about 15 feet of coal distributed in four beds, while in the centre and southern end the coal is divided into ten seams that aggregate about 55 feet in thickness. Lens-shaped beds of shale and sand are common in the coal-beds and make it difficult to recognize the different seams or to accurately estimate their thicknesses. The coal is subbituminous. For estimating the quantity of coal we may assume that the field is five square miles in extent and that the coal averages 35 feet in thickness, which gives about 170,000,000 tons.

Shan Hai Kuan Coal-Field

This field lies to the north of Shan Hai Kuan and is much broken by faults and igneous intrusions. The coal is a poor grade of anthracite and belongs to the Permo-Carboniferous period. It is mined locally at a number of places. Two seams are worked at Shih Men Tsai, five and six feet thick, respectively. The workable field may be assumed to be six square miles with coal eight feet in thickness, which gives 55,000,000 tons.

Wang P'ing Coal-Field

The visible part of this coal-field extends from the beginning of the hill country, about seven or eight miles west of Peking, westward for over thirty miles, to join what has been called the Chai Tong coal-field. The Wang P'ing coal-field is roughly "T" shaped. The part of the field corresponding to the top of the letter extends nearly north by south at the junction of the hill country and the coastal plains, while the part corresponding to the foot of the letter extends westward into the hills. The field is about thirty miles long and from two to about eighteen miles wide. As a whole, it is synclinal in structure, though a number of minor folds, considerable faulting, and some igneous intrusions break the regularity of the larger folds.

The section of rock beds found here are more or less typical of many other coal-fields of China. The section in a general way runs as follows:

1. Red sandstones with considerable conglomerate........	3,000	feet.
2. Flaggy sandstones, often carbonaceous, with some carbonaceous clay-shale and some coal-beds	800	"
3. Evenly textured, massive, greenish, hard sandstone....	600	"
4. Sandstone interstratified with carbonaceous clay-shale and coal. The carbonaceous clay-shale increases from the top towards the bottom where the big coal-bed is found..	500	"
5. Carbonaceous clay-shale with some sandstone.........	300	"
6. Sinian limestone. (The bottom is not exposed in this field)..	2,000	"

From this section it will be seen that there are two groups of coal-bearing strata separated by a massive, compact, and fine grained sandstone. The lower coal-beds occur in strata that are at present termed Permo-Carboniferous, while the upper coal-bearing group are, apparently, Jurassic. The lower coal-bearing group usually contains but one workable coal-bed varying from about ten to over sixty feet in thickness and probably averaging thirty feet over the field.

Fig. 1 shows two sections of the upper or Jurassic coal-bearing group in the western part of the field. In one section the aggregate thickness of workable coal is about thirty-five feet, while in the other it is about forty feet.

The area of the Permo-Carboniferous coal may be taken at about ninety square miles and the coal at thirty feet in thickness. The Jurassic coal-area, on account of eroded parts and apparent non-extension of the coal in the easternmost part of the field, may be taken at thirty square miles and the coal at an average of thirty feet in thickness. All the coal is anthracite and most of the thick beds and some of the thin ones have been badly crushed. The lower coal-beds run rather high in ash, 10% to 30% usually, while the thinner beds are, as a rule, somewhat better. The quantity of coal as outlined above is as follows:

Anthracite, Jurassic	1,065,000,000 tons.
Anthracite, Permo-Carboniferous....	3,195,000,000 "

Fang Shan Coal-Field

This coal-field almost joins the south-east corner of the Wang P'ing field. The field is a crescent-shaped, synclinal basin, about twelve miles long by from one to four miles wide. Both groups of coal-beds are found here, but the Permo-Carboniferous coal appears to thin towards the west and north. This Permo-Carboniferous coal is worked only in the southern part of the field where it is from about 5 to 75 feet thick, the great variation in thickness being caused by the crushing to which the bed has been subjected. Thirty feet seems a safe

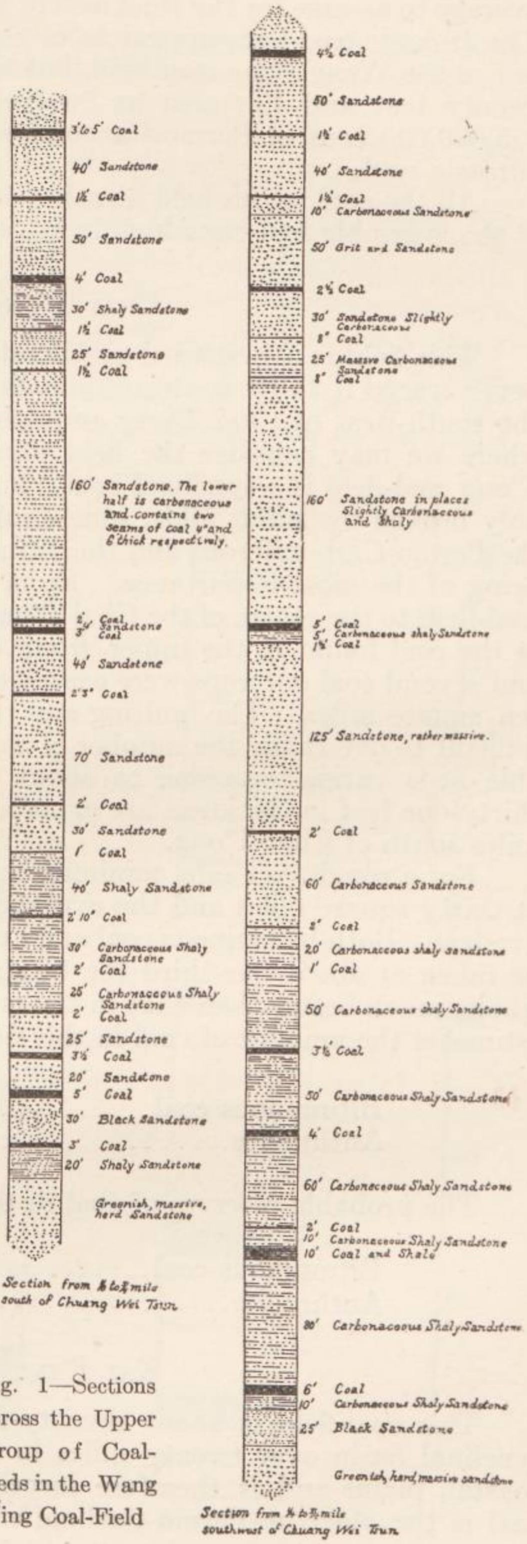


Fig. 1—Sections across the Upper Group of Coal-Beds in the Wang P'ing Coal-Field

average to assume for the thickness of this coal-bed under about ten square miles. The Jurassic coal-beds appear to be somewhat thinner, on the whole, than they are in the Wang P'ing coal-field, but it appears safe to place the thickness at twenty feet and the area at twelve square miles. These assumptions give 355,000,000 tons of Permo-Carboniferous coal and about 190,000,000 tons of Jurassic coal.

All the coal in this field is anthracite and, as in the Wang P'ing field, the coal of the lower big bed runs high in ash and is badly crushed.

Chai T'ong Coal-Field

This field is a westward continuation of the Wang P'ing coal-field. I have never traced it to its western limit, but know that it extends over ten miles to the south-west of Chai T'ong and fully that far to the north-east at the place where we may consider the field joins the Wang P'ing coal-field. The Chai T'ong coal-field is a synclinal basin, but like other adjoining fields it is considerably broken by minor folds, some faulting and some igneous intrusions. Both the Permo-Carboniferous and the Jurassic coal groups are found here, the upper being of the most importance. From near the eastern part of the Wang P'ing coal-field to the centre of the Chai T'ong coal-field, there appears to be an increase in the coal found in the upper group of coal-bearing beds. Twelve coal mines and several coal outcrops were examined by the writer in an area of about nine to ten square miles. The faulting and the scattered position of the mines made it difficult to determine the number of workable beds. The thickness of the workable beds varies from one to about thirty feet. Four coal-beds aggregating thirty-one feet in thickness are exposed in one of the mines situated about three miles south of Chai T'ong.

For a rough, yet safe, minimum estimate, we may take the area of the field at thirty square miles and the average thickness of the workable coal at thirty-five feet. Both bituminous coal and anthracite are found here. The former may be taken at about one-third the total. The quality of the coal here is, on the whole, much better than that in the two preceding coal-fields. From the above estimates the amount of coal in this field is about as follows:

Bituminous coal	386,000,000 tons.
Anthracite	772,000,000 "

The probable reserves of coal in this field we would place as follows:

Bituminous coal	660,000,000 tons.
Anthracite	1,320,000,000 "

Kai P'ing Coal-Field

This coal-field is about seventy-five miles north-east of Tientsin; it is a synclinal basin over twenty miles in length and, for the most part, lies in the coastal, plains and is therefore largely covered by alluvium and loess. The coal is the older or Permo-Carboniferous coal; the lowest beds lie about 250 feet above the Carboniferous limestone. The coal-beds are interstratified with shale and sandstone through a thickness of about 400 feet. The coal is bituminous and makes a good coke.

Fig. 2 gives comparative sections at different places over the field. The Tongshan section is at the south-west end, the Lin Hsi section near the north-east end, and the other two sections at intermediate points. At Tongshan the aggregate thickness of the workable coal is 50 to 60 feet, at Ma Chia K'ow it varies from 60 to about 80; at Chao Ke Chuang it varies from about 80 to about 90, and at Lin Hsi it varies from about 40 to 50 feet. As these sections are nearly equally spaced over the field, their average would appear to be about an average for the whole field, which would give about 64 feet or 19½ metres. The dips over the field vary from about 20° to almost vertical, but the dips near 50° predominate. As about twenty-five miles of the coal-bearing rim of the basin

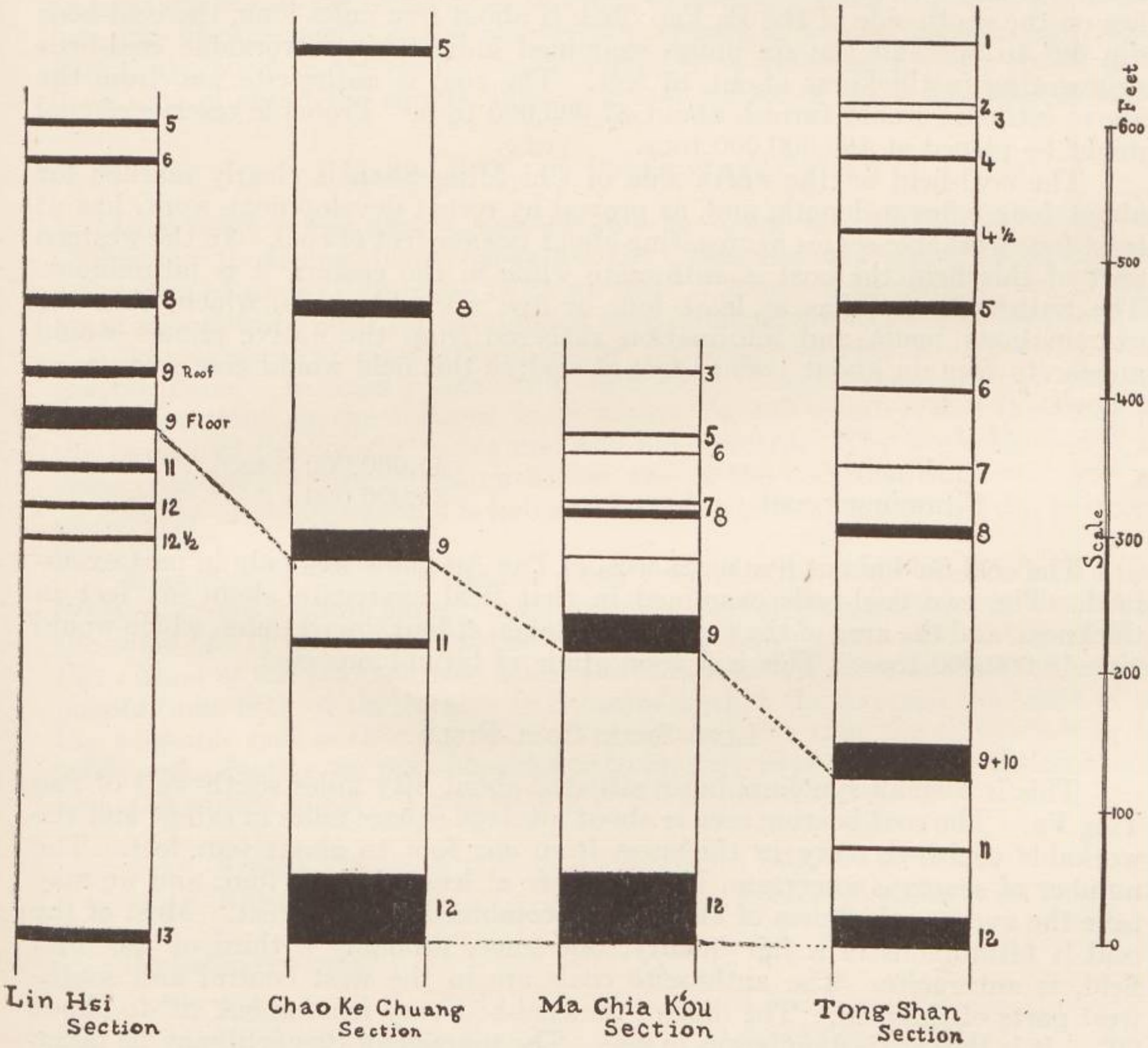


Fig. 2—Comparative Sections in the Kai P'ing Coal-Field

is well known and about seventeen or eighteen more miles are pretty definitely located, we may place the measured reserves at twenty-five square miles and the probable reserves at forty-two square miles. This gives, for actual reserves, 1,641,000,000 tons, and for probable reserves, about 2,757,000,000 tons. This coal-field has for a number of years been the seat of the most extensive coal mining in China. An average analysis of this coal gives the following: Volatile hydrocarbons, 26%; fixed carbon, 58%; ash, 15%; water, 1% ; sulphur, 1%.

Hsuan Hua Coal-Fields

These coal-fields are about sixty or seventy miles, in a direct line, north-west of Peking and lie along the line of the Peking-Kalgan railroad. They are divided into three apparently unconnected fields. There appears to be ten or twelve coal-seams, but probably only four or five are workable. The field that lies on the south side of the Pa Pao Shan is about five miles long, the coal-beds dip 60° to 80° and the six mines examined indicate four workable coal-beds aggregating in thickness about 15 feet. The coal is anthracite, and from the above estimate would furnish about 87,000,000 tons. Probable reserve of coal might be placed at 100,000,000 tons.

The coal-field on the north side of Chi Ming Shan is clearly marked for about four miles in length, and, as proved by recent development work, has at least four workable seams aggregating about twenty feet of coal. In the western part of this field the coal is anthracite while in the eastern it is bituminous. The anthracite end has at least four or five workable beds, which from the examinations made and information gathered from the native miners would appear to contain about twenty feet of coal, so this field would give reserves as follows:

Anthracite........................	45,000,000 tons.
Bituminous coal..................	39,000,000 "

The coal-field about five miles west of Pao Au Show was only in part examined. The two coal-beds examined in that field aggregate about six feet in thickness, and the area of the field may be taken at four square miles, which would give 18,000,000 tons. This is a good grade of bituminous coal.

Ling Shan Coal-Field

This is a small synclinal basin situated about fifty miles south-west of Pao Ting Fu. The coal-bearing area is about fourteen square miles in extent and the workable coal-beds vary in thickness from one foot to about four feet. The number of seams is uncertain, but there are at least three or four, and we may take the average thickness of all the beds combined at seven feet. Most of the coal is bituminous of a fair quality, but some, probably a third of the total field, is anthracite. The anthracite coals are in the west central and south-west parts of the field. The dips of the coal-bed vary from about 20° to about 80°. It is Permo-Carboniferous in age. The tonnage of this field may be taken as follows:

Bituminous coal	40,000,000 tons.
Anthracite	20,000,000 "

Ching Hsing Coal-Field

This coal-field lies about thirty miles west of Cheng Ting Fu along the line of railway running to T'ai Yuan Fu Shansi. It is bituminous and Permo-Carboniferous in age and lies in blocks that have been let down by normal faulting. At least seven workable beds of coal have been found here. These, from top to bottom, run in thickness on an average about as follows: 1, 4, 7, 2, 6, and 15 feet thick, respectively, making a total of 35 feet. These coal-beds are interstratified with about 350 feet of shales, sandstones and clays which are overlaid by about 150 feet of loess. The thick, or 15-foot, coal-bed, is not of as good quality as the other beds, but it is workable. While this field continues for some distance south of the railway that crosses it, we may consider only that part to the north of the railway as belonging to this coal-field, which would give it an area of about ten square miles or a coal reserve of about 356,000,000 tons.

Coal-Fields of South-west Chihli

Coal-fields occur almost uninterruptedly along the south-west border of Chihli from the Ching Hsing coal-field to the Chang Ho, near Chang Te Fu Honan, a distance of about 120 miles in an air line. Along a considerable part of this area the coal-fields lie at the east base of the hill country that borders the province and the coal-bearing measures dip under the loess and alluvial deposits of the coastal plains. In some places, as around Feng Chuang, there are two parallel fields, one lying in the folds of beds within the hill country, and the other at the border of the coastal plains and the hill country. The workable width of these coal-fields varies according to the dip of the beds, but may be taken at an average of about one and a half miles, which means an average dip between 30° and 40°.

Many native mines are located along the outcrops of the coal-beds in these fields, and one modern mine, which supplies the Lu Han railway, is located on the same line of outcrops, at a place about fifty miles south-west of Cheng Ting Fu. Most of the coal of these fields is bituminous but there is some anthracite, possibly one-fifth of the total. It is probable that the average thickness of all the workable coal is thirty feet or over, but in order that the estimate may be safely conservative we may consider it to be only twenty feet and the workable area 150 square miles. These data give for actual reserves:

Anthracite	851,000,000 tons.
Bituminous coal	3,407,000,000 "

Probable reserves:

Anthracite	1,602,000,000 tons.
Bituminous coal	6,814,000,000 "

All Other Coal-Fields

Besides the coal-fields enumerated above, there are a number of others, for which the available data are too meagre to make estimates of the actual coal reserves. In north Chihli there are a number of localities where subbituminous coal occurs, and also several places where anthracite is found, and there are at least two localities in the west part of Chihli where coal occurs that has not been estimated. For all these localities we make the following estimate for the probable coal reserves:

Subbituminous coal	500,000,000 tons.
Bituminous coal	500,000,000 "
Anthracite	500,000,000 "

SHAN TUNG

Richthofen* enumerates seven coal-fields in this province, of which one is an unimportant Jurassic coal-field and the six others are as follows: Fang Tze, Lin Tze, Po Shan, Chang Kin, Lin Wu, and Ichou (now called Yi Hsien coal-field).

Two of these fields, the Po Shan and the Fang Tze, are now being extensively developed by a German company, while a third field, the Yi Hsien coal-field, is being developed by a Chinese company. It seems likely that these three fields are the best ones, but being most accessible to railways has been one of the prime factors in causing them to be developed first.

Fang Tze Coal-Field

This coal-field is situated at Wei Hsien. That part of the field now being worked is about two miles wide by four miles long, and contains two coal-beds each said to be about 16 feet thick. The coal is bituminous. The dip of the beds, where worked, is about 12 degrees. The coal reserve for this field may be calculated on a basis of eight square miles and 25 feet thickness for the coal-beds, which gives 202,000,000 tons. Probable reserves, estimated on a basis of 30 feet of coal, is 245,000,000 tons.

Lin Tze Coal-Field

This is a small coal-field situated about twenty-five miles north-west of Tsing Chou. I have no data of its resources.

Po Shan Coal-Field

If one includes the coal-bearing beds on both sides of an igneous intrusion and considers that isolated outcrops of the coal-bearing beds are connected under the loess covering, this field would have an area of about 250 or 300 square miles. The company that is mining coal in Po Shan has recognized twelve coal-beds, ranging from about two feet to about twelve feet in thickness.

* "China," Vol. II, pp. 785-786.

That part of the field on which the company is located, is about five miles wide by ten miles long and the seams dip from eight to ten degrees. The coal being mined is anthracite, but parts of the field furnish bituminous coal. For estimating the coal reserves in this field we may take the thickness of the coal-beds at 25 feet and the area at 100 square miles and assume that the anthracite and bituminous coals are equally divided, which gives:

Bituminous coal about	1,360,000,000 tons.
Anthracite about	1,360,000,000 "

Lin Wu Coal-Field

This coal-field lies about sixty miles south-east of Tsi Nan Fu. It is probably fifty or sixty square miles in extent. I do not know the amount of its coal reserves.

Chang Kiu Coal-Field

This coal-field lies about thirty or forty miles east of Tsi Nan Fu. It is largely covered by loess deposits, so it is difficult to estimate its extent; however, if one considers the isolated outcrops of coal-bearing beds, as mapped by Richthofen, to be connected as one field, the area of the field would be in the neighbourhood of 300 square miles. I have no data about the coal value of this field.

Yi Hsien Coal-Field

I am indebted to Mr. Kwong* for most of the following details.

This coal-field is situated in the extreme south of Shantung province, seven or eight miles north of Yi Hsien and about thirty miles east of the Tientsin P'u Kow railway station, at Lin Cheng. It lies in a synclinal basin that extends in a north-east by south-west direction, and is about twenty miles in length. The outlines of the field are pretty clearly shown by the outcropping underlying Sinian limestone which almost encircles the field. The average width of the field is about two miles.

The coal is of good coking, bituminous quality, is firm and may be mined with a high percentage of lump coal. There are four workable coal-beds that run as follows, from top bed to bottom one:

Seam No. 1	44 feet.
Seam No. 2	16 to 30 feet.
Seam No. 3	4 feet.
Seam No. 4	4½ feet.
Seam No. 5	3½ feet.
Total	32 to 40 feet.

Seam No. 1 is a poor quality of coal. Seams 2, 3, and 4 are the best and the ones that are now being worked. For estimating the quantity of coal we

* Written communication.

may take the average thickness of the coal-beds at 25 feet and the area at 50 square miles. The area is probably somewhat greater than the above on account of the folding which gives dips of 20 to 25 degrees on the south side of the basin and 45 to 70 degrees on the north side. For probable reserves we may take the area of coal-lands at sixty square miles and thickness of coal-beds at 30 feet. These assumptions give the quantity of coal to be as follows:

Actual coal reserve about..........	1,280,000,000 tons.
Probable coal reserve about........	1,838,000,000 "

All Other Coal-Fields

For the coal-fields of which data are lacking for estimating the quantity of coal, we may reasonably assign as much as 1,000,000,000 tons, since they lie near to and between rich ones that are now being worked.

SHANSI

This province easily leads all others of China in its coal resources. Practically all of south Shansi, except the extreme south-west corner, a narrow strip running south from Tai Yuan, and a few small areas in the south-west part of the province and along the south-east border, is one great coal-field. Besides this great field there are others of considerable extent, such as the one south and south-west of Ning Wu Fu in west central Shansi, the one near Ta Tung Fu in north Shansi, and the field in extreme north-west Shansi. Besides these there are also other small fields that are little known.

South Shansi Coal-Fields

South Shansi may be regarded as an elevated plateau that has been deeply dissected, so that its valleys lie 2,000 to 4,000 feet above the coastal plains and its hills rise 4,000 to 6,000 or 7,000 feet above the plains. This plateau, at least along its eastern border, has been elevated by block faulting. Minor folds have, to some extent, entered into the structure, as shown in Fig. 4. The Sinian limestone or floor of the Coal-Measures lies almost horizontally over the most of these fields, and as the coal-bearing beds and superimposed sandstones lie practically parallel to the limestones, it is evident that 4,000 feet in depth will reach most of the coal over these fields. There is, however, some reason for believing that the fault-blocks in the west part of Shansi are somewhat more tilted and folded than is the case in the eastern part of the province. A covering of loess, varying in thickness from a few feet to several hundred feet, is found in the valleys and lower lands. The coal-beds, lying almost horizontally over most of the field, offer exceptionally favourable opportunities for mining over a large area without loss of coal.

Richthofen classed all the east half of the south Shansi coal-fields as one continuous anthracite field and estimated its area to be 13,500 square miles* and he considered that the coal in this area averages 40 feet in thickness and

* "China," Vol. II, p. 789.

amounts to a total of 630,000,000,000 tons. He also considered the bituminous coal-fields of the west part of south Shansi to equal the anthracite fields of south-east Shansi.

Willis* thinks Richthofen's estimate of the area of the anthracite fields a conservative one, but considers 40 feet too much for the average thickness of the coal over the area.

Nyström,† who has spent several years in Shansi and gathered considerable information about the coal and other mineral deposits of the province, also considers Richthofen's estimates of areas moderate and apparently accepts his quantitative estimates as fair. Kurita says,‡ "During the months of October, November and December of 1896 and 1897, the writer made an examination of much of this province; his work extended over an area of more than 200 miles north and south and thirty miles east and west—Tse Chow to Yu. This whole area is one unbroken coal-field with workable coal 25 to 50 feet in thickness. This statement is not the result of deductions from surface indications, but from an examination of actual mines as worked by the Chinese."

Shockley, who spent considerable time investigating the mineral resources of Shansi, thinks that the average thickness of the coal of south-east Shansi is somewhat less than 40 feet.¶ He expressed the opinion, however, that Richthofen's estimates were as fair as existing data would warrant.

My personal observations have been confined to two parts of the great coal-field of south-east Shansi, that is to the south-east part of the field at and around Tse Chow, and to the north-east part of the field at and around Yang Chuan. These two localities are on the west border of Shansi and are about 175 miles apart. My observations of the coal in the Tse Chow region were confined to the lower, big coal-bed which is the only seam worked in that part of the province, though it is likely that five or six feet of coal could be added if beds as thin as one foot were worked. The big seam there, according to my estimates and measurements,§ averages about 22 or 23 feet in thickness.

Figure 3 shows the coal-beds and their relative positions in the Yang Chuan, or P'ing Ting Chow region, which is about sixty or seventy miles east of T'ai Yuan Fu. At Yong Chuan there are six different beds that run from one to about twenty feet in thickness and together make a thickness of about thirty feet of coal. The lowest and biggest seam here is about twenty feet thick, while the next best bed is about four feet thick. In both the above localities the coal is anthracite and lies nearly horizontally.

Much of the coal of the Tze Chow region has a beautiful glossy, black colour, breaks with a conchoidal fracture and may be handled without soiling the hands.

Nyström has shown,‖ by analyses made from samples of coal collected from

* *Economic Geology*, Vol. III, p. 20.

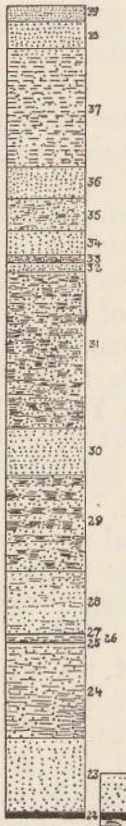
† "The Coal and Mineral Resources of Shansi, China," Stockholm, 1912, p. 34.

‡ *Eng. and Min. Jour.*, Vol. LXV, p. 491.

¶ "Notes on the Coal and Iron-Fields of South-eastern Shansi, China." *Trans. Amer. Inst. Min. Eng.*, Vol. XXXIV, p. 841.

§ *Trans. Amer. Inst. Min. Eng.*, Vol. XXX, p. 261.

‖ "The Coal and Mineral Resources of Shansi, China." Stockholm, 1912.

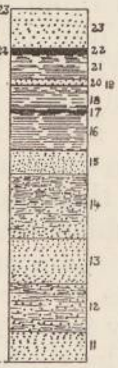


Section D

most of the coal-fields of Shansi, that the coal of south-eastern Shansi is not all anthracite, as Richthofen thought, but that the anthracite is mainly confined to the south-east and north-east corners of the field, while semi-anthracites and bituminous coals are found in other parts. His analyses did not show the occurrence of any anthracite coal in the west half of the coal-fields of south Shansi. So far as known, all the coal-fields in the northern part of the province contain bituminous coal only.

For the purpose of an estimate of the coal reserves of south-eastern Shansi, we may take the thickness of coal at 25 feet for actual reserves and 30 feet for probable reserves, and the area at 12,000 and 13,000 square miles, respectively, for actual and probable reserves, and the anthracite, semi-anthracite and bituminous coal as occurring in equal amounts. These data give the following:

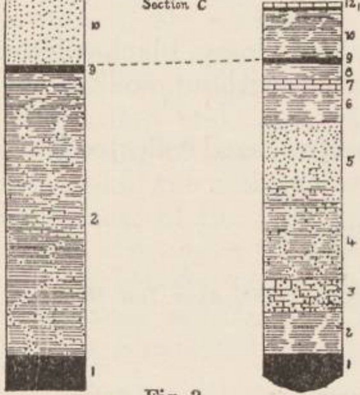
Actual reserves	Anthracite (A) about 120,000,000,000 tons.
	Semi-anthracite (A) about 120,000,000,000 tons.
	Bituminous coal (B) about 120,000,000,000 tons.
Probable reserves	Anthracite (A) about 150,000,000,000 tons.
	Semi-anthracite (A) about 150,000,000,000 tons.
	Bituminous coal (B) about 150,000,000,000 tons.



Section C

The coal-field of south-west Shansi is not so well known as that of south-east Shansi, but enough is known about it to allow of at least probable estimates being made. As is the case with many of the coal-fields of China, the best data regarding this field come from Richthofen, who has estimated the coal-bearing area of the field to be 1,000 German square miles,* equivalent to about 21,000 English square miles, and the minimum average thickness of the coal throughout the field to be 25 feet. He says, further, that a large part of the coal is available for mining because of the folds, faulting, and erosion that have taken place. I have gathered some information about coal in western Shansi from missionaries who live there, from mining engineers who have seen parts of the fields, and from merchants and travellers, and all were of the opinion that coal is abundant t ere. Although western Shansi is for the most part underlain by nearly level-lying beds, faulting, folding, and erosion have lessened the size of the mineable coal-bearing area as compared to that in east Shansi. To avoid overestimating, we may take the area to be 10,000 square miles and the thickness of coal to average 25 feet. From these data the amount of coal estimated is as follows:

Probable reserve of bituminous coal, about 255,890,000,000 tons.



Section B Fig. 3 Section A

*"China," Vol. II, p. 790.

Ta Tung Fu Coal-Field

This coal-field lies in the northern part of Shansi, near the city of Ta Tung Fu. Richthofen estimates the known extent of this field to be about twenty-seven square miles and the probable extent to be about seventy square miles. He says that there are several coal-beds and that the largest one is from twenty to thirty feet in thickness and of excellent quality.* Dobbins states † that there are two coal-fields there, one about thirteen miles north-west and the other about thirty miles south-east of Ta Tung Fu. The first, he says, is about ten miles 'ong and two miles wide, and the second about twenty miles long and as much as four miles wide. He notes that in one of the mines examined by him there were four coal-beds, separated from one another by about three feet of shale. These beds, he says, are in descending order, 7, 2½, 7, and 4 feet thick, respectively. The coal-bearing strata are Jurassic, according to Richthofen.

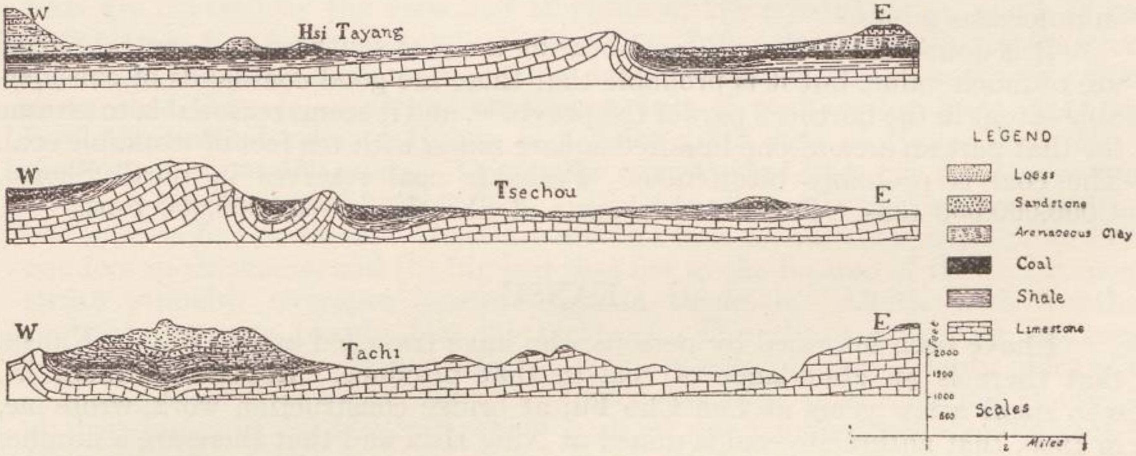


Fig. 4—East and West Sections through Hsi Tayang, Tsechou and Tachi

They lie almost horizontal and are so covered by loess that it is difficult to determine the extent of the coal-field. It seems probable that the two fields mentioned by Dobbins may be parts of one, more extensive field. In estimating the actual reserves, we may take 30 feet as the average aggregate thickness of the coal and, for the probable reserves, 40 feet; and 100 and 200 square miles as the respective areas. From these figures we get, for actual reserves of bituminous coal about 3,060,000,000 tons; and for probable reserves of bituminous coal about 8,200,000,000 tons.

Saratsi Coal-Fields

This coal-field is situated in the extreme north-west corner of Shansi and has bituminous coal of a good quality, as shown by Nyström's analysis.‡ Coal is reported to occur at Kwei-Hua Cheng, a place about twenty-five or thirty

* "China," Vol. II, p. 789.

† "Mines and Minerals."

‡ *Op. Cit.*, p. 50.

miles north-east of Saratsi. It is probable that these two localities are situated in the same coal-field. In the absence of definite data, we may estimate the probable coal reserves of this field on a basis of ten feet of coal throughout an area of twenty-five square miles, which gives: probable coal reserves, about 250,000,000 tons.

SHENSI

Richthofen says,* "Northern Shensi is full of coal north of the Wei river, near Si Ngan Fu. The first low hills rise at a distance of from thirty to forty miles, and though they are 'tu shan,' that is loess hills, the gullies are cut down into coal-bearing strata which underlie the loess. A dirty, friable coal, full of sulphurets, is mined there for local consumption. Farther north, in the departments of Fu Chau, Ya Ngan Fu and Yu-lin-fu, the coal-bearing ground was described to me as being very extensive and good kinds of coal said to be extracted in numerous mines."

It is doubtful whether the coal-bearing areas of southern and central Shensi are of much value, but it is probable that there are good coal-lands of considerable extent in the northern part of the province, and it seems reasonable to assume for that part an area of one hundred square miles, with ten feet of workable coal. The coal is probably bituminous. Probable coal reserves in north Shensi, 1,000,000,000 tons. For all other parts of Shensi, say—50,000,000 tons.

KANSU

I have been informed by persons who have travelled extensively in Kansu, that there is an abundance of coal in that province. Robert Coltman, jr., who spent a few years at Lan Cho Fu, at bridge construction work, wrote me, in 1908, that anthracite coal is mined at Ning Hsia and that there are a number of bituminous coal mines at Wu Kang Chen, a place about thirty miles south-west of Lan Chow. The latter, he says, are the most important mines in the province. The coal contains rather high percentages of sulphur and ash. Ning Hsia is in the extreme north-west corner of the province and it is probable that the coal-field of western Shansi, which extends into north Shansi, also continues westward and spreads over parts of north-east Kansu.

Richthofen says,† "Kansu is reported to rival Shansi in the richness and extent of its coal-fields. No department of the province, north of the Tsing Ling Shan, appears to be deficient in coal and in some of them a superabundance of it is said to exist. I am told that anthracite does not occur in the province, but that bituminous coal is mined in many localities in large blocks and burns with very little smoke and smell."

From the above data it is impossible to make an accurate estimate, but it is evident that coal is plentiful over large parts of the province and we can at least allow something for the supply that exists there and at the same time avoid over-estimating the coal reserves. It is probable that the anthracite at Ning Hsia gradually changes into bituminous coal a short distance away. At

* Baron von Richthofen's "Letters," 1870-1872, Shanghai, pp. 103-104.

† "Letters" to Shanghai Chamber of Commerce, 1870-1872, Shanghai, p. 108.

any rate it is probably a local field, which we may assume covers ten square miles and averages ten feet of coal throughout the area, which gives a probable reserve of about 12,000,000 tons.

For all the rest of the province, we may assume that the workable coal-fields have an extent of 500 square miles and that the coal averages ten feet in thickness, which gives about 5,117,000,000 tons.

HONAN

The coal-fields of this province lie in areas that have been affected by block faulting and by foldings. They are, therefore, remnants of a previously large coal-field. In the extreme north of the province most of the coal lies in fault-blocks, at the edge of the coastal plains and along the border of the great coal-field of south-east Shansi. A considerable part of those blocks of coal-bearing beds are covered by the loess and alluvium of the coastal plains, and it is impossible to accurately estimate their extent from the available information. We know, however, from outcrops and from prospecting that has already been done, that there is an almost continuous belt of coal-bearing beds extending from the north border of Honan to a point south-west of Hwai Ching Fu, a distance of about 150 miles. This belt is composed of from one to three or four strips or blocks of coal-bearing beds. The principal strip varies in width from one mile to five or more. There are at least four or five coal-seams more than one foot in thickness, and the big bed that lies at the bottom of the coal-bearing strata probably averages fourteen feet in thickness. All the beds together probably average twenty feet in thickness. The above estimated thickness was arrived at from a study of the coal-field, at a point about twenty miles west of Chang Te Fu, in north Honan and from the work of the Peking Syndicate at their mines at Jai-Mei-Sen, which is about one hundred miles south-west of Chang Te Fu. The rocks of this belt are of Permo-Carboniferous age. In the northern part of Honan the coal-bearing beds dip about ten degrees to the east-south-east, so the 4,000-foot depth limit would mean a width of a little over four miles for this part of the field. At one of the Lin Ho Kao coal mines, working the big bed, the miners, acting under my direction, dug through the full thickness of the coal-bed at three different places, situated about one hundred yards apart, and the thickness of the coal was found to be $10\frac{1}{2}$, 13, and $13\frac{1}{2}$ feet, respectively. In another mine about a quarter of a mile distant from the one above mentioned, three measurements of the coal-bed at different places showed it to be about 13 feet thick. About one and a half miles farther to the south, the miners told me that the coal is about 15 feet thick. At the Lin Ho Kao coal mines, about one-half of a square mile of the coal-bed is exposed and it is everywhere free from intercalated beds of shale and has only a few partings, $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness, of shaly coal. In another mine in this field, two other seams are exposed, lying 600 to 800 feet above the big coal-bed. Each of the beds is but a little over a foot in thickness. The coal in the extreme north of Honan is bituminous, but farther to the south, in the above-named belt, it is anthracite; probably not over one-tenth of the belt can be assumed to contain bituminous coal.

The Peking Syndicate's explorations in the coastal-plains country, near

Hwai King Fu, have shown that throughout a considerable area at and around their mines, there are three beds of workable coal running $2\frac{1}{2}$, 2, and 15 feet thick, respectively, in descending order. The dip averages about nine or ten degrees. The coal is a good quality of anthracite. In estimating probable coal reserves throughout this belt of coal-fields in north Honan, we may take the area to be one hundred miles in length with an average width of three miles, which gives:

Bituminous coal about.............	700,000,000 tons.
Anthracite about.................	6,400,000,000 "

For the coal-fields in Honan south of the Yellow river, Richthofen's descriptions afford the best data. According to his outlines of these fields, there are four separate coal-bearing areas,* only two of which are probably of much economic value. These two he speaks of as the Honan and the Lu Shan fields. The first, or Honan coal-field, is about thirty miles south-east of Honan Fu. It extends in an east-west direction for about twenty-five miles, but the coal-bearing area is not, probably, more than fifteen square miles in extent. The coal is anthracite and lies in beds that are badly crushed and folded. The seams that are worked are from six to ten feet in thickness. It is probable that at least ten feet of coal could be counted upon, which would give for this field the following amount: anthracite, about 175,000,000 tons.

The other important coal-field lies immediately north of Lu Shan. It is about twenty miles wide at the widest part, about forty miles long, and probably contains not less than 200 square miles of workable coal-lands. Richthofen says the seam that is most worked is six to eight feet thick and is bituminous. It would seem, therefore, that we might count on at least ten feet of coal throughout 200 square miles, which would give for this field: bituminous coal about 2,000,000,000 tons.

KIANGSU

The best known occurrences of coal in Kiangsu are in the small coal-fields on the borders of Nan King hills, east and south-east of Nan King. Both Kingsmill† and Richthofen ‡ give short accounts of these coal-fields but do not give definite details of the quantity and quality of the coal. The old mines indicated that two different coal-beds had been rather persistently worked. The probabilities are that the coal-beds in these fields are at best but one or two feet in thickness and that the coal reserves are small. The probable coal reserves may be estimated at 10,000,000 tons.

* "Atlas von China," by von Richthofen, also Richthofen's "Letters" to the Shanghai Chamber of Commerce, p. 23.

† "Notes on some outlying coal-fields in the south-eastern provinces of China." *Journal of the North China Branch of the Royal Asiatic Society*, New Series, No. III, December, 1886, p. 104.

‡ Richthofen's "Letters" to Shanghai Chamber of Commerce, Shanghai, 1870-1872, pp. 63-66.

ANHUI

Coal has been reported from a number of places in the province, but particulars of the quantity and quality of the coal are lacking for all but two of those localities. The two localities for which rough approximate estimates may be made are Ning Kwo Fu and Chi Chow Fu.

Ning Kwo Fu

Richthofen reports * that there are three coal-fields of quite limited extent in the neighbourhood of Ning Kwo Fu, in the south-eastern part of Anhui. He states that it was reported to him that the mines around Kiulitwan yielded large amounts of coal, that the bed worked was irregular in size, reaching six feet in thickness in places, and that the coal about twenty miles south-west of Kinghien (King Hsien) was even more celebrated than Kiulitwan and yielded the best coal of the province. Richthofen visited those coal-fields, but was not able to examine the coal-beds as they were not then being worked, but, from the evidence gathered, he thought favourably of the possibilities of getting good workable coal. From the above evidence it appears reasonable to assume that there may be, in the three coal-fields, at least two feet of coal throughout ten square miles, which gives about 22,000,000 tons of coal. The coal is probably all semi-anthracite.

Chi Chow Coal-Fields

According to Randolph † these fields lie in a "basin about twenty miles square, of which the old town of Che-Chow-Fu may be taken as the centre. They all lie but a few miles south of the Yang Tse." The coals gave no coke in crucible tests, showed a specific gravity of 1.7, and were high in ash. The following tabulated statement gives the principal localities where coal was ascertained to occur by Randolph, from examinations he made of coal-fields at six different localities.

Locality	Number of Coal-Beds	Thickness of all Coal-Beds 1 foot or over	Dip of Coal-Beds
Men-to-san eighteen miles south of Yen-kah-way and one mile south of Yang Tse	1	6 to 8 feet	25 degrees
See-mah-poo, nine miles north-east of Yen-kah-way	1	4 feet	20 "
Woo-shen-tung, one mile south-west of Yen-kah-way	3	8½ feet	45 "
Chin San, eighteen miles south of Yen-kah-way	1	6 to 8 feet	40 "
Tse-lung-chung, two miles south of Chin-san	1	2 to 3 feet	40 "
Kun-chok-wan, fourteen miles east of Tse-lung-chung	1	6 to 8 feet	25 "

* *Op. cit.*, pp. 66-67.

† "Notes on Some Chinese Coals," *Trans. Amer. Inst. Min. Eng.*, Vol. XV, p. 110.

No definite areas are given for the coal-fields of the above-named localities, but it appears that the localities may be grouped into about three coal-fields. We may assume that the coal averages five feet in thickness throughout twenty-five square miles, which gives about 165,000,000 tons.

HUPEI

Coal has been reported from a number of places in the province of Hupei, but those to the south-east and to the south of Hankow are probably best known.

Yi Shan Coal-Field

Both Kingsmill* and Richthofen† report one coal-bed, one to two feet in thickness, in this field. We may assume, therefore, that it contains one coal-bed that averages $1\frac{1}{2}$ feet in thickness throughout ten square miles, which gives about 17,000,000 tons.

Other Coal-Fields

At Siangki, thirty miles from the Yang Tse Kiang and eighty miles above Ichang, a Chinese company, working by native methods, is producing about 400 tons of bituminous coal per month.‡ I have no details of the extent of the coal-field nor of the thickness of the coal-beds, but it seems probable that this is a promising field for future mining. For this and all other coal-fields we may assume the coal reserves to be not less than 100,000,000 tons.

CHEKIANG

Coal occurs in several localities in this province, and it is likely that a thickness of one foot may be found in at least three separate coal-fields, but it is probable that only two of the fields have beds a foot or over in thickness that are of much extent. These fields we may call Tung Lu coal-field and Kiang Shan coal-field.

Tung Lu Coal-Field

This small field lies near Tung Lu, about fifty miles south-west of Hang Chow. It is about one-half or three-fourths of a mile long and lies in a folded and faulted area. The coal-bed is about five feet thick where it is best exposed, in an outcrop that has been prospected but has never been worked. About half the bed runs too high in ash to be of value, leaving about two feet of fair coal, which, in an area of one-half a square mile, would amount to 700,000 tons of coal. The coal is anthracite.

* *Op. cit.*, p. 99.

† *Op. cit.*, p. 67.

‡ "Memorandum on Chinese Mines," Diplomatic and Consular Reports, No. 680, Miscellaneous Series, London, 1911, p. 7.

Kiang Shan Coal-Field

This coal-field lies in the west central part of the province. It runs north-east by south-west, in a belt about thirty miles in length by one to two miles in width. The coal-seams occur in three different groups of shale, which are separated by thick beds of sandstone. The beds carrying the coal-seams are usually highly tilted and the coal is badly crushed and displaced. Most of the seams are only a few inches in thickness and it is probable that not more than two beds average as much as one foot each in thickness, over an area of ten square miles. Some of the coal—probably one-fourth—is bituminous. The amount of coal reserves, estimated from the data given above, is: bituminous coal about 6,000,000 tons; anthracite about 18,000,000 tons.

FUKIEN

Coal is known to occur in a few places in this province, and is worked to a small extent by native methods. Very little definite details are available, but it is safe to say that the coal-fields are of but little value. We may place the probable coal reserves at 25,000,000 tons.

KIANGSI

The coal-fields that occur in the west central part of Chekiang continue westward for some distance into Kiangsi to Kwang Sin Fu, where some coal is now being mined. The coal-beds, where I saw them, were several in number, but only two or three were over a foot in thickness and the area underlaid by them is probably not over ten or fifteen square miles in extent. The coal is bituminous and probably amounts to not less than 20,000,000 tons.

In the west part of the province there are coal-fields of considerable extent and importance. The best known of these is the Ping Hsiang coal-field, which is about twenty-five miles south-west of Yuan Chou.

Lo Ping Coal-Field

This is a small area lying about thirty or forty miles east of Po Yang lake. It has been referred to by a number of persons, including Richthofen, as one of the most important in the lower part of the Yang Tse valley. The workable beds will probably average not less than five feet in thickness over an area of five square miles, which gives about 25,000,000 tons of coal.

Ping Hsiang Coal-Field

The strata in this coal-field are gently folded, forming a synclinal basin about eight or nine miles long and about two miles wide. The field contains from five to six beds of coal, that are from one to ten feet thick and, in the aggregate, have a thickness of about 25 feet. The coal is bituminous and makes a good coke. The Ping Hsiang colliery, the largest coal-mining plant in south China, is situated on this coal-field. In estimating the coal reserves, we may take the coal-bearing area at sixteen square miles and the average thickness of the coal to be twenty feet. The coal does not reach a very great depth, as the synclinal fold is a very gentle one and the coal may be mined below the hills occupying the basin. The actual reserves in this field, as above outlined, are about 325,000,000 tons and the probable reserves about 400,000,000 tons.

Other Coal-Fields

An important coal-field is situated about one mile north-west of Ping Hsiang city and many others of considerable extent and value are found in west central Kiangsi. Mr. G. Leinung, the chief engineer of the Ping Hsiang colliery, who has spent many years at this work in China, and knows Kiangsi province well, tells me that, besides the Ping Hsiang coal-field, there are many more in the province equally rich in coal deposits. It is impossible, of course, to make satisfactory estimates from general statements or from reconnaissance work, but we shall not, probably, overestimate the coal in the rest of Kiangsi by placing it at 3,000,000,000 tons, or ten times that of the Ping Hsiang coal-field.

KUANG TUNG

This province contains a great number of small coal-fields of little value and a few larger ones of considerable value. The coal-beds appear to range in age from Permo-Carboniferous to Jurassic, as they do in north China.

Lien Chow Coal-Fields

These fields, three in number, are situated in the north-west corner of the province, near Lien Chow. One of the three fields is about ten miles north-east of that place, one about six miles south-west of it, and the other about ten miles south of it. Only the last mentioned one was being worked when I visited that section. Two different coal-beds, each averaging about two feet in thickness, are being worked. The coal is bituminous and coking. I did not trace the coal-field to its limits, but it is probably not more than four square miles in area, which would give about 16,000,000 tons of coal.

Small coal-fields surround Shao Chow, at distances of from about two to fifteen miles, in practically every direction. All of these fields contain coal-beds that, in places, reach over one foot in thickness, and probably every field has at least one bed that is uniformly over one foot in thickness. Three of the fields have beds that are much more than one foot in thickness. We shall describe, principally, these three fields, and shall refer to them by the names: Tung Shui, Che-Ku Shek, and Mei Shan coal-fields. These three areas, as well as all the others near Shao Chow, were, doubtless, originally connected, but on account of severe folding, faulting, erosion, and deposition of overlying beds, are now disconnected or the connection cannot be traced from surface outcrops.

Tung Shui Coal-Field

This coal-field lies from three to six miles east of Shao Chow. The part that contains the best coal is about three miles long by two miles wide. It has at least six coal-beds. Five different mines examined showed coal-beds from one to two feet thick. Native miners say that one of the beds, formerly worked near the surface and not followed in depth on account of the difficulty of handling the water, is ten feet in thickness and the extensive mining which has been done here in the past supports the statement. The coal is bituminous, though the volatile matter is rather low for such coals. In estimating the amount of coal, we may take the thickness of the coal-beds to be ten feet and the area to be five square miles, which gives 50,000,000 tons.

Che-Ku Shek Coal-Field

This coal-field lies about six miles from Shao Chow in a direction a little east of north. The outcropping coal-bearing beds that have been proven workable, are about two miles long by one-half a mile wide. The beds dip about 60 degrees to the eastward. From an examination of eight different mines in this field, it is evident that there is one bed about five feet thick and probably there are two of that thickness, besides three beds which run from two to three feet in thickness. The combined thickness of all the beds is not less than eleven, and probably as much as seventeen, feet. The area may be taken at two square miles, which gives reserves as follows:

Actual coal reserves (A) about........	25,000,000 tons.
Probable coal reserves (A) about......	40,000,000 "

Mei Shan Coal-Field

This coal-field lies north of Shao Chow at a distance of from about seven to about seventeen miles. It is about eleven miles in length by three-fourths of a mile wide. The dip of the beds varies from nearly vertical to almost horizontal, but is usually about 50 degrees. The strata probably form a synclinal basin, but only one rim of the basin is exposed; the other, if it exists, is deeply buried by beds that lie unconformably above the coal-bearing beds. The coal-bearing strata are over 2,000 feet thick and contain coal-beds as follows:

One bed about 30 feet thick; one about 20 feet; two or three from four to six feet in thickness; and six or more beds from one to three feet in thickness. The thickness of these beds varies somewhat at different places, so that the average thickness throughout eleven square miles may not be more than 40 feet, though it is probable that it is 50 feet or more. In estimating the coal reserves we may take the thickness of workable coal, throughout ten square miles, as 40 and 50 feet, for actual and probable coal reserves, respectively. The coal belongs to class A_2; it is usually badly crushed, so that the beds vary much in thickness and the proportion of lump coal obtained in mining is usually small; the firmness increases with depth, however, even where the coal is crushed. The quality of the coal is good. From the above data the reserves of this field are as follows:

Actual coal reserves about...........	473,000,000 tons.
Probable coal reserves about.........	590,000,000 "

For four small coal-fields near Shao Chow, in which the best beds are but little over a foot in thickness, we may take their combined workable area at twelve square miles and the average thickness of workable coal at four feet, which gives about 18,000,000 tons. Some of this coal is bituminous, some is anthracite, but the greater part is semi-anthracite, and it may all be classed with some degree of certainty as A_2.

Chau Pei Coal-Field

This is a small anthracite coal-field situated about twenty-five miles north-east of Ying Te. From the examination of four coal mines, distributed along about a mile of the line of outcrops, the coal was found to be badly crushed and very irregular in thickness. The thickest coal found was about five feet, but the bed probably does not average over two feet in thickness over an area of about three square miles. The dip of the coal is usually very steep. Probable coal reserve for this field is about 6,000,000 tons.

Mao Shan Coal-Field

This coal-field lies immediately west and north-west of Canton. It is about eight miles wide and over twenty-five miles long and is synclinal in structure. The harder sandstone beds, accompanying some of the coal-beds, form low ridges along which the coal-beds outcrop at a number of places. The intervening softer strata has been worn down to a lower level and covered with Quaternary deposits. The present surface of these Quaternary deposits is but a few feet above tide. It is not known that the softer beds, now covered by Quaternary, contain coal-beds, but it is highly probable that they do. Associated with the harder sandstone strata, forming the ridges, there are at least five coal-beds, varying in thickness from one to about $3\frac{1}{2}$ feet, their combined thickness being about ten feet. Probably the best outcrops of the coal are found in the ridge by Si Liang. There are some indications that the seams decrease in thickness from Si Liang to the south-west, but as most of the coal-bearing beds are covered by Quaternary deposits, especially to the south-west of Si Liang, their value can be proved only by prospecting. The part of the synclinal basin that has coal of workable thickness, is about three or four miles wide. The dips vary, but average 45 or 50 degrees. It is not known how much of this field contains workable coal, but we may safely assume as a minimum, an area of thirty square miles with an average thickness of eight feet of coal. This gives a coal reserve of 189,000,000 tons. No analyses for classifying this coal are available.

Other Coal-Fields

In the extreme south part of the province, there are said to be good coal-fields, but I have no information regarding their value. In addition, a number of small coal-fields, of little value, are known. For all these we may assume the coal reserves to be 100,000,000 tons.

KUANGSI

It has been reported by various persons that good coal occurs in abundance in this province, but I have not been able to get definite details about the coal-fields. The Chinese Government is now engaged in development work on one of these fields, at Ho Hsien, in the east part of the province, about sixty miles north of Wu Chow. The coal-beds are said to be thick.

According to Leclère* the west part of the province is underlain by strata of two coal-bearing groups. We may estimate the coal reserves of this province (though without claiming any great degree of accuracy for the estimate) to be not less than 500,000,000 tons.

HUNAN

Richthofen† says: "The whole of the south-eastern Hunan may not unjustly be called one great coal-field. The total area comprises about 21,700 square miles. Probably more than one-half this area is covered by sediments many thousand feet in thickness and a small portion is occupied by more ancient rocks." He says that the field is divided into two almost equal parts comprising the Liu river coal-field on the south-east, which has anthracite, and the Siang river coal-field on the north-west, which has bituminous coal. He does not give much data about the thickness of the coal-beds, but considers the quantity of coal to be very great.

Liu River Coal-Field

My observations in this field were confined to a portion of the south border and mainly to a small coal-field near Mei Tein, a place about fifteen or twenty miles south-west of Ping Shih. This field contains at least six coal-beds that are being worked. Four of the beds average but little over a foot in thickness each; one bed is about five feet thick; and another fifteen feet, and in places fifty or more feet thick. The average aggregate thickness of the beds, over about twenty square miles examined, may safely be taken at twenty-five feet. One other outlying border coal-field, twenty miles farther to the south-west, has beds only one to two and three feet thick. The coal-beds over most of the Liu river coal-field are badly folded and crushed. If we assume that one-fourth of the area estimated by Richthofen may be mined and that the coal-beds throughout that area average fifteen feet in thickness, the reserve coal is about 48,000,000,000 tons of anthracite.

Siang River Coal-Field

For area and for thickness of coal-beds we may assume for this field the figures used for the Liu river field, which gives about 41,500,000,000 tons of bituminous coal.

Other Coal-Fields

It is known that the extreme west part of Hunan is also abundantly supplied with coal. For these coal-fields we may assume that the coal reserve amounts to only 500,000,000 tons, though it is probably much more.

* "Étude Géologique et Minière des Provinces Chinoises Voisines du Tonkin," Paris, 1902. Pl. XIII.

† "Letters" to Shanghai Chamber of Commerce, Shanghai, 1870-1872, p. 5.

SZECHUAN

Practically all the south-east part of the province is underlain by coal-beds, and scattered coal-fields are found in many other parts of the province. The coal-bearing strata underlying the great coal-fields of south-east Szechuan overlie the Sinian limestone, as is the case in many of the coal-fields of China. Most of the rocks outcropping along the east part of the province are limestones of this series; they dip westward, forming a great basin in which lie the coal-bearing beds and a great thickness of superimposed beds. Erosion and folds have made the coal-beds available for mining at various places over the basin. The total coal-bearing area is probably not less than 50,000 or 60,000 square miles, but probably not more than 15,000 square miles is available for mining if mining is limited to 4,000 feet in depth. Richthofen's views of the Szechuan coal-fields may be outlined as follows:* The coal-bearing ground of Szechuan probably exceeds that of any other province, while the part that may be mined is probably less than that of either Shansi, Hunan or Kansu; the aggregate thickness of coal-beds is probably less than in the other principal coal-bearing provinces; the coal is inferior in quality; the best coal is in the north part of the basin, where only bituminous coal is found; the coal deteriorates towards the east and south, where some anthracite appears; the coal-beds usually lie nearly horizontally.

Hosie, who travelled extensively in Szechuan, has many references to the coal found there. † His notes on this subject may be summarized as follows: Coal is abundant in many localities and is widely diffused throughout the province; it varies in quality from lignite in the far west to bituminous in the north and anthracite in the east; the beds usually lie horizontally; the best coal, so far as it is now known, comes from the portion of the valley of the Chia-ling river lying in the sub-prefecture of Chiang-pei Tang.

Baber ‡ and others, who have travelled extensively in Szechuan, refer to the abundance of coal in many parts of the province, but, unfortunately, give little or no data about the thickness, extent, or number of the coal-beds. Probably the majority of the workable beds vary from one to about five feet in thickness. The Kiang Pei Mining Company, which held mining rights on some coal deposits on the north side of the Yang Tse Kiang, immediately below Chung Kiang, reported one coal-bed in that field to be nine feet thick and to be a bituminous coal of good quality. It is possible to make only rough approximations in estimating the coal reserves of this province. If we assume that one-fourth of 60,000 square miles of coal-bearing territory may be mined; that the average thickness of the workable coal-beds throughout the 15,000 square miles is five feet; and that about one-fourth of the total is anthracite and about one-half of one per cent. lignite; the reserves are approximately the following:

Lignite	500,000,000	tons.
Bituminous	60,000,000,000	"
Anthracite	20,000,000,000	"

* "Letters" to Shanghai Chamber of Commerce, Shanghai, 1870-1872, pp. 122-123.

† "Report on the Province of Szechuan." Presented to Parliament, London, 1904., p. 94; also "Three Years in Western China," London, 1890.

‡ "Travels and Researches in the Interior of China."

KUEICHOU

This province is well supplied with coal. Leclère reports * coal underlying most of the central and western part of the province where he made investigations. His observations on this field may be summarized as follows:

Coal occurs in beds belonging to three different periods, the Carboniferous, the Permian, and the Rhætic; a coal-bed from one to one and a half metres in thickness occurs in each of these groups at many places and thinner beds are also found; the Rhætic especially has numerous coal-beds and mines; the Carboniferous coal, though bituminous, in places approaches anthracite. It runs high in ash and, in some cases, in sulphur. The Rhætic coal has more volatile matter than the other coals, it is brighter in colour and better in quality, but does not always make a good strong coke.

Hosie, in his journey through Kueichou, from the north to the south-west corner, noted that coal was being mined at intervals of twenty to forty miles all along the route he travelled. † He gives no details about the coal-beds nor about the quality of the coal.

There are probably not less than 50,000 square miles of coal-bearing lands in this province and probably not less than 10,000 square miles contain workable coal-beds that average at least three feet in thickness. These estimates are thought to be conservative, because the Rhætic coal-beds are the most important and, being the upper ones, are not so deeply buried; they also lie nearly level over large areas and could be mined continuously for long distances. From the above estimates of area and thickness of seams, the coal reserves of this province are about 30,000,000,000 tons. The most of the coal is bituminous.

YUNNAN

The work of Duclos, ‡ Leclère, ¶ and Lantenois § has shown that most of the east part of Yunnan is underlain by coal, belonging in age to the Carboniferous, Permian, Rhætic and Pliocene. The area of the coal-bearing part of the province is probably not less than 30,000 square miles. The Palæozoic coals are mostly bituminous and give a solid coke, but some are rather low in volatile matter for bituminous coal and they are rather high in ash as a rule. The Rhætic coals are usually brighter in colour, contain more volatile matter, give a lighter coke and have less ash than the Palæozoic coals. The Pliocene coals are lignites. Leclère regards the region around Yunnan as offering the most favourable indications for good deposits of Palæozoic ‖ coal. The coal there, he says, though little known, is probably of good quality, and the beds lie regularly over large areas at depths of between about 600 and 1,500 feet. He states

* "Étude Géologique et Minière des Provinces Chinoises Voisines du Tonkin." Paris, 1902, pp. 123-133 and Plates XI and XIII.

† "Three Years in Western China," London, 1890, pp. 24, 28, 36, and map.

‡ "Compte Rendu de la Mission Lyonnaise."

¶ *Ibid.*

§ *Annales des Mines*, Tome XI. Paris, 1907, pp. 385-405.

‖ *Ibid.*, p. 151.

that coal about one metre thick and lying almost horizontally occurs a short distance to the north-west of Yunnan Fu.* The following are some of the other localities where the occurrence of Palæozoic coal and the thickness of the beds have been noted by Leclère: about twelve miles south-east of Mengtsz, where a bed, of somewhat inferior coal, about one metre thick, occurs; about forty miles south-east of Yunnan Fu, at Lou Leang, where three or four seams of bituminous coal from 1½ to 2 metres thick occur, in beds of sandstone dipping at high angles, some of this coal is very bright in colour; about twenty miles north-east of Yunnan Fu, a bed of bituminous coal about one metre thick is found; at Cha Ko, about ten miles north of Tung Chwan, in north-east Yunnan, two seams are known, one about one metre thick and another, 150 feet higher in the group, three or four metres thick but containing much shale. Besides the above, Palæozoic coal from many other localities is noted by Leclère, but the thickness of the beds is not given.

The following is a list of references on the Palæozoic coal given by Lantenois: † (1) "Tong Hai" coal-beds, thickness of coal-bed from 0.2 to 1.0 metre; (2) "Pe-tchen" coal-bed, thickness 30 to 40 centimetres; (3) "Konen-iang" coal-beds, one bed about one metre thick and another about 1.7 metres thick; (4) Y-leang coal-beds, two beds, one about one metre thick and the other about 2½ metres thick.

The Rhætic coal also has a wide distribution and the beds in places attain a thickness of about 1½ metres.

Lantenois ‡ notes eight localities where lignite is found. The places that are apparently of the most importance are given as follows:

(1) "Lam-ty" valley coal-beds. Thickness 1½ metres to probably 12 metres. (2) "Yen-fen-tchouang" mine. Five or six beds varying in thickness from 5 to 15 centimetres. (3) "Mientien" and "Pe-Kia-Tchouang" mines. Coal-bed about one metre in thickness. (4) "Si-tchouang" mine. Coal-bed five metres thick. (5) "Pow-tchoo-pa" mine. Thickness of coal (brown lignite), about 20 metres. The mine is situated in a small valley about six kilometres long by three wide. The area of the valley is, probably, approximately the area of the lignite deposit.

All the areas underlain by lignite are small and the total amount of this coal is probably not more than 100,000,000 tons. To arrive at a basis for estimating the coal resources of the province, we may assume that only about one-third of the coal in the coal-bearing area of the province can be mined. Faulting, folding, and local thinning of the beds seem to justify the reduction of the area underlain by workable seams to 10,000 square miles. It is equally difficult to estimate the average thickness for the coal. From the data given and from other facts that are known, it would appear that the beds commonly aggregate from two to five feet in thickness in the various districts where they are mined; but while it is true that these may be the places where the coal reserves are greatest, it is also true that there are probably other areas where beds one foot in thickness occur which have been ignored by the miners. If we take three feet for

* *Ibid.*, p. 80.

† *Ibid.*, pp. 390-395.

‡ *Ibid.*, p. 386.

the average thickness of the coal throughout the 10,000 square miles, it would seem that at least we are not exaggerating the amount of coal in the province. From the above data the coal reserve is about 30,000,000,000 tons. Nearly all of this coal is bituminous. This estimate gives a total tonnage nearly one-third larger than that given by Leclère *, but he states that the average thickness of the coal, as used in his estimate, is in reality too small. He made his calculation on a basis of only ten to twenty centimetres for the average thickness of the coal.

The following tables give, in a condensed form, the estimates we have made for the coal reserves of each province. In most cases only the probable reserves are given. No attempt has been made to give estimates for the coal that lies between 4,000 and 6,000 feet in depth, because such estimates, with a few exceptions, would largely be guesses and of little value as contributions to our knowledge of the coal reserves as a whole.

* *Ibid.*, pp. 150-152.

COAL RESOURCES OF CHINA

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		
	No.	Thickness	Area in Square Miles	Class of Coal	Metric Tons	Area in Square Miles	Class of Coal	Metric Tons
CHIHLI—								
Hsin Chiu	....	20 feet	6	C	120,000,000	6	C	250,000,000
Pei P'iao	6	20 "	8	B	164,000,000	11	B	220,000,000
Nan P'iao	....	12 "	20	B	150,000,000	..	B	200,000,000
Nan P'iao	....	......	..	A	150,000,000	20	A	200,000,000
P'ing K'ou	10	35 feet	5	C	170,000,000	5	C	200,000,000
Shan Hai Kuan	....	8 "	6	A	55,000,000	6	A	75,000,000
Wang P'ing	....	30 "	30	A	1,065,000,000	..	..	1,500,000,000
		30 "	90	A	3,195,000,000	..	..	4,000,000,000
Fang Shan	....	20 "	12	A	190,000,000	..	..	240,000,000
		30 "	10	A	355,000,000	..	..	400,000,000
Chai Tong	....	35 "	30	B	386,000,000	..	B	660,000,000
				A	772,000,000	..	A	1,320,000,000
K'ai P'ing	6	64 "	25	B_2	1,641,000,000	42	B_2	2,757,000,000
Hsuan Hua	4	15 "	5	A	87,000,000	5	A	100,000,000
	5	20 "	2	A	45,000,000	2	A	60,000,000
		20 "	2	B	39,000,000	2	B	50,000,000
	2	6 "	4	B	18,000,000	..	B	40,000,000
Ling Shan	3-4	7 "	14	B	40,000,000	..	B	50,000,000
				A	20,000,000	..	A	30,000,000
Ching Hsing	6	35 "	10	B	356,000,000	..	B	400,000,000
S.W. Chihli	....	20 "	150	B	3,407,000,000	..	B	6,814,000,000
				A	851,000,000	..	A	1,602,000,000
Other places	....	......	..	..	....	..	C	500,000,000
							B	500,000,000
							A	500,000,000
Total	....	....	......	......	....	......	......	22,668,000,000

COAL RESOURCES OF CHINA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate		
	No.	Thickness	Area in Square Miles	Class of Coal	Metric Tons	Area in Square Miles	Class of Coal	Metric Tons
SHAN TUNG—								
Fang Tze	2	25 feet	8	B	202,000,000	8	B	245,000,000
Po Shan	12	25 "	100	B	1,360,000,000	150	B	2,000,000,000
				A	1,360,000,000	...	A	2,000,000,000
Yi Hsien	5	25 "	50	B	1,280,000,000	60	B	1,838,000,000
All other fields	....	......	..	..	....	...	..	1,000,000,000
Total								7,083,000,000
SHANSI—								
S.E. Shansi	....	25 feet	12,000	A	120,000,000,000	13,000	A	150,000,000,000
				A	120,000,000,000	......	A	150,000,000,000
				B	120,000,000,000	......	B	150,000,000,000
S.W. Shansi	....	25 "	......	..	....	10,000	B	255,890,000,000
Ta Tung Fu	....	30-40 "	100	B	3,060,000,000	200	B	8,200,000,000
Saratsi	....	10 "	......	..	....	25	B	250,000,000
Total								714,340,000,000
SHENSI—								
N. Shensi						......	B	1,000,000,000
All others								50,000,000
Total								1,050,000,000
KANSU—								
N.E. Kansu	....	10 feet				10	A	12,000,000
All others	....	10 "				500	B	5,117,000,000
Total								5,129,000,000

COAL RESOURCES OF CHINA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate		
	No.	Thickness	Area in Square Miles	Class of Coal	Metric Tons	Area in Square Miles	Class of Coal	Metric Tons
HONAN—								
N. Honan	....	....	.....	.....	....	300	B	700,000,000
							A	6,400,000,000
Honan Fu	....	10 feet	.....	.....	....	15	A	175,000,000
Lu Shan	....	10 "	.....	.....	....	200	B	2,000,000,000
Total	....	....	.....	.....	....	.....	.....	9,275,000,000
KIANGSU	....	....	.....	.....	....	.....	A	10,000,000
								10,000,000
ANHUI—								
Ning Kwo	....	....	.....	.....	....	.....	A	22,000,000
Chi Chow	1-3	5 feet	.....	.....	....	25	A	165,000,000
Total	....	....	.....	.....	....	.....	.....	187,000,000
HUPEI—								
Yi Shan	1	1½ feet	.....	.....	....	10	B	17,000,000
All other fields	....	....	.....	.....	....	.....	.....	100,000,000
Total	....	....	.....	.....	....	.....	.....	117,000,000
CHEKIANG—								
Tung Lu	1	2 feet	½	.....	....	½	.....	700,000
Kiang Shan	2	2 "	10	.....	....	10	B	6,000,000
							A	18,000,000
Total	....	....	.....	.....	....	.....	.....	24,700,000

COAL RESOURCES OF CHINA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

DISTRICT	COAL-SEAMS		ACTUAL RESERVE (Calculation based on actual thickness and extent)			PROBABLE RESERVES (Approximate estimate)		
	No.	Thickness	Area in Square Miles	Class of Coal	Metric Tons	Area in Square Miles	Class of Coal	Metric Tons
FUKIEN	...	...	...	...	...	...	...	25,000,000
								25,000,000
KIANGSI—								
Lo Ping	...	5 feet	5	...	...	5	...	25,000,000
E. Kiangsi	...	...	...	...	...	10	B	20,000,000
P'ing Hsiang	6	25 "	16	B	325,000,000	16	B	350,000,000
All others	...	...	...	...	...	...	...	3,000,000,000
Total	...	...	...	...	...	...	...	3,395,000,000
KUANG TUNG—								
Lien Chow	...	4 feet	4	...	...	4	B	16,000,000
Tung Hsui	...	10 "	5	...	...	5	...	50,000,000
Cheku Sheck	...	11-17 "	2	...	25,000,000	25	...	40,000,000
Mei Shan	...	40-50 "	10	...	473,000,000	10	...	590,000,000
Four others	...	4 "	12	...	...	12	...	18,000,000
Chow Pei	...	2 "	...	...	...	3	...	6,000,000
Mao Shan	4	8 "	...	...	...	30	...	189,000,000
All others	...	...	...	...	...	...	...	100,000,000
Total	...	...	...	...	...	...	...	1,009,000,000
KUANGSI—								
All of Province	...	...	...	...	...	...	...	500,000,000
								500,000,000

COAL RESOURCES OF CHINA—*Continued*

GROUP I

INCLUDING SEAMS OF 1 FOOT OR OVER, TO A DEPTH OF 4,000 FEET

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		
	No.	Thickness	Area in Square Miles	Class of Coal	Metric Tons	Area in Square Miles	Class of Coal	Metric Tons
HUNAN—								
Liu River	....	15 feet	......	......	....	2,700	A	48,000,000,000
Siang River	....	15 "	......	......	....	2,700	B	41,500,000,000
All others	....	....	......	......	....	......	......	500,000,000
Total	....	....	......	......	....	......	......	90,000,000,000
SZECHUAN	....	....	......	......	....	15,000	D	500,000,000
							B	60,000,000,000
							A	20,000,000,000
Total	....	....	......	......	....	......	......	80,500,000,000
KUEICHOU	....	....	......	......	....	10,000	B	30,000,000,000
								30,000,000,000
YUNNAN	....	....	......	......	....	25	D	100,000,000
						10,000	B	30,000,000,000
Total	....	....	......	......	....	......	......	30,100,000,000

To further condense the above tables we give the total amount of coal estimated as probable reserves for each province, which is as follows:

	Metric Tons
Mongolia	1,200,000,000
Chihli	22,668,000,000
Shantung	7,083,000,000
Shansi	714,340,000,000
Shensi	1,050,000,000
Kansu	5,129,000,000
Honan	9,275,000,000
Kiangsu	10,000,000
Anhui	187,000,000
Hupei	117,000,000
Chekiang	24,700,000
Fukien	25,000,000
Kiangsi	3,395,000,000
Kuangtung	1,009,000,000
Kuangsi	500,000,000
Hunan	90,000,000,000
Szechuan	80,500,000,000
Kueichou	30,000,000,000
Yunnan	30,100,000,000
Total	996,612,700,000

The above estimates are sure, in many cases, to be far from correct, but it is believed that they will more often err in being too small than in being too large. It is very probable that the estimates given for the coal reserves of Kansu, and Mongolia, especially, are much too small, while the reserves attributed to Shansi, Kueichou, and Yunnan may be somewhat too large. On the whole we believe the data at hand fully justifies the statement that the coal reserves in China are at least as great as the total given above, and that future investigations will probably determine the real reserves to be much greater.

The following table gives a few analyses of Chinese coals.

Locality	In 100 Parts of the Original Coal					Analyst	Remarks
	Water	Volatile Hydro-Carbons	Fixed Carbon	Ash	Sulphur		
Chihli—	%	%	%	%	%		
Hsin Chiu Coal-Field..	9.97	32.41	45.78	11.88	1.91	N. F. Drake........	Average of 12 analyses
Pei P'iao Coal-Field....	3.25	32.00	58.65	6.10	....	W. A. Moller*......	Average of 2 analyses
Nan P'iao Coal-Field...	2.50	31.00	57.50	6.50	....	W. A. Moller.......	Average
P'ing K'Ou Coal-Field.	......	48.00	46.00	6.00	0.76	W. A. Moller.......	
Wang P'ing Coal-Field.	2.67	4.08	82.64	10.59	0.36	N. F. Drake.......	
Fang Shan Coal-Field..	5.11	6.83	72.14	15.91	0.17	N. F. Drake........	Average of 2 analyses
Chai T'ong Coal-Field.	1.20	21.54	71.14	6.11	1.05	N. F. Drake........	Average of 3 analyses
Chai T'ong Coal-Field.	3.62	5.31	84.93	6.13	0.43	N. F. Drake........	Average of 2 analyses
K'ai P'ing Coal-Field..	1.00	26.00	58.00	15.00	1.00	Chinese Eng. M. Co.	Average of 2 analyses
Hsuan Hua Coal-Field..	3.49	15.93	72.49	8.07	0.10	N. F. Drake........	
Hsuan Hua Coal-Field.	1.16	3.21	83.19	12.43	0.10	N. F. Drake........	
Ching Hsing Coal-Field.	0.89	27.97	61.04	9.64	1.45	C. Yang...........	
Shantung—							
Yi Hsien Coal-Field....	0.52	28.60	63.31	7.05	0.52	K. Y. Kwong*......	
Shansi—							
Tse Chou Coal-Field...	2.26	3.43	84.66	9.63	0.36	N. F. Drake........	Average of 7 analyses
P'ing Yao, S.W. Shansi..	0.49	17.81	57.70	23.98	2.80	N. F. Drake........	Average of 2 analyses
Yang Chuan, S.E. Shansi...............	1.78	7.62	80.93	9.66	1.40	C. Y. K'uang......	
Ch'in Shui S.E. Shansi...	1.28	9.79	89.06	11.60	1.80	E. T. Nystrom.....	
Ta Tung Coal-Field....	4.45	30.17	65.38	4.06	1.29	E. T. Nystrom.....	
Saratsi Coal-Field......	1.16	29.38	69.46	6.97	0.78	E. T. Nystrom.....	
Honan—							
Chang Ho Coal-Field...	0.79	14.16	75.09	9.95	0.58	N. F. Drake........	Average of 6 analyses
Jai-mei-sen Coal-Field...	......	6 to 7	84.50	10.00	....	Peking Syndicate...	Average analysis
Anhui—							
Ch'i Cho Coal-Field....	13.00	....	73.00	14.00	....	J. C. F. Randolph*.	
Chekiang—							
Tung Lu Coal-Field...	2.10	4.41	70.74	22.74	....	N. F. Drake.......	

* Authority.

ANALYSES OF CHINESE COALS—*Continued.*

Locality	In 100 Parts of the Original Coal					Analyst	Remarks
	Water	Volatile Hydro-Carbons	Fixed Carbon	Ash	Sulphur		
Kuang Tung—							
Lien Chou Coal-Field...	1.09	15.00	66.46	17.44	3.07	Frank Browne......	
Tung Shui Coal-Field..	0.80	10.47	67.62	21.11	4.37	Frank Browne......	
Che Ku Sheck Coal-Field...............	1.07	7.63	85.25	6.04	0.89	Frank Browne......	Average of 3 analyses
Mei Shan Coal-Field....	0.79	9.34	83.45	6.41	1.06	Browne & Franklin..	Average of 11 analyses
Hunan—							
Mei T'ien S. Hunan....	1.84	6.32	82.58	9.26	0.73	Frank Browne......	Average of 4 analyses
Kueichou—							
S.W. Kueichou........	0.80	9.50	....	35.00	....	Leclère*...........	Palæozoic coal
Near Kouei Yang......	0.60	12.80	....	8.80	....	Leclère*...........	Rhætic coal

* Authority.

Very little attempt has been made to closely classify the coals in the various coal-fields because they are not well known, and because in many coal-fields the coal changes in character very much at various parts of the field. The few analyses given will probably represent fairly well the principal varieties of coal found in China and will approximately represent the coals as a whole.

Coal has been mined in China for many hundreds of years but the methods of mining were rude and facilities for transportation so poor that the mines, for the most part, only supplied local demands. Improved mining methods and facilities for transportation are now making good progress, as may be seen from the table given below.

LIST OF THE MOST IMPORTANT COAL-MINING COMPANIES NOW OPERATING IN CHINA

Locality	Name of Company	Nationality of the Company	Output 1911	Output 1912
Manchuria—				
Fu Shun	South Manchuria Railway Co	Japanese	1,186,600	1,600,000*
Pon Hsi Hu		Sino-Japanese		200,000*
Chihli—				
Chi Min Shan	Chi Min Shan Colliery	Chinese		40,000*
K'ai P'ing Coal-Field	Chinese Eng. & Mining Co.†	British	1,170,163	1,453,540
K'ai P'ing Coal-Field	Lan Cho Mining Co.†	Chinese		300,000*
Ching Hsing	Ching Ching Min. Co.	Sino-German	198,000	350,000*
Lin Cheng		Chinese		200,000*
Shansi—				
Yang Chuan	Pao Chin Mining Co.	Chinese		75,000*
Honan—				
Twenty miles west of Chang Te Fu	Liu Ho Kao Min. Co.	Sino-German		75,000*
Jai-mei-sen	Peking Syndicate	British		500,000*
Shantung—				
Fangtse and Hung Shan	Shantung Bergbau Coal Co.	German	500,000*	600,000*
Yi Hsien	Chung Hsing Min. Co.	Chinese	160,000	200,000*
Kiangsi—				
P'ing Hsiang	Han Yeh P'ing Iron and Coal Co.	Chinese	700,000*	800,000*
Kuangsi—				
Ho Hsien		Chinese		No data
Total about				6,393,540

* Estimated.

† During 1912 the Chinese Engineering and Mining Co. and the Lan Cho Mining Co. amalgamated under the name of the Kailan Mining Administration.

THE COAL RESOURCES OF CHINA

BY

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(With one map in the Atlas and sixteen figures in the text)

I—INTRODUCTION

In China almost all the valuable minerals are known to occur and most of them have been worked from remote times. Among these mineral resources coal is by far the most important and is said to have been mined for several thousand years, being used as fuel for furnaces and also as a substitute for wood and charcoal in domestic use. Though Chinese mining originated in remote and ancient times, it was not developed, and most of the mines are still worked by old and primitive methods. Recently new and extensive plants have been introduced, but mining generally is in a backward state as compared with what is being done in Europe and America. As to the history of the mining industry in China, only a few sources of information are accessible to me at present. No geological survey nor mining exploitation has yet been undertaken either by the Government or by private individuals.

Geologists and mining engineers of Europe and America have paid great attention to the geology and mineral resources of the Empire, and their results have been published, in their respective countries, in extensive and interesting works. Our country is next neighbour to the great Empire, and yet our knowledge of its mineral resources is limited and very imperfect, and our reports are all fragmentary and incomplete. Under these circumstances it is not possible at present to speak with any certainty about the distribution and the reserves of coal in China. Nevertheless, I shall try to compile an article about China's coal deposits, basing my statements on facts furnished by our geologists and mining engineers, together with data obtained from reports published in Europe and America.

Among all forms of China's mineral wealth, coal has been the most important in the past, as it will be the most important in the future, extending, as it does, over wide areas in almost every one of the provinces. Some coal-fields in the provinces of Chih-li-shêng, Shan-tung-shêng and Kiang-si-shêng are now worked under the management of European engineers by European capitalists on a somewhat large scale, the annual production exceeding 200,000 tons. Besides these, thousands of small mines scattered throughout the Empire are worked according to primitive Chinese methods.

II—THE GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF COAL

The most important coal is imbedded in the Carboniferous, and next in importance comes the Jurassic coal. In the Permian also and in the Triassic, coal is known to occur, but it is not important when compared with that in the Carboniferous and the Jurassic. In the province of Yün-nan-shêng coal is said to be found in what is probably a Silurian formation, but it is insignificant in amount.

The so-called Sinian formation covers large areas in the Empire, overlaid by heavy limestone. The stratigraphical relation of the Sinian formation to the limestone is not well understood, but it is probable from their mode of occurrence that the limestone lies on the Sinian, sometimes conformably and sometimes unconformably. The thickness of the limestone is very great, being from 2,000 to 3,000 feet, sometimes even exceeding 4,000 feet, with intercalated sandstone and shale. Possibly its lowest horizon represents the pre-Carboniferous, but the greater part undoubtedly belongs to the Upper Carboniferous. Where it attains greatest development its uppermost horizon is considered to belong to the Lower Mesozoic. It extends very widely over the provinces lying to the south of the Yang-tse-kiang; while in the northern part it occupies small areas, scattered over several regions.

The coal-bearing formation rests generally on limestone, and consists chiefly of sandstone and shale, sometimes with limestone and conglomerate. Upwards it passes into the so-called Thick Red Sandstone, often without any unconformability, but to the underlying limestone it holds the same relation as that of the limestone with the Sinian formation, the coal-bearing formation lying on the limestone, sometimes conformably and sometimes unconformably. Indeed, in the coal-bearing formation are thick beds, the lower part of which belongs to the Upper Carboniferous, and the upper part to the lower Jurassic, the two formations pass into each other without any interruption, as can be seen to the west of Pe-king. Thus it will be seen that the coal occurs in the formations from the Upper Carboniferous to the Jurassic, though the coal in the Upper Carboniferous is most important and extends over large areas in the Empire, yielding extraordinarily large quantities.

The Coal-Measures of the Upper Carboniferous occupy wide areas over the provinces, especially north of the Yang-tse-kiang, and contain abundant coal-seams with thin limestone. The total thickness is generally estimated to be from 1,000 to 2,000 feet. The coal-fields in the provinces of Chih-li-shêng, Shan-si-shêng, Shan-tung-shêng, Ho-nan-shêng, Kiang-si-shêng and Hu-nan-shêng are well known; and fields in Chih-li-shêng, Shan-tung-shêng and Kiang-si-shêng are worked by modern mining methods. The coal-field of Shan-si-shêng is considered to be the largest in the Empire but it is not yet opened to us.

The most important coal in the Jurassic is found in the province of Ssŭ-ch'uan-shêng, whence it seems to continue eastward to the provinces of Hu-peh-shêng and Shen-si-shêng. Two other coal-fields, namely the field of Ta-tung in the province of Shan-si-shêng and that of Hsi-shan to the west of Pe-king are also noted. Also small coal-fields are found scattered over the Empire.

The coal in the Permian and in the Triassic is not so important as that in the Carboniferous or the Jurassic.

The stratigraphical position of the different coal-seams and their correlation have not yet been worked out.

As to the geological age of the coal-bearing formations, it is difficult to speak with any precision. The Jurassic coal-beds in many places contain a fossil flora, by an examination of which the geological horizon of the coal-seams has been established. To our regret, however, no fossils are found in the strata considered as Carboniferous, except in a few cases. Even where fossils have been found in these strata, the horizon from which they have been collected has not been carefully recorded, so that it is often difficult to fix the geological age of particular beds even after the fossils have been determined. The difficulty is enhanced by the great thickness of the coal-bearing formation, as above stated. Some geologists refer the coal-bearing formation, now known as the Carboniferous in the provinces of Kiang-si-shêng and Hu-nan-shêng, to the post-Carboniferous or Permian and even to the lowest Mesozoic. Mr. Frech in his study of fossils in China, considers the large coal-field in Shan-si-shêng as probably Permian; and those in K'ai-p'ing and some in the province of Hsing-king-shêng as undoubtedly Permian; while those in the province of Shan-tung-shêng he thinks represent the Lower Carboniferous. He finally concludes that the most important coal-fields in China probably belong to the Permian. Under these circumstances it is quite impossible to determine the geological age of the coal-bearing formation now considered as Carboniferous or to correlate the coal-seams on any sure basis; however, it seems to me that the formation probably ranges from the Upper Carboniferous to the Permian and even to the Triassic. Though with great uncertainty, I here refer the coal-bearing formation to the Upper Carboniferous, as it is now generally considered to be, since this paper is only a preliminary report, compiled from the data now accessible.

III—THE QUALITY OF COAL

There are two kinds of coal in the Chinese fields, the bituminous variety and anthracite. The anthracite is consumed by Chinese chiefly as a substitute for wood and charcoal for domestic purposes, and as fuel in limekilns. The mines working anthracite are very numerous and are scattered over almost all parts of the Empire. Not one of these is worked with a large plant but only on a small scale by old mining methods. Thus it is difficult to estimate the total output of anthracite, but it must reach a large amount. The important coal-fields yielding anthracite lie in north China, in the provinces of Chih-li-shêng, Shan-si-shêng and Ho-nan-shêng. Those in the provinces of Hu-nan-shêng, Hu-peh-shêng, Fuh-kien-shêng and Kuang-tung-shêng, are not so important as those given above. The largest coal-field is in the province of Shan-si-shêng, while the coal-fields in the province of Ho-nan-shêng and to the west of Pe-king come next. Those in the province of Shan-tung-shêng yield both bituminous and anthracite coal.

The coal worked on a large scale by modern methods all belongs to the bituminous variety. It is of good quality, black in colour, and generally cakes, being also well fitted for the manufacture of coke. The distribution of bituminous coal is very wide, extending throughout the Empire. The coal-fields of K'ai-p'ing, Ching-hsing, Lin-ch'êng, and P'ing-hsing are well known.

IV—THE QUANTITY OF COAL

For estimating the coal reserves in China we have no sure basis, as I shall explain later on, and the quantities given by several geologists and mining engineers, vary widely. Generally, they seem to have been overestimated, but from the figures given we can imagine how enormous the Chinese coal reserves are. From the area of the coal-fields and the thickness of the coal-seams the following figures have been obtained, though the data are none of them trustworthy, not being based on actual surveys.

District	Thickness	Probable Reserve			Possible Reserve
		Area	Class of Coal	Metric Tons	
Chi-li:		438 sq. km.		3,080,000,000	Enormous
K'ai-p'ing	Agg. 60 to 85 ft.	12 sq. km.	..	400,000,000	Large
Shih-mên-chai	Agg. 16 to 20 ft.	30 "	A_2	200,000,000	Moderate
Ching-hsing	6 to 20 ft.	25 "	B_2	120,000,000	Moderate
Lin-ch'êng	7 to 8 ft.	35 "	C	100,000,000	Moderate
Hsin-ch'iu	Agg. 38 ft.	8 "	C	120,000,000	Moderate
Wu-chia	33 ft.	84 "	C	1,000,000,000	
Shih-ta-fên	Agg. 12 ft.	244 "	C	1,140,000,000	
Other coal-fields	....	....	..	....	Large
Shan-tung:		104 sq. km.		650,000,000	Large
Wei-hsien	15 to 20 ft.	20 sq. km.	C	100,000,000	
Po-shan	8 to 10 ft.	14 "	B_2	50,000,000	
I-hsien	13 to 25 ft.	70 "	..	500,000,000	
Other coal-fields	....	....	..	....	Large
Shan-si:		200 sq. km.		1,200,000,000	Enormous
Ta-tung	15 to 20 ft.	200 sq. km.	..	1,200,000,000	
Other coal-fields	....	....	..	....	Enormous
Ho-nan:		30 sq. km.		200,000,000	Large
Huai-ch'ing	15 to 25 ft.	30 sq. km.	..	200,000,000	Large
Other coal-fields	....	....	..	....	Large

District	Thickness	Probable Reserve			Possible Reserve
		Area	Class of Coal	Metric Tons	
CHEH-KIANG:		95 sq. km.		120,000,000	Large
Hsi-an	4 ft.	35 sq. km.	..	80,000,000	Moderate
Chang-shan	3 ft.	35 to 40 "	B_2	40,000,000	Moderate
Other coal-fields	....	....	..	....	Large
FUH-KIEN:		30 sq. km.		80,000,000	Large
Lung-yen	8 ft.	20 to 30 sq.km	A_1	80,000,000	Moderate
Other coal-fields	....	....	..	....	Large
KIANG-SI:		278 sq. km.		1,435,000,000	Large
Fêng-ch'êng	4 to 6 ft.	200 "	..	400,000,000	Large
P'ing-hsiang	10 to 13 ft.	60 "	B_2	300,000,000	Large
Hsin-yü	6 to 7 ft.	8 "	..	20,000,000	Large
Hsing-an	4 ft.	10 "	..	15,000,000	
Other coal-fields	....	....	..	700,000,000	Large
HU-NAN	15 ft.	3,000 sq. km.	..	17,000,000,000	
SSŬ-CH'UAN	6 ft.	6,450 sq. km.	C	15,000,000,000	
Coal-fields in the other provinces	....	....	..	....	Large
Totals	....	10,625 sq. km.	..	38,765,000,000	Enormous

V—THE PRODUCTION OF COAL

There is no statistical report on the mineral production of China, except in the case of a few mines, and the same is true of the production of coal. However, we may make a probable estimate based on fairly accurate reports and other sources of information.

In the province of Chih-li-shêng, the production reaches 3,000,000 tons, about one-third being anthracite. In the province of Shan-tung-shêng the coal mined by the German company is roughly 700,000 tons, and that mined by the Chinese in several coal-fields will quite equal this amount. Thus the total amount will be about 1,400,000 tons. According to another source of information it is 1,573,000 tons. In the province of Shan-si-shêng, the environs of Tsê-chou are most famous for anthracite and furnish a large amount to the

Chinese market. The coal-field of Ping-ting-fu has recently developed, under the stimulus of railway facilities. This coal-field, together with numerous other fields in the province, will furnish quite as much coal as that raised in the environs of Tsê-chou. Thus the total amount will probably reach 4,000,000 tons. The Ta-tung coal-field yields bituminous coal, the amount of the production not being reported. In the province of Ho-nan-shêng the production raised by the Pe-king syndicate is over 500,000 tons and that of the province will reach 1,000,000 tons. In the province of Kiang-si-shêng, the P'ing-hsiang coal-field yields 610,000 tons. Other coal-fields occupy very wide areas in the province and the total amount raised in these fields will probably not fall below that amount. The production in the provinces of Hu-nan-shêng and Ssŭ-ch'uan-shêng is estimated to be 4,500,000 and 1,000,000 tons, respectively. In the province of Shen-si-shêng a large coal-field, regarded as the continuation of that in the province of Ssŭ-ch'uan-shêng, is worked at several places and the production of coal will reach a moderate amount, probably more than 500,000 tons. In the province of Hu-peh-shêng the output of the Ma-an-shan mine is estimated to be 70,000 tons, and the total production in Wu-chêng 120,000 tons, the total in the province being estimated at 200,000 tons. The production in the provinces of Cheh-kiang-shêng, Fu-kien-shêng and Kuei-chou-shêng is about 50,000 tons; of An-hui-shêng, 60,000 tons; and of Kiang-su-shêng, 30,000 tons. For the production in other provinces where I have no information, the figures are taken from *Mineral Industry.*

Province	Production estimated	Production given by "Mineral Industry"
Chih-li	3,000,000	
Shan-tung	1,573,000	
Shan-si	4,000,000	
Ho-nan	1,000,000	
Shen-si	500,000	
Kan-suh	......	500,000
Kiang-su	30,000	
An-hui	60,000	
Cheh-kiang	50,000	
Hu-peh	250,000	
Fu-kien	50,000	
Kiang-si	1,000,000	
Hu-nan	4,500,000	
Ssŭ-ch'uan	1,000,000	
Kuei-chou	50,000	
Yün-nan	....	300,000
Kuang-tung	....	50,000
Kuang-si	....	100,000
	17,063,000	950,000
		17,063,000
		18,013,000

It will be seen that this estimate of the production of coal in China, though based on probable standards, reaches nearly 18,000,000 tons, and I think the error will not exceed 20 or 30 per cent., the amount probably lying between 15,000,000 and 20,000,000 tons. Bituminous and anthracite coals are produced in almost equal quantities.

The production of coal in China has been steadily and rapidly increased year by year, especially in recent years, by the development of transportation facilities, the importation of foreign capital, and by the improvement of mining methods, and the introduction of modern mining plants. In the near future many of the coal-fields in the Empire will furnish one million tons or more a year. They will be worked with much greater activity than they are at present, and a much greater production may be expected.

VI—IMPORT AND EXPORT OF COAL

The consumption of coal in China is very small, compared with the area and population. Owing to the primitive methods of mining, China imports coal from other countries, especially from Japan, though her own coal reserves are enormous. The import and export of coal in China for the years 1907-09 were:

	Export	Import
1907	6,351 tons	1,403,472 tons
1908	27,894 "	1,504,549 "
1909	195,950 "	1,516,629 "

The export of coal is at present very small but is rapidly increasing, while the import remains almost constant. The coal consumed in the Empire is thus seen to be nearly 20,000,000 tons. It may be suggested that China, by the development of her transportation and industries, will require in the near future a much larger amount of coal than at present, but the enormous coal reserves in the Empire will suffice to meet the increased demand.

VII—CONCLUSION

From the foregoing chapters it will be seen that the coal-fields cover large areas in the Empire and the coal reserves reach the extraordinary amount of several hundred billion tons, though they are calculated on merely probable grounds and without the aid of accurate statistics. The amount may be adequate to meet the total coal consumption of the world for several hundreds of years. The development of the mining industry and of transportation facilities will promote the exploration and examination of the coal-fields in China. Further, by exploitation and drilling new coal-fields may be opened or discovered and concealed coal brought to light. Thus we have reason to believe that the amount given above is not far from correct and that it will be increased in the future.

The collieries now worked with large mining plants and yielding moderate amounts of coal are not many in number, but mines that are being worked at present by the old mining methods will, sooner or later, be equipped with large plants by which the production will be rapidly increased. The annual import of coal is now nearly 1,500,000 tons and has been almost constant through the last few years, while the export is still insignificant though rapidly increasing. Though industries as well as transportation in the Empire are rapidly developing and the consumption of coal increasing with great rapidity, the coal reserves are so enormous that China will be able not only to meet its own demands but also to supply the coal market of the Orient. Thus it is obvious that to understand the possibilities of the coal trade in the Orient we must have a good knowledge of the huge areas in China underlain by coal. It is absolutely necessary therefore to carry out a systematic geological survey of the Empire.

VIII—DESCRIPTION OF THE COAL-FIELDS

Most of the coal deposits in China are interbedded in the Carboniferous, but they are also often found in the post-Carboniferous strata, especially in the Jurassic. Of the latter, the coal-field of Ssŭ-ch'uan-shêng is the best known. Small Jurassic fields are also scattered over the Empire, especially in middle China. The geological age of the coal-bearing formations is obscure, and only in a few cases has it been possible to determine it by fossil evidence.

In these circumstances it may be found, on closer examination and study of the strata and fossils, that the geological ages of some of the coal-fields may have been mistaken and that what has been called the younger formation is really the older, and vice versa. In the present paper I have decided the geological ages according to such data as are now accessible, though they are not all reliable.

COAL-FIELDS IN THE CARBONIFEROUS

Chih-li-shêng

In the province of Chih-li-shêng the most famous is the K'ai-p'ing coal-field, which is located in the northern part of the province. The Hsi-shan field to the west of Pe-king, and the Ching-hsing and Lin-ch'êng fields in the south-western part of the province have been opened recently.

K'ai-p'ing coal-field

The K'ai-p'ing coal-field (Fig. 1) is situated on the railway, almost midway between T'ien-ching and Shan-kai-kuan, the mining centres being T'ang-shan and Lin-hsi. T'ang-shan station lies 129 km. by rail from T'ien-ching, 100 km. from T'ang-ku, and 118 km. from Ch'in-hun-tao; while Lin-hsi station is 127 km. from T'ang-ku and 90 km. from Ch'ian-hung-tao, the distance between the two stations being 27 km. The mine has been worked since the Ming dynasty, and here modern methods were first introduced into China. In 1879 a shaft was sunk at T'ang-shan as a Chinese enterprise. In 1900, the mine was transferred to the Chinese Engineering and Mining Company (the so-called K'ai-p'ing Mining Company) chiefly under the management of Englishmen. It is known as K'ai-p'ing colliery. The T'ang-shan pit is now the largest in the Empire. Its shaft was the first that was sunk, and it is the one most actively worked at present. The Lin-hsi pit is the next in importance.

The total amount of coal mined from 1881 to 1909 is roughly estimated

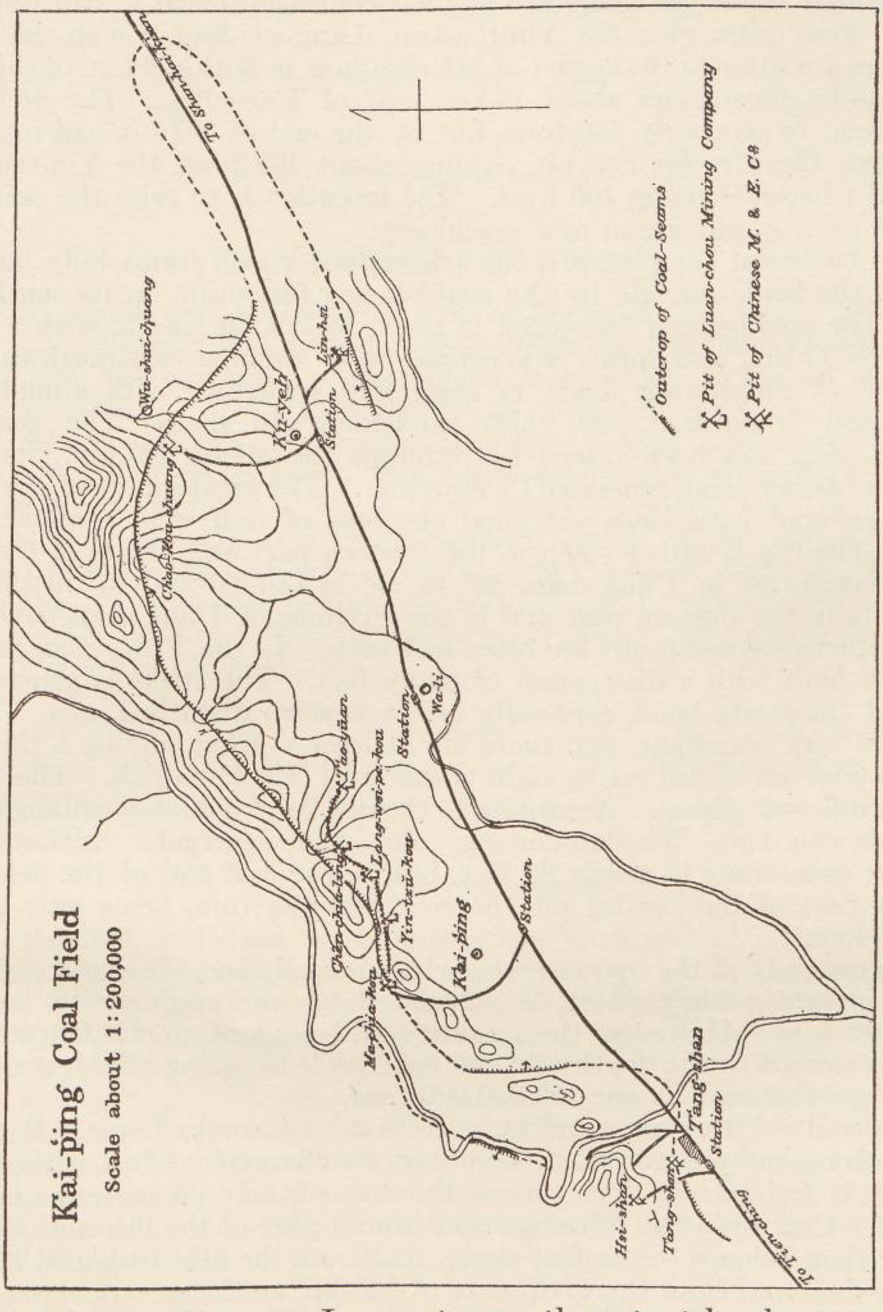


Fig. 1

Kai-ping Coal Field

Scale about 1:200,000

to have been 16,000,000 tons. In recent years the output has been as follows: 1907, 1,117,600 tons; 1908, 1,226,000 tons; 1909, 1,359,500 tons; 1910, 1,159,000 tons.

The Luan-chou colliery has been recently opened and is worked by the

Luan-chou Mining Company, its concession adjoining that of the Chinese Engineering and Mining Company. Ma-chia-kou, the headquarters of the company, lies about 4 km. north of K'ai-p'ing. These two companies have long disputed about the boundary of their concessions and it still remains unsettled. Four pits, viz., the Yin-tzu-kou, Lang-wei-kou, Ch'ên-chis-ling and T'ao-yüan are situated to the east of Ma-chia-kou, or within 6 km. of the railway, and Chao-ko-chuang lies about 16 km. east of T'ao-yüan. The daily output of coal used to be nearly 450 tons, but by the end of 1910 it had increased to 1,000 tons, the Ma-chia-kou pit yielding about 400 tons, the Yin-tzŭ-kou 100 tons and Chao-ko-chuang 400 tons. The intention is to raise the daily output to 3,000 tons by putting in new machinery.

The basement complex is a thick limestone which forms hilly land to the north of the field, overlaid by the coal-bearing formation on its south-western flank. The coal-bearing formation is about 48 km. in length, with a width of from 3 to 11 km. and forms a synclinal basin running east-north-east. It is composed of alternating strata of shale and sandstone with abundant coal-seams, and is covered with thick sandstone and shale. The coal of the northern wing has been traced by outcrops for about 48 km., its possible extension further being concealed by alluvium. The greater part of the southern wing is covered with loess, yet good outcrops of coal were examined at two places. The dip is rather steep in the western part and gentle in the eastern, being generally 50° in T'ang-shan, 20° to 25° in Lin-hsi and 45° in the middle. The strata in the western part and in the environs of T'ang-shan have suffered much disturbance and faults are often met with. In the T'ang-shan pit there is a notable fault with a dislocation of many feet. The strike is generally east-west, but the strata bend, especially in the western disturbed area. The coal-seams are very abundant, and there are at least a dozen having a thickness of over one foot each, and six or eight seams over 2.5 feet thick. The thickness varies at different places. According to the results of diamond drilling at T'ang-shan, Ma-chia-kou, Wu-shui-chuang, etc., the aggregate thickness of 13 workable coal-seams is nearly 85 feet, but at the east end of the field and the southern part of the Lin-hsi pit the coal becomes thin, being only 60 feet in total thickness.

The quantity of the coal reserves, which is easily accessible and easily mined by the present mining plant, is calculated by the engineer to be roughly 15,000,000 tons. However, the quantity will amount to 225,000,000 tons if mining is carried to the depth of 2,000 feet, while by going still deeper it would be quite possible to take out 400,000,000 tons.

The coal is bituminous and burns with a long, smoky flame. It cakes and gives a strong and porous coke. However, its character differs with each coal-seam. It is divided into three classes, the ratio of their quantities being roughly 1 : 4 : 7. Coal from the 5th seam and from a part of the 9th and 10th seams of T'ang-shan belongs to the first class; that from the 9th, 10th and 12th seams of T'ang-shan and from the 11th seam of Lin-hsi, to the second class; and that from the 3rd, 7th, 8th, 11th, and 13th seams of T'ang-shan, and from the 8th and 9th seams of Lin-hsi pit, to the third class. The yield of lump coal is 35 to 40 per cent., sometimes 60 per cent. The results of technical analyses of the coal, given by Mr. Drake, together with the result obtained by us, are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
First class.........	0.64%	22.27%	71.55%	5.54%	0.98%	1.285	.....	.....	B_2
Second class.......	0.68	21.03	67.78	10.52	0.16	1.32	.....	.....	B_2
Third class.........	0.61	19.82	64.62	15.23	0.95	1.32	.....	.....	B_2
5-ft. Seam (fit for (coke-making)....	0.62	29.49	65.10	4.78	0.68	.....	.....	.....	B_2
Lin-hsi............	1.23	26.14	62.11	10.52	0.79	1.430	7,040c	12,672	B_2
9th Seam in Ma-chia-kou.........	1.13	22.49	66.69	9.69	0.52	1.355	7,198	12,956	B_2

SHIH-MÊN-CHAI COAL-FIELD

The Shih-mên-chai coal-field is located about 35 km. north of Shan-hai-kuan in Lin-yü-hsien, and includes the villages of Hei-shan-kung-ling, Shih-mên-chai and Yi-yüan-k'ou, occupying an area nearly 35 km. in length and 4 km. in breadth. It belongs to the same formation as that of K'ai-p'ing. Three or four coal-seams are known, the upper having a thickness of four or five feet, and the lower of fifteen feet. The coal is now mined by Chinese on a small scale, the number of these small mines exceeding three hundred, and the annual production of coal being estimated to be 80,000 tons. The area underlain by coal is estimated to be 30 km. when measured to a depth of 4,000 feet, and the probable quantity of coal will amount to 200,000,000 tons. The coal is a good variety of anthracite and is non-caking. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
3.45%	8.85%	85.42%	2.28%	1.17%	1.394	5,610c	10,098	A_2
0.78	7.89	80.59	10.74	0.79	.....	.....	.....	A_2

HSI-SHAN COAL-FIELD

The Hsi-shan coal-field, surrounding the limestone of Mounts Ta-fang-shan and Ma-an-shan, which stand to the south-west of Pe-king, or west and north-west of Fang-shan-hsien, consists of sandstone and shale, with conglomerate in its upper horizon. As the field lies to the west of Pe-king it is commonly known as the Hsi-shan (west mountain) coal-field. It is connected with Mên-t'ou-kou by railway. The region covering Mei-ling, Ch'ang-k'ou-yü, and Tai-fu-chuang, which are north-west, west-north-west and north of Fang-shan-hsien, respectively, constitutes the Liu-li-ho coal-field of Mr. Richthofen and that extending westward from a point about 11 to 13 km. west of Pe-king and occupying an area of about 63 km. in length and 19 to 24 km. in breadth, was described by Mr. Drake as the Wang-p'ing coal-field. The mines worked in the field are very numerous, nearly 110 can be enumerated in the district of Wang-p'ing-hsien, and 310 in Fang-shan-hsien. This field was opened several hundreds of years ago, but we have no statistical data as to its production. In 1908, the coal mined by the Chinese Engineering and Mining Company was nearly 167,000 tons, and that taken out by numerous other mines would be at least equal to that sum. Thus the total amount mined in that year would not be less than 300,000 tons. The coal mined in the Ch'i-t'o-li, Yüan-k'ou-tien, Mên-t'ou-kou, and Chai-t'ang districts is almost all sent to the Pe-king market, the total amount being 178,950 tons.

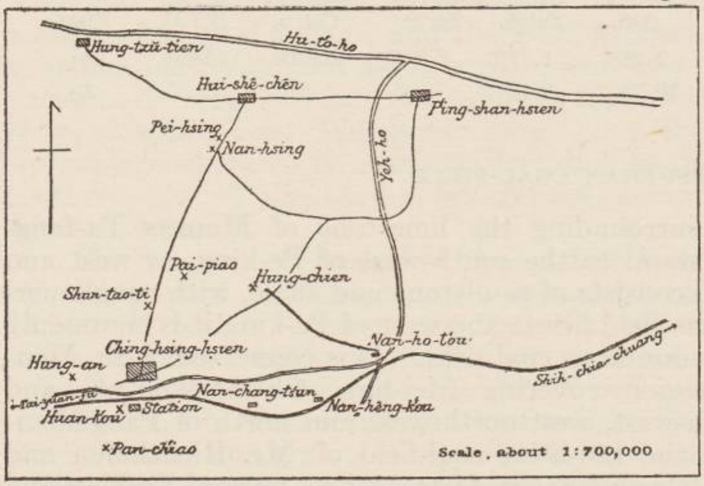
In Mei-ling the coal-bearing formation forms a syncline, imbedding six coal-seams, of which the thickest has a thickness of ten feet. In Ch'ang-k'ou-yü the thickness of the coal-seams varies from one foot to thirty feet. The formation extends thence toward the east, occupying a wide area, and forming a syncline. The strata are much disturbed and the inclination is rather steep. The quality of the coal is also very variable in different places, so that until further exploitation supplies more detailed information it is not possible to tell whether the coal mined in different places belongs to the same bed or not. Generally the coal is non-caking and burns with a short flame. The average result of technical analyses of it together with those given by Mr. Drake is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
2.48%	4.01%	75.09%	18.24%	0.28%	1.767	A_1

CHING-HSING COAL-FIELD

Ching-hsing-hsien lies on the highway leading from Chih-li-shêng to Shan-si-shêng, and is connected by railway with Chêng-t'ing-fu and T'ai-yüen-fu. The Hung-chien colliery is situated about 16 km. north-east of the town, and the Huan-kou colliery about 2 km. south-west of it, both being worked according to European methods. Besides these there are many small mines, scattered over an area about 40 km. across, with Ching-hsing as its centre; Pei-hsing, Nan-hsing, Pai-piao and Shun-tao-ti to the north, and Hung-an and Pan-ch'iao to the west and south-west are some of these (Fig. 2). The coal-field is about 24 km. long and 12 km. wide. The coal-bearing formation is composed of sandstone and shale, which dip with a gentle slope. Formerly the Hung-chien colliery was worked on a small scale by Chinese, but three or four years ago European mining was introduced. Three workable coal-seams are known, their thicknesses being 7.4 and 12.0 feet, respectively. The upper two are now being worked. The daily output is said to be 500 to 600 tons and the annual production in 1908 and 1909 was 115,000 and 193,500 tons, respectively. A railway to the colliery is now being built. The Huan-kou colliery was opened four years ago, and there we examined only one workable coal-bed four to eight

CHING HSING COAL-FIELD Fig 2.



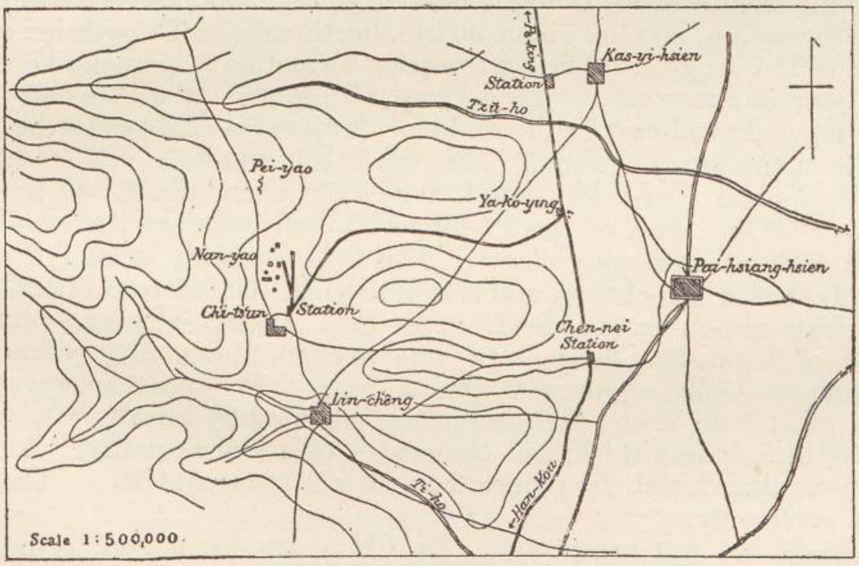
feet thick, which dips N.W. 30°. The daily output is said to be 100 to 150 tons, and the annual production will not exceed 50,000 tons. In numerous other mines, one seam, four to eight feet thick, is mined by Chinese, the correlation of the coal-seams being not yet established. The production of these mines is now ten to twenty tons daily, or about 5,000 tons a year, and, as the coal-field occupies a large area and the coal may easily be mined, it would not be difficult to increase the production by proper mining. The area underlain by coal is estimated to be 25 sq. km. and the quantity estimated reaches 120,000,000 tons. The coal is bituminous and coking. It is often difficult to get lump coal, and commonly only half of the coal taken out belongs to the lump variety. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.59%	27.97%	63.76%	7.68%	0.69%	1.312	.....	.....	B_2
0.65	28.20	63.81	7.34	0.72	1.304	7,590c	13,662	B_2
0.91	15.82	67.77	15.50	0.44	1.496	6,330	11,394	B_2

LIN-CH'ÊNG COAL-FIELD

Ch'i-ts'un is situated about 10 km. north of Lin-ch'êng-hsien in the southern part of the province. To the north of the village there are several coal

LIN-CH'ÊNG COAL-FIELD Fig. 3



mines, and these constitute the Lin-ch'êng coal-field (Fig. 3). A branch line of the Pe-king-Han-kou railway runs to the mines, making transportation easy. The field was opened about twenty years ago and the total output since then is roughly 700,000 tons. In the first five or six years the coal was worked by Chinese methods, the total yield being about 22,500 tons. In the next nine years it was worked partly by Chinese and partly by European methods, yielding 120,000 tons. In the last seven years 550,000 tons of coal were mined, during the last five years only European methods were used. Mining was first commenced at Pei-yao, and Nan-yao was opened recently. The output is said to be 600 tons a day, or about 200,000 tons a year. Two shafts are being sunk, by which it is expected that 2,000 tons of coal will be raised daily. It is now worked under the Chinese Government by a Belgian company. The coal-field occupies a wide area of not less than 25 km. in a north-south direction, and stretches out over the three districts of Kao-yi-hsien, Lin-ch'êng-hsien and Nei-ch'iu-hsien. The coal-bearing formation consists of sandstone and shale, with two workable coal-seams, each of which has a thickness of over four feet. The strike is north-south, the dip E. 20° to 30°. The area underlain by coal is estimated to be 35 sq. km. and the coal reserves to be 100,000,000 tons. The coal is semi-anthracite and caking. Generally the quantity of lump coal mined is about 50 per cent., though the lower seam yields much of it. The coal burns with a long, smoky flame and yields 33.49 per cent. volatile matter on distillation, leaving fairly good coke. The following are the results of technical analyses of it:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
1.71%	33.49%	54.80%	10.00%	1.27%	1.265	6,908c	12,434	C
1.95	28.80	51.40	17.85	0.65	.....	6,710	12,075	C

OTHER COAL-FIELDS

The Ning-shan coal-field. This field occupies a small area, forming a basin in a gneiss formation, and lies about 30 km. north-west of T'ang-hsien or 129 km. south-west of Pao-ting-fu. The coal-bearing formation is composed of sandstone and shale lying on limestone, and is covered with loess. It strikes east-north-east and forms a syncline almost in the middle. Numerous coal-seams are imbedded in the shale of the lower horizon. The coal is bituminous.

The Tz'ŭ-chou coal-field. In P'êng-ch'êng-chên, about 40 km. west of Tz'ŭ-chou or 20 km. west of the Pe-king-Han-kou railway, the coal is worked on a small scale at numerous places. The field probably belongs to the same formation as that in Lin-ch'êng, and is said to yield 100,000 tons of coal annually.

The Hsiao-niu-ch'ün coal-field. This field is situated about 60 km. west-south-west of Ch'ih-fêng-hsien, and was opened about fifty years ago, the yield at present being about 600 tons a year. The coal-bearing formation consists of sandstone, shale, and limestone, intruded by basalt. One coal-seam now worked is four feet thick, but the coal is of inferior quality. A coal-seam, which is now abandoned, is reported to be of better quality. The coal is a variety of anthracite.

Coal-fields not yet prospected. In Ch'ü-yang-hsien coal is mined on a small scale at several places, the villages of Pai-shih-kou and Yeh-pei-ts'un being noted for their mines.

The Nan-p'iao coal-field is situated about 50 km. west of Chin-chou and lies outside the Great Wall. It extends into the province of Hsing-king-shêng, and is described in the paper on the coal resources of Manchuria.

In the districts of Su-chou, Yi-chou, Wan-hsien, Ch'ü-yang, Ling-shou, San-ho Han-tan-hsien, etc., coal is also known to occur. The geological age of these coal-fields is not known but they seem to represent the Palæozoic.

SHAN-TUNG-SHÊNG

In Shan-tung-shêng the coal-bearing formation is scattered over the whole province, especially from Chi-nan-fu eastward to Ching-chou-fu, where it forms synclinal basins in the older formations. Coal-fields are also known to occur in I-chou-fu and I-hsian in the southern part of the province. The annual production of coal in the province is estimated to be 1,573,000 tons.

WEI-HSIEN COAL-FIELD

The Wei-hsien coal-field lies about 14 km. south of Wei-hsien and forms an undulatory plateau. The coal-bearing formation is composed of sandstone and shale, underlaid by basement limestone, and runs generally from east to west, with a gentle dip of 12° to 16° to the north. The upper bed yields a Jurassic flora, but the lower horizon seems to belong to the Upper Carboniferous, and I here assign the coal-bed to the Carboniferous. The coal-field is nearly 8 km. long and 7 km. wide. There are three coal-seams known. The upper belongs to the Jurassic, and is of poor quality. The middle is thirteen to seventeen feet thick, while the lower has a thickness of four to six feet, both the latter being considered to belong to the Carboniferous. Fang-tsŭ colliery, worked by the Shan-tung Bergbau Gesellschaft, about 1 km. west of the station of the same name, is the largest in the district. Of the three coal-seams known, the upper is of inferior quality and not workable. From its fossils it is known to belong to the Jurassic. Three hundred to 400 feet below that seam comes the Carboniferous coal, about twelve feet thick, and a third seam about thirteen feet thick lies about 160 feet below the second. The production in recent years has been: 1907, 145,000 tons; 1908, 223,000 tons; 1909, 272,000 tons; 1910, 229,000 tons. The An-êrh-kêng mine has recently been opened to the north of Fang-tsŭ station. The amount of coal raised by Chinese is estimated to be 100,000 tons a year. The area of the coal-field is nearly 56 sq. km., and that underlain by coal is estimated to be 20 sq. km., from which we get 100,000,000 tons as the amount of coal reserves. The coal generally cakes, and the results of its technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
2.80	30.70%	51.80%	14.70%	0.97%	1.409	6,160c	11,088	C
2.01	30.60	51.23	16.16	1.22	.....	6,550	11,790	C

PO-SHAN AND TZŬ-CH'UAN COAL-FIELDS

The Po-shan coal-field is situated about 4 km. west of Po-shan and is reached by a branch line of the Shan-tung railway. The coal-bearing formation consists of sandstone and shale, dipping W.N.W. 3° to 4°, and is covered with loess. There are six workable coal-seams with thicknesses varying from 1.8 to 7.0 feet. The coal is bituminous. In Hei-shan to the south-east of the town, a coal-seam six to eight feet thick is being worked. The Po-shan colliery is situated about 6 km. from the Tsŭ-ch'uan station. It is said that the field embraces an area of 15 sq. km. and the coal reserves have been estimated to be 50,000,000 tons.

The coal is generally of the caking variety. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.95%	16.25%	77.72%	5.08%	0.96%	1.336	7,370c	13,266	B_2
1.27	19.61	67.82	11.30	3.36	1.292	7,150	12,870	B_2

Tzŭ-ch'uan is situated to the north-east of Po-shan. The coal-seams probably belong to the same horizon as that in Po-shan, but they are cut off by faults at several places. There are numerous seams, but only one is over two feet thick. This is being worked. Many pits are found east of Tsŭ-chüan-hsien, especially at Hung-yang-p'o, where the adits of almost one hundred can be counted. The coal is better than that in Wei-hsien. It is of the caking variety. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.48%	17.88%	73.01%	8.63%	1.16%	1.246	7,270c	13,086	B_2
0.40	16.66	70.80	12.14	0.80	1.392	6,930	12,472	B_2
0.44	15.61	69.77	14.18	0.54	1.266	6,820	12,276	B_2
0.55	14.35	78.69	6.41	0.52	1.249	7,150	12,870	B_2
0.61	17.12	69.13	13.14	1.76	1.278	6,930	12,474	B_2
0.50	16.32	72.28	10.90	0.96	1.286	7,020	12,636	B_2
1.03	13.71	61.64	23.62	0.41	1.504	5,610	10,098	B_2

Besides the mines worked by the German company, there are numerous small mines run by Chinese enterprise, especially at the Ch'a-shan and in the region along the railway between Po-shan and Tzŭ-ch'uan, about 200 adits being found there, it is said. The coal is from one to three feet thick and belongs to the anthracite class.

The production of coal in the fields worked by the German company, in 1908, 1909 and 1910, was 72,000, 160,000, and 252,000 tons, respectively, the daily output being now 700 tons, it is said. The Hung-shan colliery is best known. The production in 1908, mined by Chinese, was estimated to be 145,000 tons. The total production of coal in the fields is probably at least 600,000 tons. The small adits now mined by the Chinese were all opened before the concession of the field was granted to the German company, which now has an exclusive monopoly. The German company intends to raise the daily output to 3,000 tons.

I-CHOU COAL-FIELD

H'ung-t'u-tien is located about 10 km. south of I-chou-fu. An undulatory plateau extends from the village towards the south and west. The basement complex is limestone, overlaid by the coal-bearing formation, composed chiefly of shale with subordinate layers of sandstone. The formation dips E. 15° to 30°, and many coal-seams crop out at different places along the Su-ho river. The coal is three to five feet thick and is bituminous. Coal-seams, which it is believed occur in the lower part of the strata, have not yet been exploited. In the region about 20 km. west of I-chou-fu, three coal-seams were examined, and may be followed towards the south and west. In the environs of Fêng-huang-t'an, about 24 km. south-west of I-chou-fu, abandoned mines were counted to the number of over thirty. Some of these have recently been reopened and yield 18,000 tons of coal annually. Three coal-seams are known there, the upper being good and the other two of very bad quality. The Ch'uan-chia-chuang coal-mine of Ch'ua-ch'êng-hsien yields about thirty-five tons per day. The coal in the field is bituminous, the results of technical analyses of it being as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Fên-huang-t'an—									
Upper Seam............	0.68%	20.62%	76.68%	2.02%	1.68%	1.279	7,425c	13,365	B_2
Lower Seam............	0.67	16.81	51.58	30.96	8.36	9.589	4,950	8,910	B_2

I-HSIEN COAL-FIELD

The I-hsien coal-field occupies a large area, extending over 26 km. in length and 6 km. in breadth. It was opened about twenty years ago, and at that time it was only accessible by a small river on the south, but recently about 60 km. of railway between the colliery and T'ai-êrh-chuang has been completed. The daily output of coal amounts to nearly 800 tons, and it is intended to increase it to 2,000 tons by putting in a large mining plant. It is probable that the field has yielded annually about 250,000 tons of coal for the last few years. There are three coal-seams, the middle having a thickness of thirteen to twenty-five feet. The angle of inclination is rather gentle, being 10° to 17°. The total amount of coal available in the field has been estimated to be 237,000,000 tons, while one engineer gives the amount as 300,000,000 to 600,000,000 tons. There are collieries also at Tsao-êrh-chuang about 15 km. north of I-hsien at Shan-chia-lin and at T'ao-chuang-tso-ts'un. The coal belongs to the bituminous class.

OTHER COAL-FIELDS

The Chang-ch'iu coal-field. Fu-ch'uan is situated about 35 km. south of Chang-ih'cu-hsien. A coal-seam examined about 4 km. south-west of Fu-ch'uan has a thickness of eight feet, and one north-west of Fu-ch'uan is about four feet thick. The coal-bearing formation rests on limestone and forms a monoclinal fold dipping N. 20°. The coal is generally of the caking variety. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.43%	1813%	66.86%	14.58%	0.50%	1.370	6,820c	12,276	B_2

The T'ai-an coal-field. South of T'ai-an two coal-seams are known to occur, but they are not worthy of description here.

The Hsin-t'ai coal-field. This field, about 4 km. from Kêng-chia-chuang, is situated north-west of Hsin-t'ai-hsien and consists of sandstone and shale, imbedding numerous coal-seams and dipping N.N.E. 8°. Coal two feet thick, at a depth of 50 to 100 feet, is being worked. Mr. Schenk determined the fossil flora in the field as belonging to the Jurassic, but as the horizon of fossil-bearing strata is not clearly stated, I here refer the formation to the Upper Carboniferous as in the case of Wei-hsien. At Yen-chuang, situated to the north of Hsin-t'ai, numerous coal-seams, dipping at an angle of about 30°, are being examined, the value of the coal in the field having not yet been determined. The coal is of the caking variety, the result of a technical analysis of the Ta-hsien coal being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
1.744%	37.386%	58.89%	1.98%	2.231%	1.277	7,590c	13,662	C

The Ta-hsieh colliery is situated about 12 km. west of Ai-t'ou, which lies about 20 km. north-west of Hsin-t'ai-hsien. It is worked on a small scale to meet the domestic demand. Coal in Liang-hsiang, about 6 km. south of Ta-hsieh, and that in Ching-ts'un, about 3 km. south of Liang-hsiang, are also worked on a small scale.

The Mêng-yin coal-field. The Wên-nan colliery is situated north of Mêng-yin-hsien and the coal is mined on a small scale for domestic use. The coal is bituminous, the result of a technical analysis of it being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
1.89%	31.65%	61.13%	5.33%	1.80%	1.316	7,205c	12,969	B_2

Coal-fields not yet prospected. In the prefecture of Têng-chou, coal is found at several places, as at Wên-fêng-ting to the south of the town, at Ma-shan-chai to the south of Fu-shan-hsien, and at Hai-yang-hsien and Chi-hsia-hsien, the deposit in the last locality being reported to be especially good. We are informed that two coal-seams, about three feet thick, have been found about 80 km. south of Chiao-chou. Mêng-fu in Ch'ang-yi-hsien, and Ching-shan-wa and Ta-kun-lun-tai-chia-ti in Ch'ang-lê-hsien, lie to the east and west of Wei-hsien, and the coal there is imbedded probably in the same formation as that in Wei-hsien. The coal of the last-named locality is of good quality and is said to have been mined for several hundred years. The Nan-wu coal-field, south of Po-hsing-hsien, adjoins the concession of the German company and is worked on a small scale. At Lin-tzŭ-hsien, I-tu-hsien, and Kao-yüan-hsien, south of the Po-hsing coal-field, coal is said to occur. The Lai-wu coal-field is said to occupy a large area, but I have no data respecting it. At Tu-shan-chuang, south of Chu-chou, coal-seams considered to be the same as those in I-chou, are known to occur. Lu-shan-tien is situated about 15 km. north-west of Têng-hsien. There the coal-seams are said to occupy an area of 19 sq. km. and the coal is of good quality. Coal is said to occur also at Liang-shan-chai in Shou-chang-hsien.

Shan-si-chêng

In all China Shan-si-shêng is the province most noted for its coal reserves. The coal stretches over two large fields to the east and west of the Ch'in-ling mountain range, which runs from north to south through the centre of the province. Besides there are small scattered coal-fields in the environs of Wu-t'ai-hsien. Though the reserves are large, on account of the difficulties of transportation the coal is only worked by old methods on a small scale, mostly to meet the domestic demand. The coal on the eastern side of the mountain range belongs, for the most part, to the anthracite variety, while that on the western side is bituminous.

WU-T'AI DISTRICT

In the environs of Wu-t'ai-hsien there are several small coal-fields. The T'ien-ho and Yo-t'ou fields, to the east and south-east of Wu-t'ai-hsien, respectively, are situated near or along the T'ai-shan-ho. The coal-bearing formation consists of alternating strata of sandstone and shale, underlaid by limestone of the Sinian formation, and forms a synclinal basin. Numerous coal-seams of various thicknesses are known to occur. In T'ien-ho, there are nine coal-seams over one foot in thickness, their aggregate thickness being, it is said, more than thirty-one feet. An 8-foot seam in the middle and a 3-foot seam in the lower part are being worked. The mode of occurrence of the coal in Yo-t'ou is quite the same as that in T'ien-ho. The coal mined at Tung-yeh-chên to the south-west of Wu-t'ai-hsien is of good quality, and is carried to the Tai-chou-fu market. The coal in the district is all bituminous.

THE COAL-FIELD TO THE WEST OF THE CHIN-LING MOUNTAIN RANGE

The T'ai-yüan plain, situated in the middle of the province, is surrounded by an undulatory Carboniferous plateau, which continues southward to P'ing-yang-fu along the Fên-ho river and still farther to Ch'ü-wu-hsien, Chiang-chou-fu and Yi-ch'êng-hsien. From T'ai-yüan-fu it extends still farther northward to Kuo-chou. As much of the region is covered with loess, the outcrops of coal can only be followed along the tributaries of the Fên-ho, which flow east from the Lien-chih mountain range, lying between the Fên-ho and the Hoang-ho rivers and west from the Ch'in-ling mountains, lying to the east of Fên-ho. The coal is at present being mined mostly near the outcrops. The wide area near the main stream of the Fên-ho is nearly all covered with heavy loess, and the coal is being worked only where outcrops of coal-bearing strata are met with, here and there, on the river. The basement complex of the two mountain ranges, Lien-chih and Ch'in-ling, is composed chiefly of limestones of an era extending probably from the Cambrian to the Carboniferous. The coal-bearing formation overlies the limestone and consists of sandstone and shale, forming a syncline. Numerous coal-seams are worked in several places. To the west of P'inng-yang-fu, the strata, with a rather gentle dip, imbed many coal-seams, of which one, twelve feet thick, is the only one worked. Near by, to the north, two beds, two to three feet thick, respectively, are also being worked. In Yü-tzŭ-hsien there are important outcrops in twelve places. At one of these, in Huo-shao-tsui, the coal is nearly eighteen feet thick. In Hsiao-i-hsien the coal was examined at fourteen places, that in Chung-wang-kou and Luan-yai-kou being eighteen feet thick. The Pei-lu-p'o coal-seam in Hsiang-ning-hsien, is nearly thirteen feet thick. Other important and well-known localities are K'u-nan-shang and Pai-chien-k'u.

The area of the coal-field, as above stated, is very great, stretching from

Chiang-chou and Ch'ü-wu-hsien in the south to Kuo-chou in the north, through P'ing-yang-fu and T'ai-yüan-fu. Its east and west extension is 40 to 48 km.

THE COAL-FIELD TO THE EAST OF THE CH'IN-LING MOUNTAIN RANGE

The coal-field lying to the east of the Ch'in-ling mountain range also occupies a large area, probably not less than that of the western field. The environs of Tsê-chou-fu are famous for their coal. In Nan-ts'un, to the south-west of Tsê-chou-fu, coal-seams nearly thirty feet in aggregate thickness are worked by a shaft about 300 feet deep. Ta-t'ieh is situated to the north of Ta-ching-kuan and about 6 km. south of Nan-ts'un. Hard anthracite is here imbedded in the undulatory strata of the Carboniferous, the thickness of the coal varying from four to forty feet. The coal is actively worked in Sun-ts'un and Chang-ling, to the north-east and west of Tsê-chou-fu, respectively, at a depth of over 200 feet. The thickness of the coal varies, being generally from fourteen to twenty-four feet. The coal-seams of Yang-chêng-hsien have a thickness of from seven to ten feet, but the coal is of inferior quality. The environs of T'ai-yang, about 25 km. north of Tsê-chou-fu, are also famous for their coal. In Shu-yüan-t'ou, Li-ch'uan, Ta-chi, Wu-mên, Ssŭ-ma-shan, Êrh-shih-li-p'u, etc., coal having a thickness of from twelve to thirty feet, is being mined. The amount of coal taken out in the neighbourhood of Tsê-chou-fu is estimated to be 2,000,000 tons, and the total production in the province is probably not less than double that amount.

P'ing-ting-fu is situated in the northern part of the eastern field. The coal-bearing strata occupy a tolerably large area and form an undulatory plateau sloping gradually to the east. The important coal-seams in the area lie 200 to 300 feet under ground, and have an aggregate thickness of from twenty to thirty feet. The coal mined is of good quality. The formation seems to extend northward to Mêng-hsien, southward to Lê-ping-hsien, and eastward to Ching-hsing-hsien in Chih-li-shêng, forming a vast, undulatory plateau. The numerous mines north and south of the P'ing-t'an river are worked by a Chinese company. Of these the coal at Mai-ti-kou, Chuang-chuang-kou and T'ieh-lu-kou is of good quality and has a thickness of nearly eighteen feet. In Yen-tzŭ-kou modern methods are being used, while in Mai-ti-kou and Chuang-chuang-kou they are soon to be introduced. The Yung-chia-kou pits in Shou-yang-hsien, about 27 km. south of the Yung-chia station, are also worked by the same company, the coal-seams now mined being two in number, with thicknesses of nine and seven feet, respectively. The total output of the company was: in 1908, 2,200 tons; 1909, 5,600 tons; 1911, 21,000 tons.

The coal-seams at Chuang-shui-kou and Yin-wan-chên in the same region are also important, that at Yin-wang having a thickness of nearly eighteen feet. In Mên-hsien coal is known to occur in Ma-chia-ti and Ch'ing-ch'êng-chên. The P'ing-ting coal-field probably continues southward to Tsê-chou, but between the two there is no area where the coal is actively worked.

THE QUALITY AND QUANTITY OF COAL

The coal is of the non-caking variety, but its quality is different in different places. The results of technical analyses of it are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
P'in-ting....................	3.28%	7.84%	84.61%	4.27%	0.86%	1.400	5,500c	9,900	A_2
"	3.44	7.77	84.49	4.30	1.15	1.390	5,830	10,493	A_2
Shih-pa-tsui..................	2.32	5.36	81.71	10.62	0.71	1.403	5,720	10,296	A_1
"	2.88	5.16	87.18	4.80	0.74	1.382	5,225	.....	A_1
Yang-ch'üan................	1.31	6.85	81.41	10.44	0.39	1.410	5,445	.....	A_1
"	2.36	7.22	79.78	10.68	1.75	1.444	5,225	.....	A_1
"	2.59	6.85	81.60	8.96	0.83	1.457	5,170	9,306	A_1
Tai-yüan (Western Mountain)	2.21	9.28	87.80	0.72	1.20	1.333	6,600	11,880	A_2
" " "	1.26	11.90	77.03	9.82	1.33	1.345	6,160	11,088	B_1
" " "	1.13	13.65	80.06	5.16	1.01	1.303	6,765	12,177	B_1
Tai-yüan (Eastern Mountain)	3.48	12.10	81.24	3.18	1.70	1.406	6,050	10,890	B_1
" " "	2.30	16.71	69.41	11.58	1.30	1.382	5,665	10,197	B_1

The principal localities for coal are given in the annexed map.

The coal-fields above described have not yet been well explored or prospected and the correlation of the several coal-seams has not been definitely determined. The thickness of the coal-seams is very variable, and it is difficult to estimate the average for such a large area, so that the thicknesses given in different reports do not always agree but often differ widely, though perhaps this is due to local variations. However, we are led to believe from the data accessible that the aggregate thickness is not less than fifteen feet. Assuming this thickness and taking the area of the coal-field given by Mr. Richthofen, the total quantity of coal reserves would be approximately 240,000,000,000 tons, as against Mr. Drake's estimate of 350,000,000,000 tons and Mr. Richthofen's of 650,000,000,000 tons.

Ho-nan-shêng

The large coal-field of Ho-nan-shêng, lying in the northern part of the province, is considered to be a continuation of the great Shan-si coal-field. Other smaller coal-fields are found scattered throughout the province.

HUAI-CH'ING COAL-FIELD

The Huai-ch'ing coal-field is situated in the northern part of the province and continues across the Ta-hang-shan mountains into Shan-si-shêng. It may conveniently be divided into three sections. The eastern section extends from a point north of Hsiu-wu-hsien north-westward to a region about 4 km. east of Li-fêng, with abundant mines scattered between. From north of Hsiu-wu-hsien the Coal-Measures continue eastward to Hui-hsien and there bend northward, thus occupying a vast area. The middle section adjoins this on the west, and extends to a region about 10 km. east of Ching-hua-chên. It occupies an area about 10 km. long and 4 km. wide, in which over a hundred adits are found. The coal in the environs of Li-fêng is most noted, and the collieries of Pai-shan, Ch'ang-k'ou and Chiao-cha, lying east of Ching-hua-chên, yield nearly 600,000 tons of coal annually. The western section borders on the middle section, and occupies the western part of Chi-yüan-hsien.

The depth of the mines, worked by the Chinese method, varies at different places, being generally from 120 to 400 feet. Numerous coal-seams are known to occur, but as the correlation of the strata has not yet been established, the mutual relations of the several seams are not well known. The thickness of the seams varies at different places, and is generally twenty to thirty feet, but in some localities 3- or 4-foot seams are being worked. The coal-bed at Pei-shan-ssŭ in Ch'ing-hua-chên lies directly on the limestone, and dips gently E. 8°. The Chiao-cha colliery in Hsiu-wu-hsien, under the management of the Pe-king syndicate, is the largest in the field, and a seam twenty-two feet thick was recently discovered at a depth of 710 feet. The production in 1909 was 231,731, and in 1910, 357,205 tons. In Pai-shan twenty-four adits are worked at present at a depth of 120 to 200 feet. The coal is mined mostly by farmers, and yields nearly 30,000 tons a year. Ch'ang-k'ou is situated at about 8 km. east of Ching-hua-chên or 10 km. west of the Chiao-cha colliery. Over eighty adits are now being worked there, yielding about 600 tons daily. The annual production is said to be 210,000 to 220,000 tons. The production shows a gradual yearly increase. The coal is a hard anthracite of good quality. The coal reserves in the field have been estimated at 200,000,000 tons.

SCATTERED COAL-FIELDS SOUTH OF THE HOANG-HO

The coal-bearing formation is found in scattered localities between the Hoang-ho and Nan-yang. It is underlaid by the Archæan or Sinian formation, is covered with loess, and strikes east-west. A coal-seam about 20 km. south-east of Kung-hsien, is mined at a depth of about 200 feet, and is six to eighteen feet thick. The field is rather limited in extent. Coal-seams are also found in two places between Ju-chou and Lu-shan-hsien. The Lu-chuang field is the more northerly of the two and is of small area. A six to eight-foot seam is worked there at a depth of about 200 feet. Ch'un-tien is situated about 12 km. north-east of Lu-shan-hsien, and the coal there seems to extend to the west and also towards the east as far as Pao-fêng-hsien. Coal five to six feet thick is worked at a depth of 150 feet. It is bituminous, and much of it is crushed by local disturbances. The coal-seam worked north of Ch'un-tien is six to eight feet thick. The seam at Mi-hsien and Jung-yang-hsien is considered to be a continuation of the seam in the above coal-fields. The coal-bearing formation, stretching east and west from the Chiu-lung-shan mountain between Nan-yang-hsien and Nan-chao-hsien, dips N. by E. 45°. The coal-field south of Têng-fêng-hsien extends to the west. The annual production of coal in I-yang-hsien is said to be about 100,000 tons. Numerous adits are scattered throughout the environs of Ch'u-kao-li in the south-west corner of K'ai-fêng-fu prefecture. The coal is of good quality. Several hundred tons are mined each year, and carried to Ju-chou and Yu-chou for sale. Coal is said to occur also in Ch'uen-shan-hsien and Yen-shih-hsien.

Liu-ho-kou in An-yang-hsien is situated in a convenient position near the Pe-king-Han-kou railway and is said to yield about 100,000 tons of coal annually.

SHÊN-SI-SHÊNG AND KAN-SUH-SHÊNG

Shên-si-shêng. Hsiao-tao-ho is situated east of Tzŭ-yang-hsien, lying about 40 km. west of Hsing-an-fu. Limestone and shale are seen cropping out there. The dip is rather steep and often reversed; in Hsiao-tao-ho it is N.E. 15° to 40°. The coal-seams are interbedded in shale, the thickness varying from one foot to twelve feet. Though the coal is of rather inferior quality, yet it is more or less actively worked, as the transportation is easy.

At Pai-chiu-hsia, a village lying between P'ing-li-hsien and Chên-p'ing-hsien, limestone is accompanied by shale, and at T'sêng-chia-chü the limestone has interbedded with it quartz-mica-schists in addition to shale. Anthracite is found in the strata and is being worked, though the seam is thin. At Lao-hsien coal is also known to occur.

Kan-suh-shêng. The Carboniferous sandstone and shale, stretching over the region between Ting-ch'iang and Shan-tan to the south-east of Kan-chou, contain a few coal-seams which are being worked on a small scale. Near Shu-hsien in the north-west the coal is also worked. About these coal-fields we have no data.

KIANG-SU-SHÊNG, AN-HUI-SHÊNG AND CHEH-KIANG-SHÊNG

Kiang-su-shêng. Good anthracite, with only a little sulphur and ash, is found in Hsi-shan in Su-chou, and Lin-shan in Shang-yüan-hsien, about 20 km. from Nan-ching. It is said that two shafts have been sunk in Hsi-shan. The coal is said to be good, both in quality and quantity. It is mined at present on a small scale, the production being insignificant. In Tan-t'u-hsien and Chü-jung-hsien also coal is known to occur. In Li-kuo-hsien, on the eastern shore of the Wei-shan-hu, the coal is worked on a small scale.

An-hui-shêng. The Hsüan-ch'êng coal-field. The coal in this field was discovered about fifty years ago. The Carboniferous, consisting of shale and sandstone, extends south of the town. Three workable coal-seams are imbedded in the strata, the thicknesses varying from three to over ten feet. The inclination of the strata is moderate, being 20° to 30°. The coal is first met with at a depth of nearly 100 feet. The coal is mostly non-caking. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class	
1.65%	19.39%	55.20%	23.77%	2.21%	B_2	Non-caking
1.18	24.40	56.69	17.73	3.88	B_2	Non-caking
0.40	25.40	55.80	18.40	2.31	B_2	Non-caking
0.87	17.28	61.72	20.13	2.38	B_2	Caking

The coal in Kuang-tê-chou on the east, and Ch'ih-chou on the west-south-west, is probably a continuation of that in Hsüan-ch'êng, and the quality is quite similar. The thickness of the coal is said to vary from one foot to twenty feet. The coal in Niu-t'ou-shan in Kuang-tê-chou is well known.

In Ching-hsien and Fan-chang-hsien coal is said to occur in several places, but it has not yet been prospected by us.

Cheh-kiang-shêng. The T'ung-lu coal-field. The environs of T'ung-lu-hsien consist of Carboniferous sandstone and shale, with coal-seams underlain by *fusulina* limestone, which crops out at the north of the town. The strike of the Coal-Measures is nearly east-west or east-north-east, and the dip north or south, the course of the Ch'ien-t'ang-chiang river corresponding to the axis of a large synclinal basin. The angle of inclination is variable, being 20° to 70°. Anthracite is found in three places. The coal found at Huang-fu, about 25 km. north-north-west of the town, is four feet thick. In the Carboniferous, extending from east to west, about 10 km. south of the town, coal is imbedded. It is of bad quality and not worth mining.

Coal is known to occur in Yü-k'êng-hsien, Yü-ch'ien-hsien.

In the province of Hu-peh-shêng, it is said, coal is found at various places, and the regions around Wang-yen, Li-t'u-tun, K'ang-chung, etc., are mentioned as localities where seams from three to twenty-five feet in thickness are found. Unfortunately we have no reliable data respecting these coal-fields. In T'ien-yu-shan, lying north-north-west of Li-ch'uan-hsien, heavy sandstone rests on limestone and two or three coal-seams are imbedded in the sandstone. From here to Wan-hsien in the province of Ssŭ-ch'uan-shêng, the coal has been examined at several places, and many mines are being worked between Lang-chia-chü, near the province boundary, and T'ien-yu-shan.

In the environs of Wu-ch'ang-fu, many coal-fields are known. The Ma-an-shan colliery was opened about twenty years ago, and the annual production, mined by the Han-yang Company, is estimated to be about 70,000 tons. Small mines, worked by Chinese on a small scale, yield 50,000 to 60,000 tons a year. In Kuei-chou and Hsing-shan-hsien, near the Yang-tse-kiang, bituminous coal is known to occur. From Liu-chia-ch'ang in Chih-chiang-hsien along the river, about 60 km. south-east of Wu-ch'ang-fu, coal-seams run almost from east to west. The coal is of inferior quality and is chiefly used as fuel for lime-kilns. Near the Ta-yeh iron mine, coal is known to occur, but the seam is thin, and though it is being worked it is hardly worth mentioning.

In Yi-tu-hsien and Ch'ang-yang-hsien coal is also known to occur. In Hsing-kuo-chou coal is found near the boundary between the province and Kiang-si-shêng, and is said to be very rich. A mine there is said to yield sixty tons a day. In Tang-hsien, Nan-chang-hsien, Pa-tung-hsien, Tang-yang-hsien, Ching-shan-hsien, Ma-ch'êng-hsien, T'ao-hua-ling in Han-yang-fu and Hsien-ning-hsien coal is said is occur.

Fuh-kien-shêng

In the province of Fuh-kien-shêng coal is worked at several places, but as there are no facilities for transportation there is no mine in active operation.

SHAO-WU COAL-FIELD

From Shao-wu-hsien south-westward about 8 km. along the highway between Shao-wu-hsien and Yen-p'ing-fu, there are outcrops of the Carboniferous formation, cut up by granite on both sides. The mine was opened about ten years ago, and yields about fifty tons of coal a day. The formation strikes

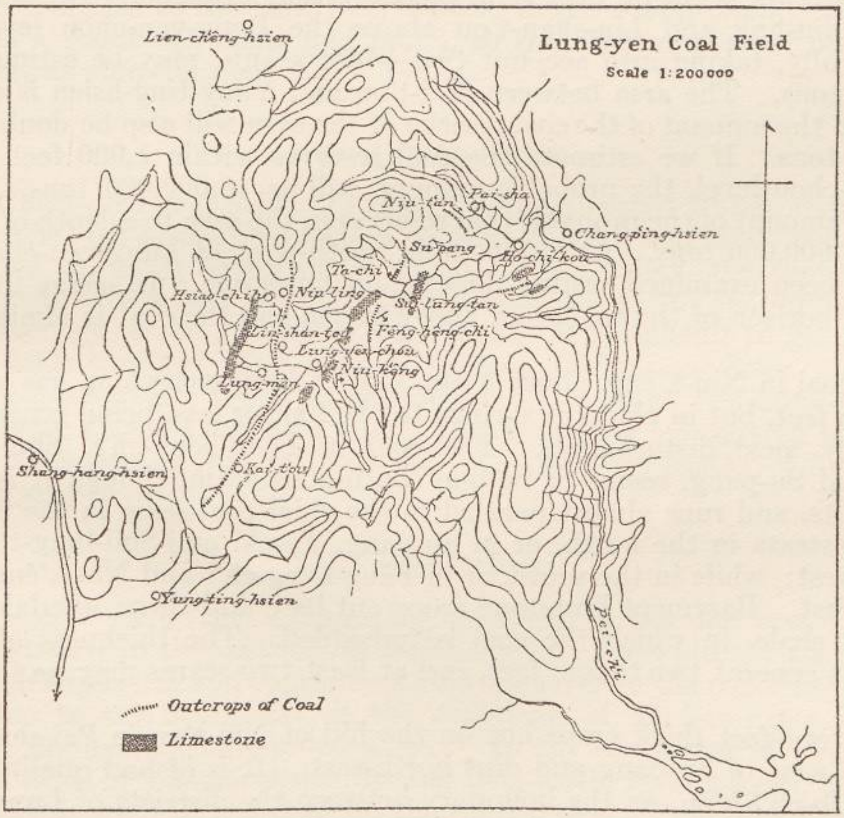
N. 20° E., and extends farther along the strike or in a nearly north-south direction with a breadth of about 8 km. It consists of heavy white sandstone in the upper, and chiefly of black shale in the lower, part. At Mei-t'an-ling about 10 km. east-south-east of Shao-wu-hsien, the dip is east and west with an angle of nearly 30°, forming a syncline. One workable coal-seam is known to occur, its thickness being about eight feet. The coal is a good anthracite with little sulphur and is non-caking. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U.	Class
4.67%	4.75%	84.07%	4.30%	2.23%	.....	.....	A_1
4.50	4.75	86.90	3.85	2.02	5,885c	10,593	A_1

LUNG-YEN COAL-FIELD

The Lung-yen coal-field (Fig. 4) occupies an area about 80 km. long in an east-west direction, and about 40 km. wide, covering the region between Lung-

Fig. 4



yen-chou and Chang-p'ing-hsien, with the Lung-yen-chou basin as the centre of the field, and extending to the districts of Yung-ting-hsien, Shang-hang-hsien and Lien-ch'êng-hsien. The coal-field forms an undulatory plateau in the eastern part of the watershed between the provinces of Fuh-kien-shêng and

Kiang-si-shêng, drained by the Pei-chi, which flows through its central part. The Coal-Measures consist of shale and sandstone, underlain by *fusulina* limestone. The strike is generally N. 30° E., and the dip north-west or south-east, forming anticlines and synclines. The angle of inclination is generally moderate, being 30° to 40°, in exceptional cases 70° to 80°. The number of coal-seams is probably not less than two, the thickness varying from two to four feet.

The coal-seams running from north-north-east to south-south-west through the plateau west of Lung-yen-chou, are worth attention. At Niu-ling one workable seam, four or five feet thick, is found at a height of over 500 feet above the Lung-yen-chou level, and is considered to extend on north-north-eastward. It seems to continue also to Lin-shan-t'ou, which is about 5 km. south-west of Niu-ling. There a similar coal-seam is exposed. It extends still farther southwestward, to Lung-mên, where the coal becomes much crushed, owing to local disturbances, and the strata incline very steeply. Still farther south-westward, the coal is exposed in Kai-t'ou and extends through the district of Yung-ting-hsien. We may infer that there is at least one coal-seam below the one referred to above. The total distance over which the coal extends is probably 35 km., though the seam is cut off at several places in that distance. The coal reserves between Niu-ling and Lin-shan-t'ou above the Lung-yen-chou level, or 500 feet vertically, taking into account two 4-foot seams, may be estimated to be 3,000,000 tons. The area between Kai-t'ou and Yung-ting-hsien is double the above, and the amount of the coal reserve of the area will also be double, making 6,000,000 tons. If we estimate the coal reserves within 1,000 feet below the Lung-yen-chou level, the probable amount will be 18,000,000 tons. Thus, the aggregate amount of the probable coal reserves in the area to a depth of 1,000 feet, will be 27,000,000 tons. At Hsiao-ch'ih, north-west of Lung-yen-chou, a coal-seam has been examined resting directly on limestone. It seems to represent the lower horizon of the coal-seam above given, and the coal is similar to it in quality.

The coal in Niu-k'êng, about 4 km. east of Lung-yen-chou, has a thickness of over six feet, but in places it shrinks to one foot or less, being generally badly crushed by local disturbances. The coal in Fêng-hêng-ch'i, Shui-lung-t'an, Ta-chi, and Su-pang, seems to be one continuous seam, though it is often cut off by faults, and runs almost parallel to the chief coal-seam in the west. The dip of the strata in the north, or in Su-pang, Ta-chi and Shii-lung-t'an, is west or north-west; while in the south, or in Fêng-hêng-ch'i and Niu-k'êng, it is east or south-east. Basement limestone crops out here and there, overlaid by sandstone and shale, in which the coal is imbedded. The thickness of the coal-seams is, in general, two to four feet, and at least two seams may be followed for a distance.

Coal four feet thick crops out on the hill of Niu-t'an in Pai-sha, about 12 km. north-west of Su-pang and dips north-east. It is of bad quality. To the south of Ho-ch'i-k'ou, on the boundary between the districts of Lung-yen-chou and Chang-p'ing-hsien, the coal has also been examined.

The coal is anthracite. In Niu-ling, Lin-shan-t'ou, Shui-lung-t'an, Ta-chi and Pai-sha, it is chiefly lump coal, while in Lung-mên and Niu-k'êng, it is much crushed, owing to local disturbances. The following are the results of technical analyses of it :

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
Niu-ling	5.07%	3.77%	85.63%	5.43%	.....	A_1
"	5.03	3.40	85.93	5.18	.....	A_1
"	3.98	5.32	70.91	19.79	.....	A_1
Lin-shan-t'ou	5.18	4.03	72.57	18.22	.....	A_1
"	5.20	3.34	68.19	23.27	.....	A_1
Shui-lung-t'an	5.03	3.99	75.57	15.41	.....	A_1
"	5.53	3.72	84.72	5.93	.....	A_1
"	5.51	3.97	81.62	8.72	.....	A_1
Ta-chi	5.14	3.47	85.01	6.38	.....	A_1
"	4.54	3.87	86.40	5.19	.....	A_1
Pai-sha	5.25	3.20	68.87	22.68	2.23%	A_1
"	4.83	4.97	64.28	25.72	.....	A_1

As exploitation of the coal has not been carried very far, the correlation of the seams has not yet been established and it is at present impossible to tell their number or the horizons to which they belong; but, from the geological relations, we are led to the view that the coal in the west probably reappears in the east as a result of folding and faults, so that the number of coal-seams is not so great as above stated.

OTHER COAL-FIELDS

The Chien-ning coal-field. Li-shan is situated about 10 km. east of Chien-ning-fu. The coal-bearing formation consists of shale and sandstone with coal-seams. One workable coal-seam crops out in the valley, the thickness being about six feet, with a thin parting. It strikes N. 10° to 30° W., dipping W. 45°. The coal belongs to the anthracite variety, and it is difficult to get lump coal.

Coal-fields not yet prospected. Between Chien-yang-hsien and Chung-an-hsien coal-seams are found at several places, such as Niu-ming-t'an, Hsia-mei, Chia-yao, Chang-yüan-lung, etc. The seams are considered to belong to the same formation as that in Shao-wu. At Chên-yen-hsiang in An-ch'i-hsien coal is also said to occur.

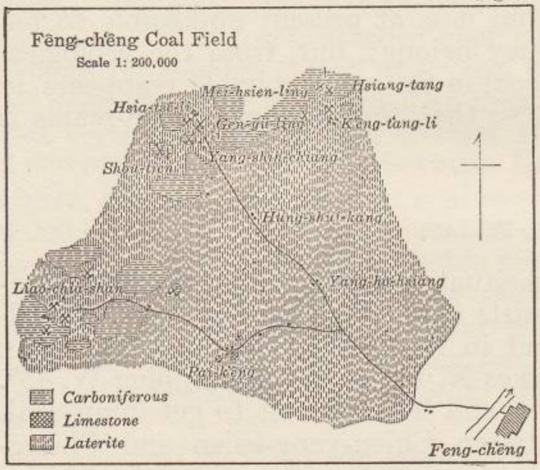
KIANG-SI-SHÊNG

In Kiang-si-shêng the P'ing-hsiang coal-field is the one best known. It extends eastward to the districts of I-ch'un-hsien, Fên-yi-hsien, Hsin-yü-hsien, and Fêng-ch'êng-hsien, and continues across the river to the coal-field of Li-chia-tu. Farther to the north-east lie the coal-fields of Yü-kan-hsien, Wan-nien-hsien, Lê-p'ing-hsien, Ching-tê-hsien, etc. To the south-east of Lê-p'ing-hsien lie the coal-fields of Yü-shan-hsien, Kuang-fêng-hsien, I-yang-hsien, etc. Other large coal-fields seem to run through the central part of the province from east to west, the coal-field of Lien-hua-t'ing being well known and probably extending to the southern coal-field of Hu-nan-shêng. In the southern part of the province lies the coal-field of Hsin-fêng-shêng, which probably extends to the coal-field of Kuang-tung-shêng.

FÊNG-CH‘ÊNG COAL-FIELD

The Fêng-ch‘êng coal-field (Fig. 5) includes many villages, such as Hsiang-t‘ang, K‘enge-t‘ang-li, Hsia-tsê-li, Shou-t‘ien, Liao-chia-shan, and Nan-shên-ling, which lie within a distance of 7 km. north-west or west of Fêng-ch‘êng-hsien. The field was opened about sixty years ago, and for the last few years the mining has been carried on rather actively in K‘eng-t‘ang-li, where over 400 mines are being worked in an area of about 2 km., producing 20,000 tons a year. It is said that the amount mined in the field is about 2,000 tons a day, but this estimate seems to be too large. From information now available it is concluded that the annual production probably does not exceed 100,000 tons. The country abounds in hills, generally twenty to thirty metres high, the highest, near Kêng-t‘ang-li, being only about 100 metres. The basement complex is limestone, overlaid by sandstone and shale with coal-seams. Widespread laterite, with a thickness of about twenty to thirty metres, but thinner in the west, makes the outcrops of rock very rare, so that it is difficult to correlate stratigraphically the different parts of the formation. The coal-bearing formation has a variable dip and strike. In Hsiang-t‘ang it dips S.E. 15°; in Hsia-tsê-li, S. or S.W.; in Shou-t‘ien, E.; and in Liao-chia-shan, S.; and at last S.W. Thus it will be seen that the coal-seams bend, with the formation, like the letter S, forming in the middle a syncline with a gentle slope. At Chu-mu-kuan also, about 10 km. west of Nan-shên-ling, many coal-seams are known to occur. In Hsiang-t‘ang a seam one or two feet thick is worked at a depth of forty feet, while in Hsia-tsê-li 7-foot coal is mined at a depth of 80 feet to 130 feet. The area containing coal is about 25 km. in an east-west direction and about 8 km. north and south, giving about 200 sq. km., from which the total amount of coal has been estimated to be nearly 400,000,000 tons.

Fig. 5



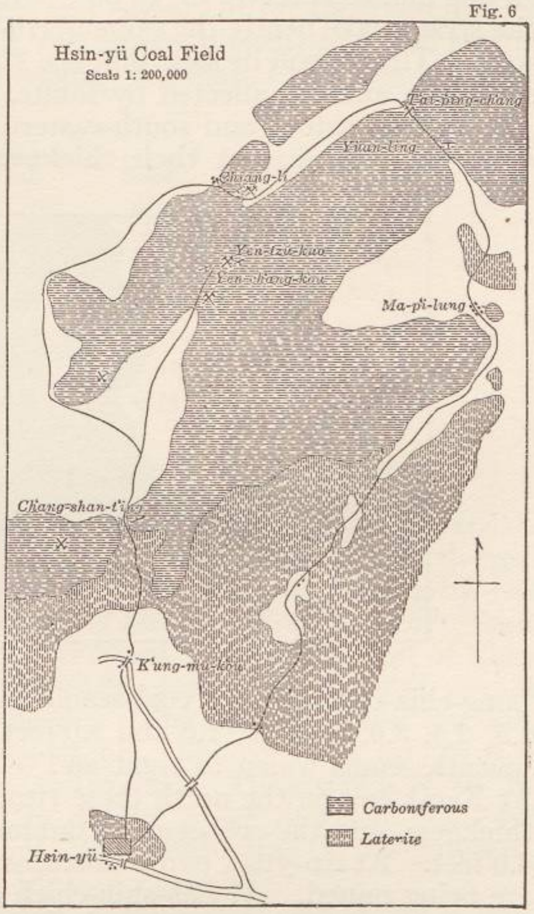
HSIN-YÜ COAL-FIELD

The Hsin-yü coal-field (Fig. 6) includes the two neighbouring villages, Tai-p‘ing-ch‘ang and Yen-ch‘ang-k‘ou, the former lying about 24 km. north-north-east of Hsin-yü-hsien, and the latter about 18 km. north of the same town. The coal was mined first under the Ming dynasty and reopened about thirty years ago. The daily production is only about sixty tons. The topography and geology are quite similar to those in Fêng-chêng, but here we observe outcrops of heavy sandstone with conglomerate, lying on the coal-bearing shale. The strike is N. 60° E., dip S.E. 30° to 60°, but in the south the dip is north-west, forming a syncline. A coal-seam six to eight feet thick, imbedded in shale, is mined at a depth of about 200 feet. The coal is brittle and is difficult to get in lumps. The coal reserves may be estimated at 20,000,000 tons.

I-CH‘UN COAL-FIELD

Chung-chia-fang is situated about 13 km. north of I-ch‘un-hsien, from which I-ch‘un, the name of the field, is derived. The date of the opening of the field is not known. The daily output of coal at present is about forty tons. The topography and geology of the environs of the village are quite similar to those of the Hsin-yü coal-field. Here the coal-bearing strata run N. 60° E. and dip S.E. 45°. Three coal-seams of 0.8, 3.0 and 0.8 feet are known, the upper seam being first met with at a depth of about 120 feet. The lower and upper coal-seams are of inferior quality, only the middle one being worth mining.

Fig. 6



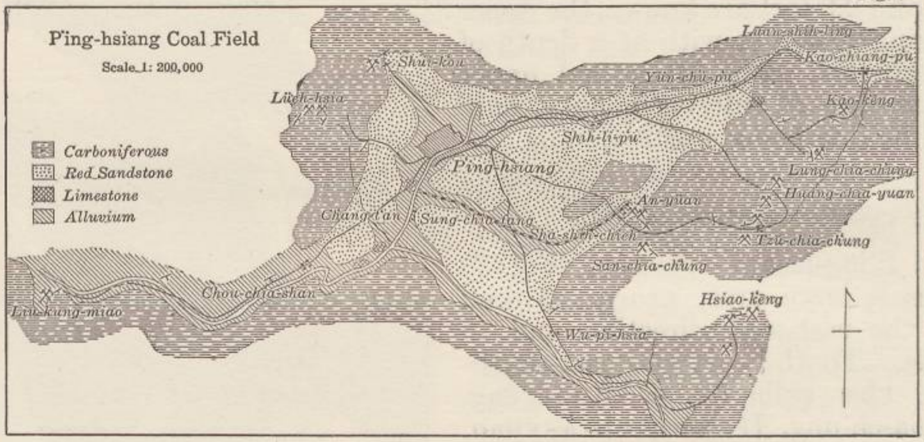
P‘ING-HSIANG COAL-FIELD

The P‘ing-hsiang coal-field (Fig. 7) embraces a large area, nearly 25 km. long in the east-west direction, and 10 km. wide. To the east and east-south-east lie the collieries of Kao-k‘êng, Lung-chia-ch‘ung, Huang-chia-yüan, Tzŭ-chia-ch‘ung, Hsiao-k‘êng, San-chia-ch‘ung, Sha-shih-chieh, An-yüan, etc.; to the north-west, the collieries of Shui-k‘ou, Lüeh-hsia, etc.; and to the west, the colliery of Liu-kung-miao, etc. The coal in the field was mined as early as two hundred years ago for domestic use. About fifteen years ago a large mining plant was introduced, and the coal is now worked under the management of German engineers. The annual production exceeds 500,000 tons; it was 520,000 and 610,000 tons in 1909 and 1910, and it would not be difficult, it is said, to raise the daily output of coal to 3,000 tons. The collieries are connected with the railway and the coal is transported to Hu-nan-shêng, where it is loaded into junks.

The coal-field forms an undulatory plateau, bounded on the north and south by mountain ranges, and drained by the P‘ing-ch‘uan, which flows almost through the centre of the field. The coal-bearing formation which forms a plateau near P‘ing-hsiang-hsien and along the river, consists mainly of shale with subordinate layers of sandstone and conglomerate, overlaid by heavy sandstone with conglomerate. The lowest horizon is grey *fusulina* limestone. The strike of the Coal-Measures is north-east, though the strata are often folded or bent in a north-west or east-west direction. The dip is generally gentle, but is sometimes steeply inclined. In the environs of An-yüan the strata have a strike of N. 20° to 45° W., dipping S.W. 20° to 47°, while in Tzŭ-chia-chung and Huang-chia-yüan, beyond the mountain lying to the east, the strike is N. 70° to 80° E., with a dip of N. 25°. The Coal-Measures at Lung-chia-ch'ung and Kao-k'êng have nearly the same strike as those in An-yüan and San-chia-ch'ung and dip S.S.W. 10° to 30°. At Shui-k'ou, Lüeh-hsia, and Liu-kung-miao the strata have nearly the same north-east strike, dipping north-west and south-west. Thus it will be seen that the strata suffer foldings, forming anticlines and synclines, and are affected by faults.

In the eastern and south-eastern part of the field the workable seams are seven in number, but their thickness varies greatly in different places. At

Fig. 7



Lung-chia-ch'ung seven coal-seams have been examined, their thicknesses being 2.5, 3.5, 3.0, 2.5, 3.5, 1.0 and 5.0 feet, respectively. In the mine the third and seventh seams widen to eight and ten feet in thickness, and are being worked. At Kao-k'êng on the north these two seams become thin, being only one foot in thickness, and the coal-seams examined there are 0.4, 0.8, 0.9, 0.4, 6.0, 1.0 and 4.0 feet. At An-yüan two coal-seams over six feet thick, lying in the lower part, are being mined. At Sha-shih-chieh and San-chia-ch'ung the coal-seams of the upper part are being worked, the thickness of the coal in San-chia-ch'ung being 1.5, 3.0 and 4.0 feet. At Hsiao-k'êng three coal-seams have a thickness of 4.0, 3.0 and 2.0 feet, respectively. Thus at least two coal-seams, though subject to local variations, have an average thickness of over 5 feet, so that the aggregate thickness is probably not less than 10 feet.

In the north-western and western part of the field, two or three coal-seams, lying near to one another, have been examined, though their correlation with those in the other parts has not yet been studied. From their geological relation it will be seen that the coal-seams of the area seem to correspond to those of the upper horizon in the eastern part, and it is highly probable that at least four coal-seams may be found under the coal now worked. The dip in the area is rather steep, being generally 40° to 60°. In some mines of Lüeh-hsia three seams, 2.0, 3.0, and 5.0 feet thick are imbedded in strata twenty feet thick, and in the other mines these seams unite into one fifteen feet thick with thin partings. At Liu-kung-miao there are three coal-seams, 3.0, 3.0, and 5.0 feet thick, with partings of two or three feet between them.

As to the coal reserves, no calculation based on actual survey has been made, but from the area above described and the thickness of the coal, as well as the inclination of the coal-seams, one engineer has estimated the available quantity of coal to be 300,000,000 tons.

The coal is bituminous, of good quality and caking, fit for the manufacture of coke. It is jet black and lustrous, hard, brittle and difficult to get in lumps. It burns with a long, smoky flame. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
1.35%	23.73%	55.02%	19.50%	0.45%	.....	B_2
1.70	30.33	63.34	4.63	0.48	.....	C
3.50	33.50	55.75	7.25	0.49	.....	C
0.93	25.94	68.82	4.31	0.46	1.312	B_2
0.96	26.63	68.36	4.05	0.67	1.300	B_2
0.82	20.93	64.33	13.92	0.47	1.406	B_2
0.94	22.39	69.96	6.71	0.52	1.356	B_2

LI-CHIA-TU COAL-FIELD

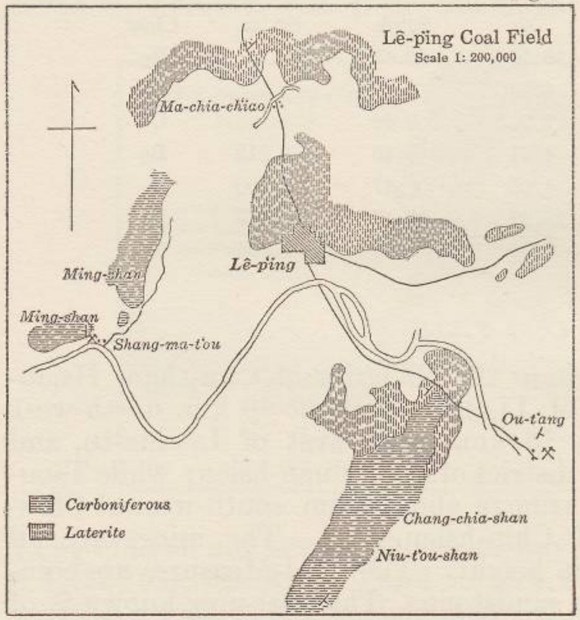
In the Li-chia-tu coal-field we include the collieries of Chu-shan, Hsiao-ling and Tsou-ma-ling in the environs of Li-chia-tu, about 40 km. north-west of Lin-ch'uan-hsien. Chu-shan, about 16 km. south-west of Li-chia-tu, and Hsiao-ling, about 6 km. north, are in the district of Lin-ch'uan-hsien; while Tsou-ma-ling, about 16 km. north-east of the same or about 8 km. south-west of Chin-hsien-hsien, belongs to the district of Chin-hsien-hsien. The mines are all found on hills about 100 to 200 metres in height. The Coal-Measures are composed chiefly of shale, covered by thick sandstone. The coal now known is of inferior quality, and its thickness is only one to two feet. The strike is N. 80° E., dip generally N. 15° at Chu-shan; N. 60° E. dip 25° to 50° at Hsiao-ling; and N. 40° W. dip N.E. 75° at Tsou-ma-ling. The production is insignificant, the monthly output not exceeding thirty tons.

The coal-fields above described run from east to west, occupying a large area in the province. Though the relation of the coal-seams has not yet been worked out, it is certain that they belong to one continuous formation. The total quantity of coal in the fields is very large, though it has not yet been calculated from exact data. As already stated, the coal reserves of the Fêng-chêng coal-field have been estimated to be 400,000,000 tons, and those of P'ing-hsiang to be 300,000,000 tons. From the geological relations and the data obtained, I have been led to suggest that the coal reserves in the remaining coal-fields will be found to be as great as the sum of the amounts in these two fields. A railway between Chiu-kiang and Nan-ch'ang is now in process of construction, by which the coal in the fields will easily be transported to Chiu-kiang, a port on the Yang-tse-kiang, where ocean steamers may safely call throughout the year. The coal will thus be put on the Oriental market.

COAL-FIELDS IN JAO-CHOU-FU

The Lê-p'ing coal-field (Fig. 8). Ou-t'ang is situated about 2 km. south-east of Lê-p'ing-hsien. The coal is mined on the farms of Ou-t'ang, on the east and west of which rise hilly ranges which run south-south-west. Sandstone with conglomerate crops out in the western hills and strikes N. 20° E. with the dip N.W. 30°. It is said that, underground, the strata dip south-east, probably forming an anticline. There are three coal-seams known. The upper has a thickness of one foot at a depth of ten feet, the middle is two feet thick at a depth of 150 feet, and the lower is eight feet thick at a depth of about 250 feet. The coal of the two upper seams is of inferior quality and not worth mining, while the lower is of good quality, with less sulphur, and is the one now worked. The annual production is said to be nearly 20,000 tons.

Fig. 8



About 12 km. south of Lê-p'ing-hsien lie Chang-chia-shan and Niu-t'ou-shan, where the strata strike N. 30° E. and dip south-east. The lower horizon of the strata is conglomerate, overlaid by sandstone with coal, which may be a continuation of that in Ou-t'ang.

The collieries of Hung-p'êng and Li-nao are situated about 2 km. west of Shang-ma-t'ou near Mount Ming-shan which rises about 10 km. west of Lê-p'ing-hsien. The Coal-Measures run from north to south, with a gentle dip towards the west. There are said to be two coal-seams, the upper having a thickness of six or seven feet, and the lower of thirty feet. About twenty-five years ago the coal was actively worked, but the mines have been abandoned owing to the difficulty of pumping out the water.

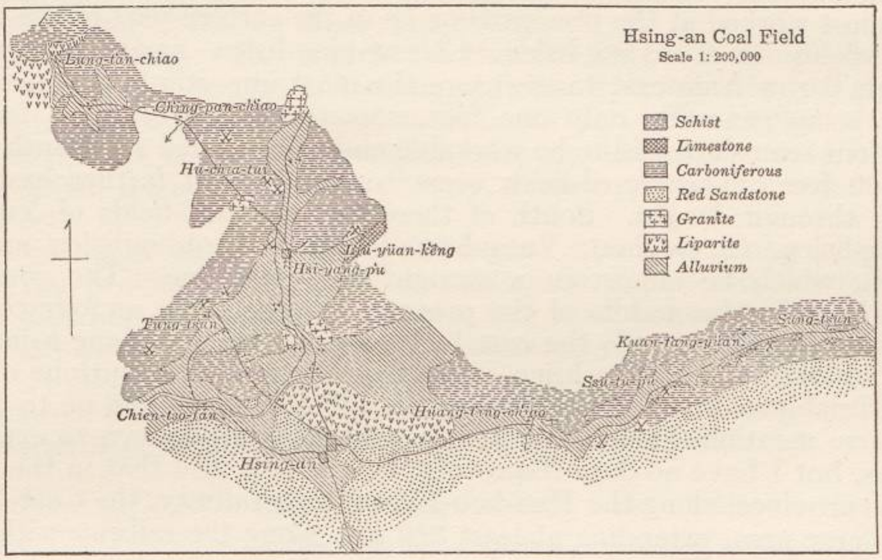
The Wan-nien and Yü-kan coal-fields. The Lê-p'ing coal-field seems to continue north-eastward to the coal-fields of Wan-nien-hsien and Yü-kan-hsien. In the latter the coal was once actively worked. Owing to excessive water, however, mining is now abandoned. The Yü-kan-hsien coal-field embraces a plain, with small hills, 50 to 200 feet high, rising from it. The coal crops out on the lower part of the hills. The thickness varies from 0.5 to 2 feet. Two or three coal-seams are now known, with the strike east-north-east and dip north-north-west. The coal in the area was formerly worked.

HSING-AN COAL-FIELD

The Hsing-an coal-field (Fig. 9) includes the collieries of Hu-chia-tui, Tung-ts'un and Kuan-t'ang-yüan. Kuan-t'ang-yüan is situated about 14 km.

east of Hsing-an-hsien; Hu-chia-tui about 8 km. north of the same town; and Tung-ts'un about 4 km. south-west of the last named village. Besides these there are numerous small mines in the environs of these villages. For about ten years the coal has been worked for domestic use. The output of the field was nearly twenty tons a day in its most flourishing time. Though there are many working mines, the output is now quite insignificant, being only five or six tons a day. The basement complex is the crystalline schists, overlaid by limestone. The Coal-Measures consist chiefly of shale in the lower, and of sandstone in the upper, part, underlaid by crystalline schists and *fusulina* limestone. In the southern part of the field the so-called Red Sandstone covers a wide area. The strata are found to be often intruded by granite and liparite. The strike of the Coal-Measures is N. 30° E. with varied dips. The coal-seams

Fig. 9



now known are few in number. At Hu-chia-tui the coal is said to be first met with at a depth of forty feet, and is from four to five feet thick. The mine is now filled with water and it is not possible to inspect the coal underground. The Coal-Measures here dip N.W. 45°. The three coal-seams at Tung-ts'un are all thin, but it is said that one seam four feet thick lies deeper down. The dip of the strata here is S.E. 50°. At Kuan-t'ang-yüan one coal-seam having a thickness of from one foot to fifteen feet, dips S.E. 30°. The coal reserves are estimated to amount to 15,000,000 tons.

COAL-FIELDS NOT YET PROSPECTED

The environs of Chiu-kiang. Bituminous coal of inferior quality is worked for domestic use at Lao-ya-chien in Jui-ch'ang-hsien. At Chu'an-chia-ch'an, south of Jui-ch'ang-hsien near the boundary separating the district from Tê-an-hsien, bituminous coal of good quality is mined for fuel for steamers and locomotives. The quantity of coal is said to be large and it is soon to be worked on a larger scale. The coal found in Hsüeh-shan-ling, on the boundary between the two districts of Hsing-tzŭ-hsien and Tê-hua-hsien, is also mined. In Tê-hua-hsien the coal is worked near the north-western shore of the Po-yang-hu and also in the south-eastern corner of the same district, in Wan-nien-hsien.

In Hsin-fêng, in the southern part of the province, bituminous coal is known to occur and seems to continue to the south-west. It is said that the coal extends into the province of Kuang-tung-shêng.

In Chi-an-fu, Lu-ling-hsien and Ching-te-hsien, coal is also said to occur, and anthracite in Hsing-kuo-hsien, Ch'ien-shan-hsien and Ch'ien-ch'an-hsien. The coal-field in Tê-hsing-hsien seems to be a continuation of that in Lê-p'ing-hsien.

Hu-nan-shêng

In the province of Hu-nan-shêng there are many coal-fields, but all those that are most worked at the present time lie in the eastern part of the province. The coal-fields of Lei-yang-hsien, Ch'ang-ning-hsien and Ch'i-yang-hsien, which form a row from east to west, are the most important. The coal-seams are thin, being generally only one foot, sometimes two or three feet thick. Three or four seams are said to be workable and to be mined at a depth of about 300 to 400 feet. These coal-fields seem to extend still farther eastward to Ch'a-ling, through An-jên. South of these, are the coal-fields of Yung-chou, Kuei-yang-hsien, Ch'ên-chou, Yung-hsing-hsien, Hsing-ning-hsien and Kuei-tung-hisen, which lie almost in a straight east-west line. The coal-field of Hsin-hua-hsien in the middle of the province imbeds three or four coal-seams two or three feet thick. To the east lie the coal-fields of Hsiang-hsiang-hsien, Hsiang-t'an-hsien and Li-ling-hsien. The last one seems to continue on to join the P'ing-hsiang coal-field in Kiang-si-shêng. To the north and on to the south of the above mentioned areas, many large coal-fields are known to extend over wide areas, but I have no data respecting them. It is said that in the southern half of the province, along the Han-kou-Kuang-tung railway, the Coal-Measures occupy a large area, extending at least 320 km. along the railway with a width of at least 97 km. The number of coal-seams has not been ascertained, but three seams are certainly known and probably there are others. The coal belongs to both the anthracite and bituminous varieties. As to its quality, no information is now accessible to me, except the statement that anthracite is mined along the Lei-chui river; while the coal in the district along the Hsiang-chiang river is bituminous. As to the output, we have only an estimate, based upon the number of coal-laden junks passing Yo-chou, that the annual production of anthracite is from 4,000,000 to 5,000,000 tons.

The area over which coal occurs is probably not less than 56,203 sq. km., and that in which the coal can be easily mined, more than 3,111 sq. km. The coal-seams are at least three in number, and the least aggregate thickness is fifteen feet. With these figures, we may estimate the probable coal reserves to be about 17,000,000,000 tons.

Ssŭ-ch'uan-shêng, Kuei-chou-shêng and Yün-nan-shêng

Ssŭ-chûan-shêng. In Yüeh-sui anthracite is found in a formation considered to be the Silurian. It is non-caking and of inferior quality. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
3.74%	3.55%	53.38%	39.33%	0.40%	A_1

Anthracite is found to the east of Hui-li, near the province of Yün-nan-shêng, and is being worked by the natives. To the north of Chao-hua, coal is found in the Palæozoic limestone, but it is not important.

In the eastern corner of the province, along the Ta-ning-ho, north-west of Ta-ning-hsien, there are collieries at T'ung-kuan-kou and T'ang-mu-shu-lin, where the coal is being mined on both sides of the river. The coal-bearing formation consists mostly of grey limestone with intercalated shale, and forms a syncline along the river. The coal is generally found in the shale, but sometimes in the limestone, the thickness being three to four feet. In T'ai-t'u, of Ch'i-chiang-hsien, Permian coal is found near the Mesozoic coal and is considered to be a continuation of that in Kuei-chou-shêng.

Kuei-chou-shêng. The coal is interbedded in the Carboniferous, which extends over the eastern part of Wei-ning-hsien and stretches on to Tung-ch'uan-hsien in Yün-nan-shêng. It is said to be important. The thickness of the coal worked at present is three to five feet. In the district about 15 km. east of Wei-ning-hsien, the coal is rather actively worked and is supplied to the Wei-ning market.

The coal-field north of T'ung-tzŭ-hsien, extending along the boundary between the province and Ssŭ-ch'uan-shêng, is considered to represent the Permian, and one coal-seam two to three feet thick is known. In the environs of T'ung-tzŭ-hsien, Coal-Measures of the same age run from north-east to south-west.

Palæozoic coal is also said to occur in Yun-ning-hsien and An-nan-hsien.

The results of technical analyses of the coal are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class	
Wei-ning	0.72%	22.84%	72.60%	3.80%	1.83%	B_2	Caking
Tung-ch'uan	1.56	7.12	64.45	26.87	1.14	A_2	Non-caking
"	0.50	15.10	65.74	18.67	0.40	B_2	Non-caking
Tung-tzŭ	2.03	12.19	70.51	13.14	2.13	B_2	Non-caking

Yün-nan-shêng. The coal mined on the east of Hsüan-wei is chiefly supplied to local zinc furnaces. Carboniferous coal is also found in that region, about 25 km. north of Yün-nan-fu. In Ta-kuan, Chao-t'ung-hsien, Tung-ch'uan-hsien and A-mi-chou, Palæozoic coal is said to occur.

COAL-FIELDS IN THE MESOZOIC

Chih-li-shêng

Ta-an-shan and Wang-p'ing-kou coal-field. As I have stated above, the Carboniferous to the north of the Ma-an-shan and Ta-an-shan mountains or west of Pe-king, contains coal. Sandstone and shale, which overlie the Carboniferous on the north, seem to represent the Permian or Triassic. The lower Jurassic, in the north, lies directly on these beds and consists of shale and sandstone. The strike is north-east, and the dip north-west or south-east, forming a syncline. The strata considered as Permian or lower Triassic, imbed ten or more coal-seams, but in some places a smaller number are met with. In Yang-kia-fang, south-east of Yang-shan, lying west of Pe-king, shale and sandstone dip S.S.E. 30°. There four coal-seams were examined, the thickest being ten feet or more; they are now being worked. North of the pass over Ta-an-shan we find numerous adits, and on the north coal is being worked. The lower Jurassic coal is worked at several places between T'sai-tang and Mei-ling. The formation near Ts'ai-tang consists of shale and sandstone, and dips W.N.W. 40°. There four coal-seams were examined, the uppermost being thin, the second having a thickness of five to nine feet, and the third and lowest being one foot to three feet thick, sometimes widening to five feet.

CHI-MING-PAO COAL-FIELD

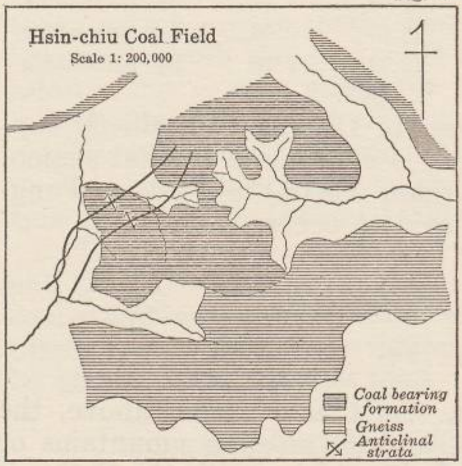
The Chi-ming-pao coal-field is situated in Hsüan-hua-fu near the highway between Hsüan-hua-fu and Pe-king. The field consists of Liassic sandstone and shale imbedding bituminous coal, and dipping E. by S. 45°. In 1909 about 6,500 tons of coal were transported to Pe-king for sale and the annual production has been estimated to be nearly 50,000 tons. The coal is of the caking variety, the results of technical analyses of it being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
2.68%	26.30%	56.06%	14.96%	0.37%	1.494	5,780c	10,404	B_2
4.00	37.70	41.04	7.26	0.26	1.346	6,710	12,078	C

HSIN-CH'IU COAL-FIELD

The Hsin-ch'iu coal-field (Fig. 10) is situated in Fu-hsin-hsien and lies about 120 km. west-north-west of Hsin-min-fu. The field was discovered about fifteen years ago, and the production since its opening has been as follows: 1898-1903, 10,800 tons; 1904-1907, 14,000 tons; 1908-1909, 10,000 tons.

Fig. 10



The total production has been nearly 34,800 tons. The intention is now to raise the production by greatly extending the operations. The coal-field consists of undulatory hills, bounded by mountains of gneiss of the basement complex. The trend of the gneiss is north-east, and the dip is generally towards the north-west, but in the southern part it is to the south, the coal-bearing formation lying in the synclinal basin that is thus formed. The coal-bearing formation consists of sandstone, shale and conglomerate. Generally, heavy sandstone occupies the upper horizon, while alternating strata of shale and sandstone with several coal-seams constitute the lower part. The strike of the strata is north-east and two anticlines and one syncline may be observed. The angle of inclination is sometimes steep, often with angles of 75°, or sometimes almost horizontal, but is generally 30° in the south and lower in the north. The coal-field is about 13 km. long and 8 km. wide. The important coal-seams are three in number, the thickness varying within wide ranges. The upper seam is thin, being two to three feet thick at the west end, widening to twelve feet in the middle part, and thinning out to the east. The average thickness is considered to be not less than five feet. The next seam lies about eighty feet below the upper and varies in thickness from two to twenty feet, being thickest in the middle portion. Its average thickness is estimated to be eight feet. The lower seam lies about seventy feet below the second seam, and is the most important. Where thickest it attains a thickness of eighty feet with a few partings, but it becomes thinner towards the west, being twelve feet thick there. The average thickness is twenty-five to thirty feet. The aggregate thickness of the workable coal-seams in the coal-field seems to be at least thirty-eight feet. An area 12,000 feet long and 6,000 feet wide along the dip will easily be workable. The coal reserves of this field are estimated to be 120,000,000 tons. The coal is hard and pitch black in colour. It cakes slightly and burns with a long flame. It is not difficult to get lump coal. The coal of the lowest horizon is the best in quality. The results of technical analyses of it are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash.	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Upper Seam.......	14.00%	31.00%	51.50%	3.50%	0.40%	.....	.....	.....	C
" "	14.00	29.5	48.50	8.0	trace	.....	.....	.....	C
" "	7.36	35.96	50.76	5.92	0.94	1.354	6,215c	11,187	C
" "	5.89	30.61	57.30	6.20	0.78	1.474	6,270	11,286	C
Middle Seam.......	1.06	35.35	53.17	10.42	2.81	1.331	5,830	10,494	C
" "	7.57	37.88	52.40	2.15	0.64	1.296	7,260	13,068	C
" "	8.33	35.52	48.63	7.52	1.44	1.316	5,830	10,494	C
Lower Seam.......	8.70	36.83	46.68	7.79	0.67	1.34	5,500	9,900	C
" "	11.4	25.60	57.80	5.20	trace	.....	.....	.....	C
" "	4.50	36.10	47.80	11.60	.....	.....	.....	.....	C
" "	12.89	34.99	48.52	3.60	0.59	.....	.....	.....	C
" "	9.00	35.00	47.00	9.00	.....	.....	.....	.....	C

WU-CHIA COAL-FIELD

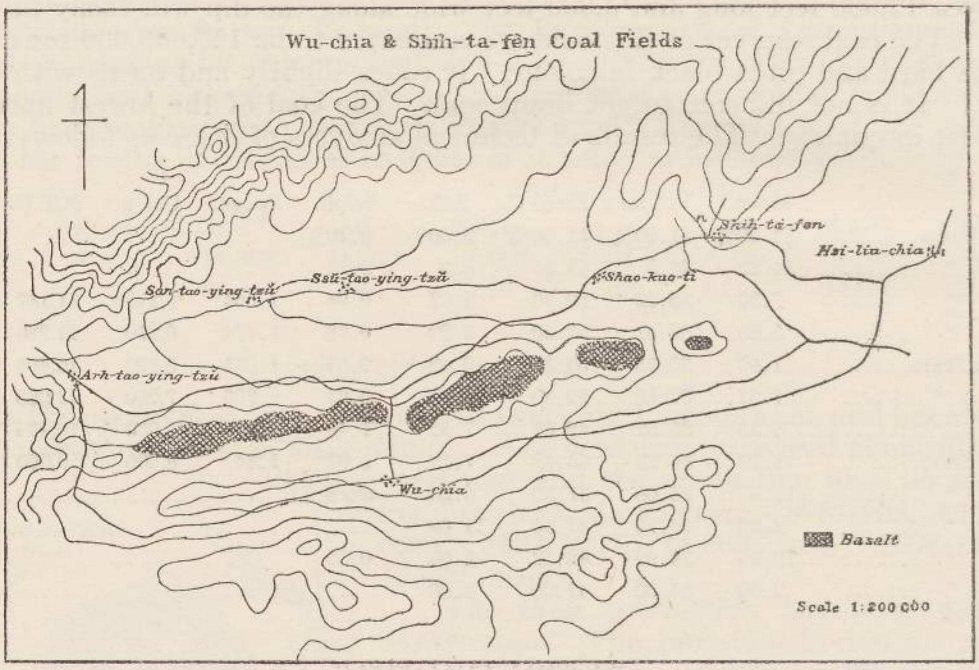
The Wu-chia coal-field (Figs. 11 and 12) is situated about 40 km. south-south-east of Ch'ih-fêng-hsien, and is said to have been opened about 150 years ago. Six collieries are at work at present, yielding 2,500 tons a year. The land is a hilly plateau covered with thick loess. The coal-bearing formation belongs to the Mesozoic and is intruded by basalt, which forms hills in the area. As a result of disturbances and of the eruption of volcanic rocks the formation is much contorted, so that the dip and strike are very variable, as shown in the figure. As a whole, the formation has a strike of N. 20° to 30° W., dipping S.W. 15° to 35°. There are four workable coal-seams known, and of these, one, eleven feet thick, is now being worked. The one above the worked seam has a thickness of eight feet, and the two below thicknesses of six feet and twelve feet, respectively. The quantity of coal cannot be estimated with certainty, since no exact survey has been carried out. The area of workable coal is nearly 84 sq. km. and a conservative aggregate thickness for the seams is thirty-three feet; from which data one engineer has estimated the amount of coal at 1,000,000 tons for coal reserves, and 304,000,000 tons for coal which is certain to be mined. The coal is of a brown, bituminous variety and caking. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U.	Class
17.94%	34.30%	43.59%	4.17%	0.48%	5,060c	9,108	C

SHIH-TA-FÊN COAL-FIELD

The Shih-ta-fên coal-field (Fig. 11) lies immediately to the east of the Wu-chia field and the village of Shih-ta-fên, about 12 km. east-north-east of Wu-

Fig. 11



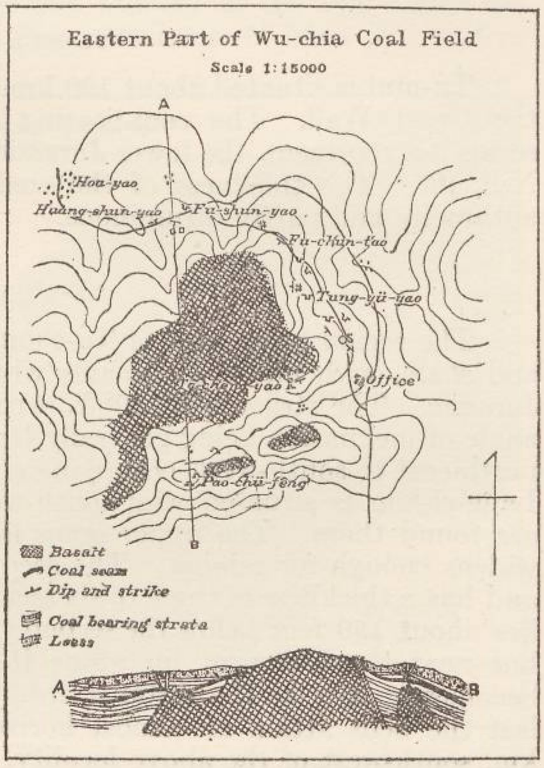
chia. There are numerous abandoned mines, the history of which is not known. At present two Chinese companies are working there and the yield is about thirty tons of coal a day. The topography and geology are quite similar to those of the Wu-chia field, but the formation seems to represent the lower horizon of that in Wu-chia. The dip and strike are often variable, but generally speaking the strata run N. 25° E., dipping W.N.W. 25°. Three workable coal-seams are known to occur, their thickness being 5.5, 5 and 3 feet, respectively. The area underlain by workable coal is estimated to be nearly 244 sq. km., and the aggregate thickness of the coal-seams is twelve feet, from which the amount, 1,140,000,000 tons, has been estimated. The coal is similar to that in Wu-chia, and is slightly caking. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U.	Class
15.73%	37.39%	40.19%	7.05%	1.55%	5,335c	9,603	C

OTHER COAL-FIELDS

The Ta-lieh-shan and Hsiao-lieh-shan coal-field. This field is situated about 30 km. east of P'ing-ch'üan-chou. The mine was recently opened and the production is still very small, being only about fifteen tons a month. The field is a hilly plateau, composed of shale, sandstone, and limestone, which are considered to be Mesozoic. The one coal-seam now known is overlain by thick limestone and runs N. 60° E., dipping N.N.W. 30°. The seam is thin and the coal of an inferior quality, so that a detailed description is not necessary. Coal is also found at the west of the Ta-lieh-shan coal-field, within a radius of about 12 km., with Pa-tao-ho in Luan-p'ing-hsien as the centre.

Fig. 12



The Ch'i-chia-tzŭ coal-field. This coal-field is situated about 5 km. north of Ch'ing-ho-pien-mên, outside the Great Wall. It was opened about twenty years ago, but the production is insignificant. The coal-field is a hilly plateau lying along the western bank of the Ch'ing-ho and is composed chiefly of sandy tuff running nearly east to west, with the dip S. 5° to 10°. Of the two coal-seams now known, the upper one is over one foot thick. The lower seam, which is worked, lies from thirty to forty feet below the upper and has a thickness of two to three feet. The geological age of the formation has not yet been established, but it is said to represent the lower part of the Mesozoic. The coal belongs to the bituminous variety and is non-caking. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.
3.12%	27.3%	46.9%	23.68%	0.12%	5,632

Coal-fields not yet prospected. The Ping-kou coal-field. This field is situated near the boundary of Kharachin. There four seams are known to occur in an area of 2 sq. km. The production is not known, but seems to be large, judging from the amount realized from the tax on the coal.

Coal is found at several places within a distance of about 65 km. from Chao-yang-fu. Some of these are: Hsing-lung-kou, Kang-tzŭ-ling and Fêng-huang-ch'êng, lying to the north, south, and east of the town, respectively. The coal is an anthracite.

Along the Pe-king-Chang-chia-k'ou railway coal is known to occur at several places. The coal-seams known to occur in the districts of Yü-chou, Hsi-ning, Pao-an and Ch'ih-ch'êng-hsien, in the prefecture of Hsüan-hua-fu, seem to belong to the Mesozoic, and the coal in Lung-hua-hsien and Ch'ang-p'ing-hsien probably belongs to the same formation.

Shan-si-shêng

TU-MUL COAL-FIELD

Tu-mul is situated about 100 km. north-east of Ta-t'ung-fu and lies outside the Great Wall. The coal-bearing formation consists mainly of shale, and seems to represent the lower Jurassic. The strike is N. 50° W. and the dip N.E. 18°. The thickness of the coal is nearly five feet. The coal is partly anthracite and partly bituminous.

TA-T'UNG COAL-FIELD

The region lying west of Ta-t'ung-fu is hilly. It is composed of sandstone and shale, with many coal-seams which are considered to represent the lower Jurassic. The strike is N. 30° E. with a gentle dip towards the north-west, the angle of inclination being generally less than 10°. The coal-field stretches from north-east to south-west, occupying a basin about 97 km. long and 24 km. wide. Lang-el-kou is situated west-south-west of Ta-t'ung-fu, and three coal-seams are found there. The upper seam is too thin to be worked, but it sometimes widens enough for mining. The second one lies about 250 feet below the first and has a thickness of three to six feet. The lowest is said to be the thickest and lies about 150 feet below the second. The dip angle is gentle, as above stated, but near the basement limestone it is often greater than 30° and generally becomes gentler as the distance from the basement complex increases, until at last the beds attain an almost horizontal position. Hai-ku-tzŭ lies about 10 km. south-west of the above locality, or about 25 km. from Ta-t'ung-fu. Here the thickness of the coal is twenty to thirty feet, but it is difficult to get lumps. The coal-field extends towards the south and seems to continue into the district of Huei-yen-hsien. The coal has the appearance of anthracite but burns with a long flame. The coal reserves are estimated at 1,200,000,000 tons.

Shen-si-shêng and Kan-suh-shêng

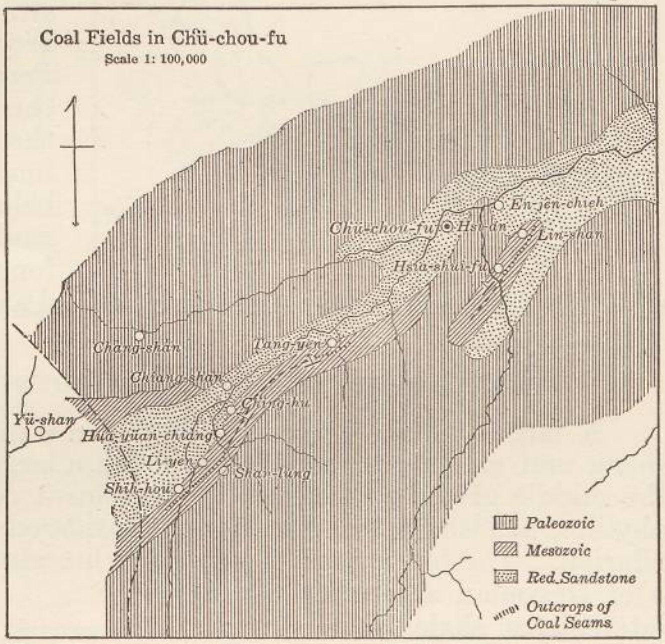
Shen-si-shêng. The region between Hsing-an-fu and P'ing-li-hsien is composed of metamorphosed rocks, consisting of phyllite and schists, which probably represent the Permo-Mesozoic. The coal interbedded in the formation is worked in the northern and eastern parts of P'ing-li-hsien; but as the strata are much disturbed, mining is difficult, and consequently the production is insignificant. At Lao-hsien, midway between P'ing-li-hsien and Hsing-an-fu, coal is also observed.

Kan-suh-shêng. The strata, extending south and north-west of Lan-chou-fu seem to represent the era from the Upper Carboniferous to the Trias. Coal-seams are interbedded in the strata.

Cheh-kiang-shêng and Kiang-si-shêng

Cheh-kiang-shêng (Fig. 13). On the upper Ch'ien-t'ang-chiang, the Palæozoic formation occupies a large area, on which a thick complex, consisting chiefly of sandstone, has been deposited near the river. The formation is considered to belong to the Jurassic and the coal is interbedded in it. In Hsia-shui-fu, about 15 km. south-east of Hsi-an-hsien in Ch'ü-chou-fu, coal is found about 130 feet below the surface. The thickness and number of the coal-seams are unknown, but it is said that one seam attains a thickness of from four to five feet and dips S.E. 45°. The coal was actively worked fifteen years ago. Numerous adits are found in Lin-shan about 15 km. east of Hsi-an-hsien. The coal-seams there probably represent a continuation of those in Hsia-shui-fu, the total distance over which they extend thus reaching about 60 km. The coal reserves have been estimated at 80,000,000 tons. The coal is of inferior quality.

Fig. 13



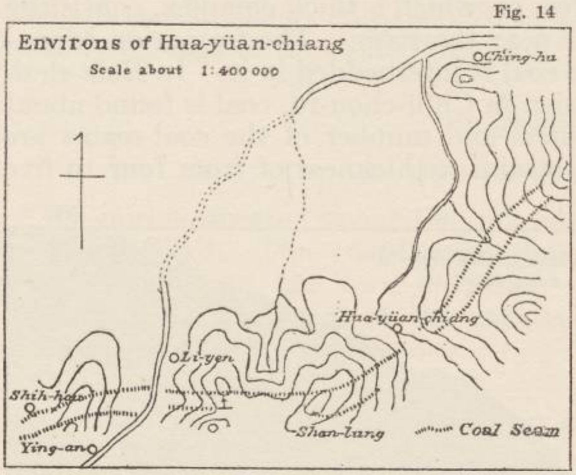
The coal-fields of Ying-an, Shih-hou, and Chêng-t'ang (Figs. 14 and 15), lying near the river and south of Chiang-shan-hsien, are composed of the same formation as in Hsi-an. Three coal-seams are known, striking nearly east-west and dipping N. 50° to 60°. The upper seam is thickest, being three to four feet. The second one is of inferior quality. The lowest one was formerly worked, but nothing is now known about the seam. The formation continues on the eastern side of the river, where the two coal-seams were examined, the lower one being the thicker of the two. The dip of the strata is nearly N. 70°. Abandoned adits are also found in T'ang-yen, about 10 km. south of Wu-chi-li, lying about 20 km. east-north-east of Chiang-shan-hsien. Here the strata run N. 70° E., dipping N.W. 70°, or vertical. The coal is interbedded in one continuous formation, the total distance over which it extends being estimated to be 60 km. and the coal reserves to be 40,000,000 tons. The coal is caking, and of rather good quality. The results of technical analyses of it are as follows:

	Moist.	Vol mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Lin-shan..........	0.72%	15.47%	75.99%	7.82%	0.69%	1.418	7,205c	12,969	B_2
Shan-lung.........	0.41	18.65	70.13	10.82	2.06	1.446	6,820	12,076	B_2
Shih-hou..........	0.42	19.27	72.11	8.20	1.05	1.395	7,095	12,771	B_2

In Chin-hua-fu, Lan-ch'i-hsien, Ch'ang-shan-hsien, Sui-an-hsien, Chien-te-hsien, Ch'u-chou, Wên-chou, etc., coal is also known to occur.

Kiang-si-shêng. In Yü-shan-hsien the Mesozoic coal extends westward to Kuang-fêng-hsien and is considered to be a continuation of the coal in Chang-shan-hsien in Cheh-kiang-shêng.

Fig. 14



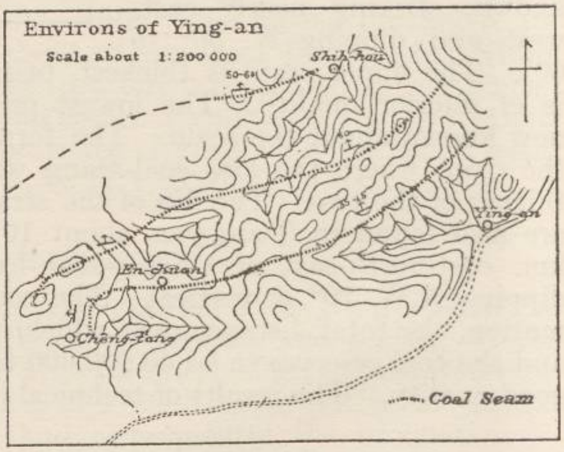
Hu-peh-shêng

Permo-Mesozoic. Alternating strata of sandstone and shale with grey limestone, considered to be Permo-Mesozoic and underlain by the Carboniferous, are seen along the Yang-tse-kiang. A coal-seam is found in the limestone about 8 km. below Pa-tung-hsienk and is being worked. Six thin coal-seams are found in the limestone about 3 km. up the river from Kuei-chou. It is mined and made into briquettes.

Ssŭ-ch'uan-shêng, Kuei-chou-shêng and Yün-nan-shêng

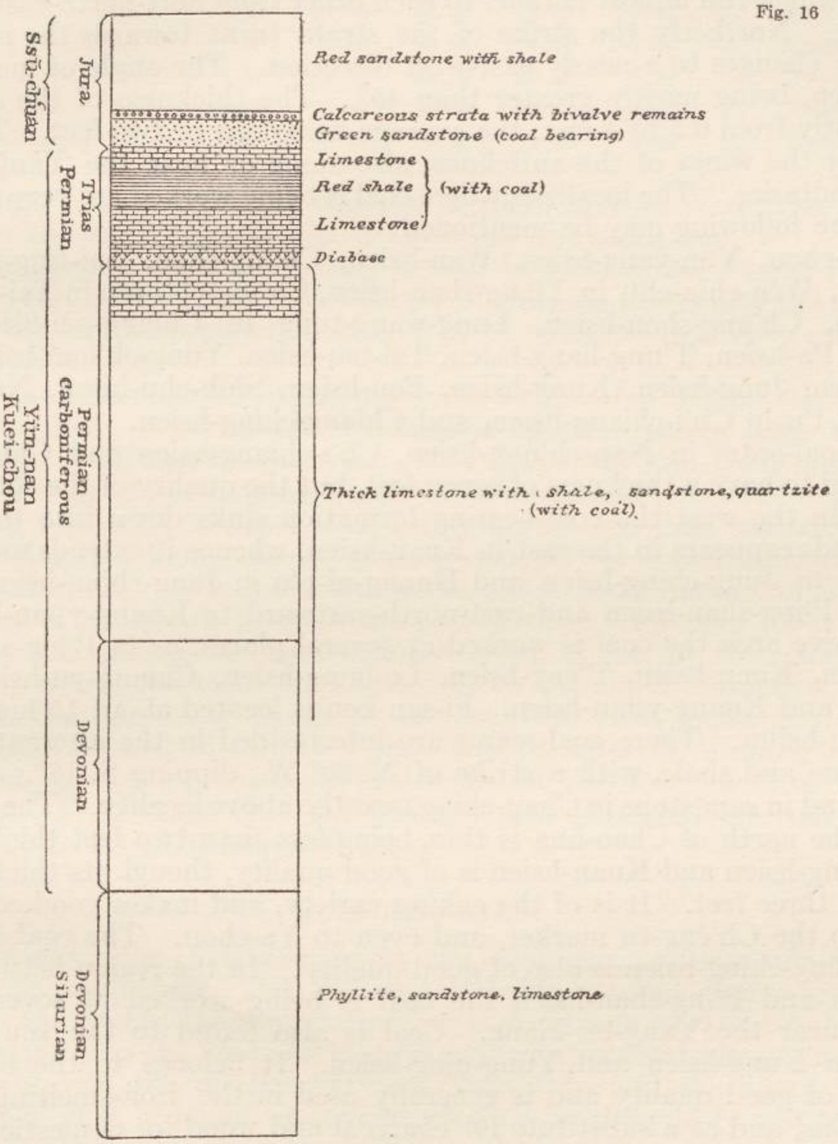
A large plateau covers the large area in Kuei-chou-shêng and Yün-nan-shêng and extends to Ssŭ-ch'uan-shêng, a large basin in Ch'êng-tu occupying the middle of the province. The basement complex of the region consists of phyllite, sandstone and limestone, considered to represent the Devonian and Silurian. The lower part of the thick limestone which overlies the formation, is of Devonian age, while the upper intercalates shale, sandstone and quartzite with coal-seams and represents the Carboniferous and Permo-Carboniferous. Another heavy limestone formation, with red shale in the middle and diabase sheet in the lower part, rests on it and also contains coal-seams. It is the Permo-Trias. Most of the coal-seams in Kuei-chou-shêng and Yün-nan-shêng are interbedded in these two formations. Whether these formations have been deposited without interruption is not yet established, but it is often difficult to decide to what horizon the coal-seams belong. Green sandstone occupies wide areas in Ssŭ-ch'uan-chêng, overlying the limestone, and coal-seams are interbedded in it also. It is said to represent the Jurassic. The important coal-seams in Ssŭ-ch'uan-shêng lie in this formation. Calcareous strata with abundant bivalve

Fig. 15



remains overlie the sandstone. The red sandstone with red shale of the uppermost horizon, the so-called Red Sandstone, also occupies wide areas. In fact most of the coal-seams in these provinces lie in the different formations, as above stated. The strata show many foldings and faults, so that the same

Fig. 16



formation is repeated several times in these areas. An ideal section is shown in Fig. 16.

SSŬ-CH'UAN-SHÊNG

The large coal-field in the middle of the province extends farther eastward into the three provinces of Hu-peh-shêng, Shen-si-shêng, and Kan-suh-shêng, and covers nearly half of the province. The basement complex is limestone, overlaid by thick sandstone with subordinate layers of shale. The geological age of the sandstone is not yet ascertained, but it is considered to represent a period extending from the Triassic to the Jurassic. Eastward from the Ch'êng-tu basin the formation is much folded, so that we can enumerate more than ten synclines, which run almost parallel to each other from nort-north-east to south-south-west. Northerly the strike of the strata turns towards the north-west, and finally changes to a nearly east-west direction. The angle of inclination is rather steep, being mostly greater than 45°. The thickness of the coal-seams varies mostly from 0.5 to 4 feet, the average being one or two feet. The coal is mined near the wings of the anticlines, also along or near the Yang-tse-kiang and its tributaries. The localities where coal is being worked are very numerous. Of these the following may be mentioned:

K'uei-chou, Yün-yang-hsien, Wan-hsien, Chung-chou, Sui-ting-fu, Liang-shan-hsien, Wên-chia-chü in Liang-shan-hsien, Ch'ing-ch'i-p'u in Tai-chu-hsien, Ch'ü-hsien, Ch'ang-shou-hsien, Lung-wang-tung in Chiang-pei-hsien, Fêng-mên-ya in Pa-hsien, T'ung-liang-hsien, Tai-tsu-hsien, Yung-ch'uan-hsien, Yung-ch'ang-hsien, Jung-hsien, Kung-hsien, Fou-hsien, Shih-chu-hisen, Nan-ch'uan-hsien, T'ai-t'u in Ch'i-chiang-hsien, and Chiang-ching-hsien.

The coal-seam in Nan-ch'uan-hsien, Ch'i-chiang-hsien and Chiang-ching-hsien is said to have a thickness of seven feet, but the quality of the coal is rather inferior. In the west the coal-bearing formation sinks down into the Ch'êng-tu basin and reappears in the east in Kuan-hsien, whence it extends south-south-westwards to Jung-ching-hsien and Huang-ni-p'u in Jung-ching-hsien and still farther to P'ing-shan-hsien and east-north-eastward to Kuang-yüan-hsien. In this extensive area the coal is worked at several places, as in P'ing-shan-hsien, O-mei-hsien, Kuan-hsien, P'eng-hsien, Lo-hung-hsien, Chiang-yu-hsien, Chao-hüa-hsien, and Kuang-yüan-hsien. Fi-san-kou is located about 15 km. north of Kuan-yuan-hsiün. There coal-seams are interbedded in the alternating strata of sandstone and shale, with a strike of N. 80° W., dipping S. 18°. One coal-seam is found in sandstone in Chau-ching near the above locality. The coal-seam found at the north of Chao-hua is thin, being less than two feet thick, and the coal in P'êng-hsien and Kuan-hsien is of good quality, though its thickness does not exceed three feet. It is of the caking variety, and makes good coke. It is supplied to the Ch'êng-tu market, and even to Ya-chou. The coal in Huang-i'-pui in Jung-ching-hsien is also of good quality. In the region between Junk-ching-hsien and P'ing-shan-hsien the coal is being worked at several places, especially near the Yang-tse-kiang. Coal is also found to the south of the river, as in Kung-hsien and Yung-ning-hsien. It belongs to the bituminous variety, is of good quality and is generally used in the iron-smelting furnaces and limekilns, and as a substitute for charcoal and wood for domestic use.

The coal is caking in some localities and non-caking in others.

The results of technical analyses of it are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class	
P'êng	2.34%	37.78%	58.23%	1.65%	0.15%	C	Caking
Lung-wang-t'ang	1.10	28.30	65.05	5.10	p.46	..	Non-caking
Yung-ch'uan	1.52	25.58	60.94	11.96	0.61	B_2	Slightly caking
Jung-chang	1.55	34.00	55.13	9.32	0.69	C	Caking
Kuan	1.83	32.69	63.84	1.64	0.42	..	Caking
Chao-hua	1.56	32.76	48.88	16.80	5.20	..	Non-caking
Jung	1.83	26.69	60.28	11.20	0.68	B_2	Non-caking
Perm-Trias Ch'i-chiang	1.60	10.15	76.45	11.80	1.64	A_2	Non-caking

The Red Sandstone basin occupies a small area at Yen-yüan-hsien, and coal is also known to occur in the strata below the sandstone.

The colliery of Lung-wang-tung is said to yield about 70,000 tons of anthracite a year. Based upon the number of working mines and the area of the coal-field, the annual production of coal in the province has been estimated at about 1,000,000 tons.

As to the coal reserves in the province, we have no reliable data on which to calculate them. The coal-field doubtless extends over a large area about 403 km. from north-east to south-west, and about 322 km. from north-west to south-east in direction, making about 129,000 sq. km. As above stated, the coal-bearing formation is much folded, forming no less than ten anticlines, the angle of inclination being mostly greater than 30° or sometimes vertical. As the thickness of the coal is generally two feet and the inclination of the strata is rather steep, it is difficult to work the coal farther down than 1,000 feet below the surface. In general the coal within 4-5 km. of the dip from the anticlinal axis may be considered to be workable. From the above statement we are led to the view that the total length of the coal-field must be at least ten times 403 km. with a breadth of 1 and 3-5 km. The thickness is variable, but we may safely count upon three workable coal-seams of two feet thick, or, in all, six feet of coal. From these data one geologist has estimated the coal reserves in the province to be 15,000,000,000 tons.

KUEI-CHOU-SHÊNG

In the environs of Kuei-yang-fu the coal-bearing formation runs from north-east to south-west, and the coal is being worked rather actively. In An-shun-fu the coal in the same formation is also being worked by the Chinese. Near Pi-chieh-hsien the coal has been examined at several places and seems to be important. In the district between Tsun-yi-fu and the northern part of Ta-ting-hsien, coal is found at several places. In Tu-yün-fu and Yin-chiang-hsien, coal is also known to occur. The coal-bearing formation is considered to represent the Permo-Trias.

The coal is anthracite or semi-anthracite, the result of its technical analysis being as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class	
Kuei-yang	0.35%	18.88%	72.33%	5.84%	2.60%	B_2	Caking
An-shun	2.69	10.46	73.49	13.36	2.05	A_2	Non-caking
Pi-chieh	1.94	9.95	79.00	8.80	0.29	A_2	Non-caking

YÜN-NAN-SHÊNG

The Red Sandstone basin west and north-west of Yün-nan-fu occupies a tolerably large area, as in Ta-yao, Yao, etc. The coal is interbedded in the strata below the Sandstone and is considered to represent the Jurassic. In P'ing-yi-hsien coal is also said to occur.

KUANG-TUNG-SHÊNG AND KUANG-SI-SHÊNG

No information about the coal-fields of Kuang-tung-shêng and Kuang-si-shêng is accessible to me at present. The following localities where coal is known to occur, may be mentioned:

Kuang-tung-shêng. Kuei-shan-hsien, Hsi-ling in Hua-hsien, Wêng-yüan-hsien, Lê-ch'ang-hsien, Shih-hsing-hsien, P'ing-shih in Ju-yüan-hsien, T'ang-yü-ling in Yang-shan-hsien, Tê-ch'ing-fu, Yang-ch'un-hsien, Lien-chou and Ch'êng-hai-hsien.

Kuang-si-shêng. Ho-hsien, Fu-ch'uan-hsien, Wu-chou, Nan-ning-fu and Pai-sê-ting.

The coal-seams found in Ta-ling in Ho-hsien are nine in number, the thickness being: first seam, 3.0 feet; second, 2; third, 5.7; sixth, 1.5; seventh, 4; eighth, 8; and ninth seam, 3 feet. The daily output is nearly 20 tons.

THE COAL RESOURCES OF COREA

BY

KINOSUKE INOUYE

Director of the Imperial Geological Survey of Japan

(With two maps in the Atlas and eleven figures in the text)

I—INTRODUCTION

The mining industry in Corea seems to have been developed in remote times or at least earlier than in Japan, but at present there is no large Corean mine equipped with modern machinery. As to the mineral resources of the peninsula, little is known to us except such information as comes through the reports of geologists and mining engineers of our own and foreign countries, which are difficult of access. During the years 1904 and 1905 a geological reconnaissance survey was carried out by a number of geologists and mining engineers sent out by the Imperial Government of Japan; and afterwards, under Mr. T. Kochibe, superintendent of the mineral survey of the Corean Government, a detailed survey of some mining districts was completed. After Corea had been united to Japan a geological survey was undertaken by Mr. S. Kawasaki, geologist in charge, to whom I am greatly indebted for much valuable information, specially furnished to me.

The important mining industries are those of gold, copper, iron, coal and graphite. Gold ranks first in output, the other minerals being far below it. The annual production of coal scarcely exceeds 100,000 tons. Except the Phyŏng-yang coal-field, which is the chief producer of coal, there is none that yields over 2,000 tons a year, most of them being worked by Coreans in a small way and by primitive methods. To enumerate all the collieries, or to ascertain their output, would be quite impossible, as they are mined by farmers when they have nothing else to do, and are frequently closed when working becomes difficult on account of depth or mine water and reopened when conditions are more favourable. This primitive method of mining is retained chiefly because of the inferior quality of the coal and the thinness or unequal thickness of the seams, which make it difficult to mine on a large scale.

II—THE GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF COAL

The coal occurs in the Palæozoic, the Mesozoic and in the Tertiary. The Mesozoic coal is the most important, and the greater part of the coal mined in

Corea is furnished by it. The coal-bearing Palæozoic is scattered over the country in small areas, some of which have not yet been surveyed. So far as known, the Palæozoic coal is not important, and it is not expected that a large quantity of it will be discovered in the future. The Tertiary, which was deposited in small basins of the older formations, along or near the coast of the Sea of Japan, imbeds several coal-seams of inferior quality, which are worked on a small scale for domestic use.

The Palæozoic formation occupies two large areas, besides smaller, scattered patches. The Corean formation, a name which I have proposed in contradistinction to the so-called Sinian formation, consists chiefly of quartzite, clayslate and sandstone in the lower, and of limestone and marl in the upper part, and is considered partly to represent the Sinian formation. The coal-bearing Palæozoic, in correlation with that in Manchuria, seems to represent the Carboniferous and overlies the Corean formation. It consists of clayslate and sandstone, and is intruded by granite. It is scattered throughout the country, but the areas are small, so that it is considered probable that the greater part has been carried away by erosion.

The important coal-bearing Mesozoic occupies a tolerably large region in Phyöng-an-dō, besides smaller areas scattered here and there in the country. It lies on basement gneiss or Palæozoic limestone, and consists of shale and sandstone. By the fossil flora found in the formation it has been proved to represent the Jurassic. In many places it is intruded by eruptive rocks, such as granite, porphyrite, etc.

The Tertiary, deposited mostly on the coast of Kyöng-syang-dō and Ham-gyöng-dō, rests unconformably in small basins on older formations, such as gneiss, the Palæozoic, the Mesozoic, granite, etc. It consists of shale, sandstone, conglomerate and tuff, and is intruded by andesite and basalt or is sometimes covered by basalt. The fossils, which abound in the tuff and shale, have not yet been studied, but they seem to represent the younger Tertiary.

III—THE PRODUCTION AND CONSUMPTION OF COAL

The production of coal is rather small, though the coal-mining industry is in a progressive state. It was quite insignificant before 1907, when the management of some coal-fields was transferred to Japanese hands, and the Phyöng-yang coal-field was prospected for a large mining enterprise. Since that time the production has gradually increased, that in 1911 being as follows:

Phyöng-yang	100,000 tons.
An-jyu	1,937 "
Ham-heung	1,500 "
Kyöng-syöng	600 "
Chyang-gi	654 "
Total	104,691 tons.

The production of other collieries is insignificant and it is certain that the total production in 1911 did not exceed 110,000 tons.

Most of the coal is exported to Japan, but the import is far greater than the export, as is shown by the following table:

	EXPORT			IMPORT		
	To Japan	To China	Total	From Japan	From China	Total
1907........	2,042 tons		2,042 tons	104,761 tons	50 tons	104,811 tons
1908........	1,253 tons	5,734 tons	6,987 "	187,302 "	177 "	187,479 "
1909........	40,986 "	3,976 "	44,962 "	83,667 "	40,262 "	123,929 "
1910........	69,615 "	3,148 "	72,764 "	72,947 "	57,420 "	130,367 "
1911........	84,294 "	2,590 "	86,885 "	223,017 "	12,394 "	235,411 "

The coal raised in the Phyöng-yang coal-field belongs to the anthracite or semi-anthracite variety, which easily crumbles to powder. It is sent to Japan for the manufacture of briquettes. Most of the coal imported is of a bituminous variety, the large consumers being the railways and steamships. Thus it will be seen that the consumption of coal in Corea does not exceed 250,000 tons, a very small amount as compared with the area and population. This is due to the absence of large manufacturing industries, coal being unnecessary at present. However, transportation facilities are developing and industries will not long remain unchanged. There is reason to believe, therefore, that a larger amount of coal will be consumed in the near future.

IV—THE QUALITY AND AMOUNT OF COAL

No detailed geological survey of the peninsula has yet been carried out, but some coal-fields have been specially surveyed, so that the amount of coal can be calculated with tolerable accuracy. As described later on, the average thickness of the seams does not exceed three feet, the thick seams thinning out rather abruptly in short distances, so that for a safe and conservative estimate we take a vertical extension of 500 feet below the surface for the actual reserves, with an additional 1,000 feet for the probable reserves, unless otherwise mentioned. On this basis we get the following figures for the coal reserves in Corea.

ACTUAL RESERVE

Coal-Field	Thickness	Area	Class of Coal	Metric Tons
Phyöng-yang	4 to 20 feet	$1\frac{95}{100}$ sq.km.	A.B.	8,600,000
Southern Section	8 to 20 "	$\frac{2}{5}$ "	A.B.	2,500,000
Eastern Section:				
Ko-pang-san	10 to 20 "	$\frac{7}{10}$ "	A.B.	4,000,000
Pong-hoang-dong	4 to 5 "	$\frac{1}{20}$ "	A.B.	100,000
Nam-gang	6 feet	$\frac{4}{5}$ "	A.B.	2,000,000
Kyöng-syang	4 to 8 feet	$\frac{33}{100}$ "	D_2	600,000
Na-nam	8 feet	$\frac{3}{100}$ "	D_2	100,000
Säing-keui-ryöng	4 "	$\frac{3}{10}$ "	D_2	500,000
Chyang-gi	15 "	$\frac{1}{4}$ "	D_1	1,700,000
	7 "	$\frac{2}{5}$ "	D_1	1,300,000
Yöng-il	12 "	$\frac{1}{4}$ "	D_1	1,400,000
Totals		$3\ \frac{9}{50}$ sq.km.		13,600,000

PROBABLE RESERVES

Coal-Field	Thickness	Area	Class of Coal	Metric Tons	Possible Reserve
An-jyu	2 to 15 feet	$2\frac{1}{10}$ sq.km.	C	9,450,000	Moderate
Sin-gol	15 feet	$1\frac{1}{2}$ "	C	9,000,000	
Yong-nyön-ni	2 "	$\frac{3}{5}$ "	C	450,000	
Phyöng-yang	4 to 20 feet	$12\frac{1}{2}$ "	A.B.	36,900,000	Large
	4 to 20 "	$\frac{1}{2}$ "	A.B.	2,500,000	
Eastern Section:					
Ko-pan-san	10 to 20 "	$\frac{4}{5}$ "	A.B.	5,000,000	
Pong-hoang-dong	4 to 5 "	$\frac{1}{5}$ "	A_1	400,000	
Ko-bi-ni	7 feet	1 "	A_1	3,000,000	
Nam-gang	6 "	$5\frac{1}{2}$ "	A	15,000,000	
Western Section	5 to 6 feet	$4\frac{1}{2}$ "	..	11,000,000	
Kyöng-syang	4 to 8 "	$3\frac{3}{10}$ "	D_2	6,000,000	Moderate
Na-nam	8 feet	$\frac{3}{10}$ "	D_2	1,000,000	
Säing-keui-ryöng	4 "	3 "	B_2	5,000,000	
Chyang-gi	15 "	$\frac{4}{5}$ "	D_1	5,500,000	Moderate
	7 "	$1\frac{1}{2}$ "	D_1	5,000,000	
Yöng-il	12 "	1 "	D_1	5,500,000	
Totals		$21\frac{1}{5}$ sq.km.		68,350,000	Large

The coal is of four kinds, anthracite, semi-anthracite, brown coal, and lignite. The coal interbedded in the Palæozoic is all anthracite, part of which passes into graphite as a result of contact metamorphism by granite. That in the Mesozoic is anthracite, semi-anthracite or bituminous coal, the anthracite or semi-anthracite being most important. The Tertiary coal is an inferior lignite, which is consumed by Coreans as fuel for domestic use and for their salt pans.

With the exception of gold, the mineral resources of Corea as now known are quite limited and the total output does not reach a large amount. As to the coal-mining industry, only the Phyöng-yang coal-field is worth mentioning, being now somewhat extensively equipped. Whether the coal in Corea will suffice for its own developing industries and means of transportation, we cannot decide in the present unfinished state of the detailed geological survey, though we feel that extensive fields, capable of supplying a very large amount of coal, cannot be expected. The large consumers of coal at present are the railways and steamships, only a very small amount being employed for domestic fuel and in the industries. Corea will be a consumer of imported coal for many years yet, though we have reason to expect that the present production will be largely increased.

V—DESCRIPTION OF THE COAL-FIELDS

Coal-Fields in the Palæozoic

The coal known to occur in the Palæozoic is found in only a few places and only two localities have been examined. It all belongs to the anthracite variety.

YONG-TANG-NI COAL-FIELD, SOUTH HAM-GYÖNG-DŌ

Yong-tang-ni is situated about 12 km. south of Ko-üon lying on the highway between Uön-san and Ham-heung. The coal is found in two small areas, one near the village and the other about 5 km. south of it. The Palæozoic formation covers the area generally and is intruded by granite, by which the formation suffers contact metamorphism. It is divided into three series, a lower, consisting of biotite schist, biotite slate and phyllite, sometimes with quartzite; a middle, of limestone with clayslate; and an upper or coal-bearing series of black clayslate with coal, sandstone and marl. The lower series has a thickness of 3,300 feet, and the middle of from 10,000 to 11,600 feet. The Coal-Measures lie on the limestone of the middle series conformably, a very few feet of marl being always found between these two series. The greater part of the Coal-Measures has been eroded away, so that they now remain only in small patches. The coal is often metamorphosed by the contact action of granite so as to become graphite, as in Heuk-syök-lyöng in Yöng-heung, where earthy graphite is being mined. The coal found in an area between Yong-tang-ni and Syu-pan-dök, about 3 km. west of Yong-tang-ni, rests in a synclinal basin on the limestone and runs west-north-west, being 6 km. long and over 1 km. wide. The coal near Yong-tang-ni is either changed to graphite by the intrusion of granite or is severely disturbed. In Syu-pan-dök the coal-seam dips N. 40° and is seven feet thick. It thins out to 0.5 foot towards the east and is covered by soil in the west. To the north the series dips south and forms a syncline as does the underlying limestone, but no outcrop of coal is found there. In San-chyŏi-dong, about 4 km. south of Syu-pan-dŏk, the Coal-Measures run west-north-west, the extension being about 8 km. by 1 km. As to the coal, nothing is known with certainty at present, but, from the results of a trial working, it is reported that three coal-seams, with a thickness of from 5 to 20 feet, occur in the area. In Syŏng-hyŏn-ni, about 4 km. north of Syu-pan-dŏk, the Coal-Measures run from east to west, but no outcrop of coal is now known.

The coal is lustrous and similar to that of Phyŏng-yang. It easily breaks up into powder, so that it is difficult to get it in lumps. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Class
9.24	7.67	78.25	4.84	A_2

KAI-CHHYŎN COAL-FIELD, SOUTH PHYŎNG-AN-DŌ

The Kai-chhyŏn coal-field is situated about 10 km. east-north-east of Kai-chhyŏn and includes the two villages of Oa-uŏn and Yong-bong-ni. The environs of Kai-chhyŏn are underlain by Palæozoic strata intruded by granite, by which the formation suffers contact metamorphism. The Palæozoic is divided into three series, as in Yong-tang-ni, the lower consisting chiefly of mica schist, phyllite and quartzite with thin limestone, and the middle of limestone with clayslate. The upper series represents the Coal-Measures, and consists chiefly of sandstone and clayslate sometimes with limestone. The sandstone is generally thick in the upper, and the clayslate in the lower, part, in which coal-seams are interbedded. Near Oa-uŏn several outcrops of coal have been examined, the thickness varying from a few inches to over ten feet. The strike is nearly west-north-west and the dip at low angles. The strike near Yong-bong-ni about 2 km. north-east of Oa-uŏn, is nearly east-west forming an anticline with dip angles of 40° to 50°. The coal-seam cropping out near the highway dips with an angle of 30°. To the north of Kai-chhyŏn, beyond a mountain and near Peuk-uŏn on the Chhyŏn-chhyŏn-gang, the coal, as a result of contact metamorphism with granite, changes to graphite, which is mined at two or three places. The coal is an anthracite of good quality and easily breaks up into powder. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
5.21	5.89	83.53	5.37	0.25	A_1

COAL NOT YET PROSPECTED

In the following localities coal is known to occur:

Chho-san in North Phyōng-an-dŏ; Syun-chhyŏn and Măing-san in South Phyŏng-an-dō; Chhyŏng-san in North Chhyüng-chhyŏng-dō; Chyŏng-syŏn and Sam-chhyŏk in Kang-uŏn-dō.

The result of technical analyses of the coal in Chhyöng-san is as follows.

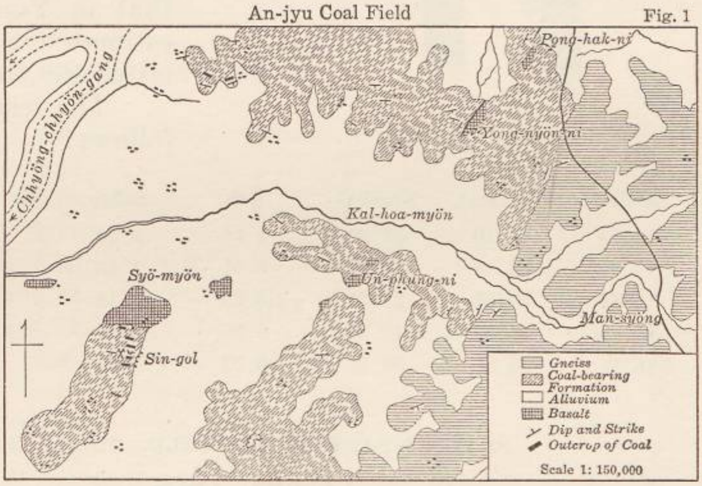
Moist.	Vol. mat.	Fixed C.	Ash	Class
1.95	4.37	65.83	27.85	A_1
11.41	3.36	61.98	23.25	A_1

Coal-Fields in the Mesozoic

AN-JYU COAL-FIELD, SOUTH PHYÖNG-AN-DŌ

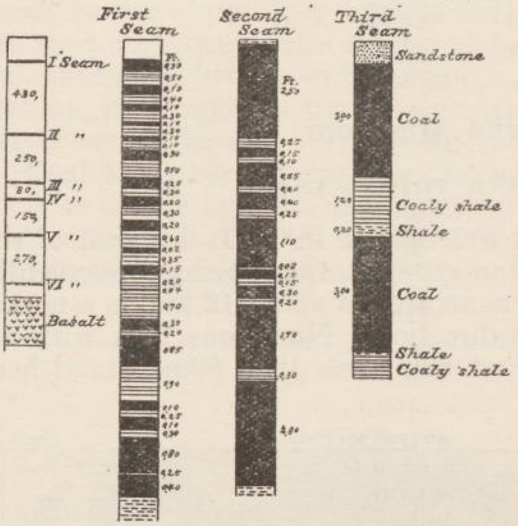
The An-jyu coal-field (Fig. 1), which was opened in 1911, lies west of the railway line between the Sin-an-jyu and Man-syöng stations, being conveniently reached from Man-syöng station. It covers an area of about 12 km. in a north-south and about 8 km. in an east-west direction. Numerous hills with an average height of 15m. to 20m., the highest being less than 80m., stand here and there in the plain, between the Chhyöng-chhyön-gang and the railway. The field is limited on the east by gneiss, on which the coal-bearing Mesozoic rests unconformably. The lower part of the coal-bearing formation consists chiefly of conglomerate, alternating with shale and sandstone; and the upper, of shale with thin sandstone and coal. As the field is a tract of low hills and plains, no good outcrop, making it possible to correlate the stratigraphical relation of each coal-seam, has been found. The strike is nearly east-west, and the dip is south, the angle of inclination being 20° to 30° in the north and 15° in the south. However, in the eastern part the strike changes to nearly north-south or north-east. Probably a fault will be found to run nearly north and south through Un-phung-ni and Yong-nyön-ni. The dip is west near the gneiss boundary and east near the fault, possibly forming a syncline. Basalt is found along a line considered to be a fault between Pong-hak-ri and Yong-nyön-ni, and also in the west, intruding the formation as sheets. A hill range at Sin-gol consists of sandstone and shale, intruded by basalt on the north. Six coal-seams are said to occur striking N. 80° W. with the dip S. 10° to 20°. The lowest, three to four feet thick, is found near basalt. The five other seams, beginning with the upper, are 12, 12, 7, 2 and 3 feet, respectively, in thickness. The second seam contains an inferior, clayey portion, so that the good, workable part is seven feet instead of twelve, and the first contains many partings, as shown in Fig. 2. The least aggregate thickness of the workable coal-seams is 15

An-jyu Coal Field Fig. 1



feet. The environs of Yong-nyŏn-ni are underlain by conglomerate, sandstone and shale, the coal cropping out on the west of the village and striking north-north-east. To the north it sinks under the alluvial deposits of the plain and again appears in a hill in Pong-hak-ri, where it is covered near the railway by the alluvial deposit. The strike is north-east, dip S.E. 40° to 70°. The thickness is variable, being often less than 2.5 feet. The hanging wall is basalt, while the foot wall is loose sandstone. In the north-west, coal crops out in three places, the thickness being 1 to 1.5 feet. The strike is N. 70° E. on the east and N. 80° W. on the west, dip S. 20°. The amount of coal in Sin-gol is much larger than that in Yong-nyŏn-ni, the former being estimated to be 9,000,000 tons and the latter 450,000 tons.

Fig. 2



The result of technical analyses is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
12.52	41.10	38.20	0.18	0.19	....	6,276	11,286	C
14.64	39.48	38.97	6.91	1.46	....	5,940	10,692	C
15.43	37.58	38.71	8.28	0.18	1.33	6,160	11,088	C
17.18	36.33	40.23	6.26	0.19	1.32	6,380	11,484	C
18.11	32.81	39.35	9.73	0.23	....	5,060	9,108	C

PHYŎNG-YANG COAL-FIELD, SOUTH PHYŎNG-AN-DŌ.

(*Plate 2*)

In the Phyŏng-yang coal-field we include the region of the coal-bearing formation, which stretches nearly from east to west, and occupies an area about 60 km. long and 20 km. wide. Phyŏng-yang is situated almost in the centre of the field and is the principal market and municipal town of the Phyŏng-an-dō.

The date of the opening of this field is not recorded; but for the last twenty-five years the coal has been mined on a small scale by Coreans for domestic use. More recently mining in Să-dong and Ko-pan-san has been carried on by French engineers. In 1906 the mining rights were transferred to the Corean Government, and later to the Japanese Government. Collieries are now in operation in Să-dong and Ko-pan-san. The production of coal since 1907 has been as follows:

1907......	2,150 tons.	1908......	46,487 tons.
1909......	53,493 "	1910......	79,738 "
1911......	100,000 " (estimate).		

The basement gneiss bounds the north-western portion of the field; while Palæozoic formations adjoin the other parts. Both of these older formations also crop out in small areas here and there in the field. The coal-bearing formation rests on them and for convenience may be divided into an upper and a lower series. The lower series consists of shale and sandstone with breccia, sometimes thin limestone, and contains seams of anthracite in its lower horizon. By the fossils imbedded in the strata, the formation has been proved to represent the Jurassic. The upper series consists of shale, sandstone and conglomerate, which are often tufaceous and interbedded with thin seams of brown coal. The stratigraphical position of the upper series is not well known, but it lies on the lower series unconformably. Quartz porphyry and porphyrite are found intruding the formation, the granite occupying only small areas. The coal-field is conveniently divided into the northern, the southern, the eastern and the western sections.

The coal is of the anthracite or semi-anthracite variety and easily breaks up into powder. It is black and non-caking. The results of technical analyses of it are as follows:

SOUTHERN SECTION

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
7.03	20.53	67.93	4.61	.....	.....	.....	.....	B_2
4.47	14.89	70.84	9.80	.....	.....	.....	.....	B_1
15.51	24.70	47.58	12.21	.....	.....	.....	.....	B_2
.....	10.40	81.10	8.50	1.20	.....	.....	.....	A_2
2.89	7.56	83.16	6.39	.....	.....	.....	.....	A_2
3.63	10.53	82.50	3.34	.....	.....	.....	.....	A_2
.....	16.10	77.60	6.30	0.47	.....	.....	.....	B_2
.....	15.10	80.80	4.10	0.65	.....	.....	.....	B_1
10.47	20.26	58.37	10.90	.....	.....	.....	.....	B_2
23.68	29.64	35.84	10.84	.....	.....	.....	.....	B_2
.....	16.90	81.30	1.80	0.55	.....	.....	.....	B_2
2.00	15.20	78.10	4.70	0.70	.....	.....	.....	B_1
2.88	11.29	81.04	4.79	0.64	.....	.....	.....	A_2
.....	11.00	81.50	7.50	0.85	.....	.....	.....	A_2
1.75	4.15	85.97	8.13	0.45	.....	.....	.....	A_1
11.82	22.77	61.14	4.27	.....	.....	.....	.....	B_2
9.80	21.79	64.22	4.19	.....	.....	.....	.....	B_2
8.97	19.79	66.55	4.69	.....	.....	.....	.....	B_2
6.08	14.78	70.60	8.54	.....	.....	.....	.....	B_1
5.81	13.88	71.49	8.82	.....	.....	.....	.....	B_1
1.73	8.29	84.12	5.86	.....	.....	.....	.....	A_2
1.23	8.43	85.43	4.91	2.28	.....	.6490	.....	A_2
6.45	15.08	74.77	3.70	0.37	1.472	.....	.....	B_1
5.49	16.24	72.12	6.15	.....	.....	.....	.....	B_2
4.61	13.44	75.56	6.39	.....	.....	.....	.....	B_1
.....	10.00	86.20	3.80	0.77	.....	.....	.....	A_2
1.83	10.05	83.77	4.35	0.56	1.402	.....	.....	A_2

EASTERN SECTION

Ko-pang-san District

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
3.25	5.51	62.66	28.58	0.34	1.976	.....	.....	A_1
3.70	8.10	76.60	11.60	0.70	.....	.....	.....	A_2
.....	5.70	79.00	15.30	0.46	.....	.....	.....	A_1
4.15	3.68	79.58	12.59	.....	.....	.....	.....	A_1
4.89	7.92	75.83	11.36	.....	.....	.....	.....	A_2
2.20	8.25	72.26	17.29	.....	.....	.....	.....	A_2
11.50	18.44	64.04	6.02	.....	.....	.....	.....	B_2
22.12	26.63	30.89	20.36	.....	.....	.....	.....	B_2
16.30	28.37	35.03	20.30	.....	.....	.....	.....	B_2
19.78	27.06	34.20	18.96	.....	.....	.....	.....	B_2
19.32	26.90	35.03	18.75	.....	.....	.....	.....	B_2
21.06	26.69	36.45	15.80	.....	.....	.....	.....	B_2
15.45	28.87	43.91	11.75	.....	.....	.....	.....	B_2
18.27	25.71	39.53	16.49	.....	.....	.....	.....	B_2
12.77	25.03	44.70	17.50	.....	.....	.....	.....	B_2
17.73	24.48	44.39	13.40	.....	.....	.....	.....	B_2
13.51	25.14	52.63	8.72	.....	.....	.....	.....	B_2
10.62	20.50	43.45	25.43	.....	.....	.....	.....	B_2
15.01	23.32	53.25	8.42	.....	.....	.....	.....	B_2
14.23	18.24	55.60	11.93	.....	.....	.....	.....	B_2
7.96	17.35	58.66	16.03	.....	.....	.....	.....	B_2
4.64	12.90	77.66	4.80	.....	.....	.....	.....	B_1
3.42	10.25	64.02	22.31	.....	.....	.....	.....	B_1
3.56	9.48	80.36	6.60	.....	.....	.....	.....	A_2
3.82	9.00	82.77	4.41	.....	.....	.....	.....	A_2
3.21	8.39	83.65	4.75	.....	.....	.....	.....	A_2
3.24	7.60	78.42	10.74	.....	.....	.....	.....	A_2
1.22	7.40	86.80	4.58	.....	.....	.....	.....	A_2
2.67	7.94	78.67	10.72	.....	.....	.....	.....	A_2
2.63	6.57	80.61	10.79	.....	.....	.....	.....	A_2
20.16	24.57	32.65	22.62	.....	.....	.....	.....	B_2
17.33	23.24	36.10	23.33	.....	.....	.....	.....	B_2
17.51	20.70	53.42	8.37	.....	.....	.....	.....	B_2
14.59	23.82	56.13	5.46	.....	.....	.....	.....	B_2
12.99	20.86	52.21	13.94	.....	.....	.....	.....	B_2
3.97	7.31	72.03	16.69	.....	.....	.....	.....	A_2
8.31	24.93	56.58	10.18	.....	.....	.....	.....	B_2
1.41	8.55	81.78	8.26	.....	.....	.....	.....	A_2
1.90	7.74	80.64	9.72	.....	.....	.....	.....	A_2
2.20	7.55	82.77	7.48	.....	.....	.....	.....	A_2
3.35	6.79	84.22	5.64	0.42	1.465	.....	.....	A_2
1.60	10.50	79.70	8.20	0.90	.....	.....	.....	A_2
.....	11.80	84.30	3.90	0.85	.....	.....	.....	A_2
2.55	2.55	64.19	30.71	0.37	.....	.....	.....	A_1

Pong-hoang-dong District

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
3.15	3.89	79.69	13.27	.....	.....	.....	.....	A_1
3.45	4.26	86.20	6.09	.....	.....	.....	.....	A_1
2.57	3.60	77.74	16.09	.....	.....	.....	.....	A_1
3.67	3.71	83.51	9.11	.....	.....	.....	.....	A_1

Ko-bi-ni District

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
2.77	3.32	80.31	13.60	.....	.....	.....	.....	A_1
4.57	12.88	77.44	5.11	0.74	.....	.....	.....	A_2

The District Along the Nam-gang

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
14.45	24.70	53.46	7.39	0.18	1.505	.....	.....	B_2
1.81	7.96	77.82	12.41	.....	.....	.....	.....	A_2
3.57	5.80	69.20	21.43	0.28	.....	.....	.....	A_1
5.40	32.70	53.30	8.60					
5.65	8.82	77.46	8.07	0.27	1.598	.....	.....	A_2
4.98	7.55	78.10	9.37	0.31	1.563	.....	.....	A_2
.....	16.90	81.30	1.80	0.55	.....	.....	.....	A_2
2.29	4.31	89.18	4.22	.....	.....	.....	.....	A_1
5.53	4.68	62.43	27.36	.....	.....	.....	.....	A_1
2.18	4.61	89.97	3.23	2.03	.....	7,150	12,870	A_1

NORTHERN SECTION

The northern section is not important. Coal is found in Kam-peuk-san and near Syö-pho, and was formerly worked near Kam-peuk-uön.

Kam-peuk-uön is situated about 6 km. north of Phyöng-yang. The Kam-peuk range, about 120 m. high, runs in a nearly east-west direction for about 4 km. It consists of shale and sandstone with breccia and nodules of marl. The strike is generally east-north-east, dip N.N.W. 30° to 40°, but at the southern foot of the range the strata are much disturbed. It is here that the coal crops out, its thickness varying from 0.2 to 6 feet. It becomes generally thinner towards the west.

One coal-seam crops out about 2 km. north of Syö-pho on the Seoul-Wijyu railway, or about 4 km. north of Kam-peuk-uön. Here the strata are much disturbed, and the thickness of the coal is very variable.

The coal is badly crushed and belongs to the class of anthracite that powders easily.

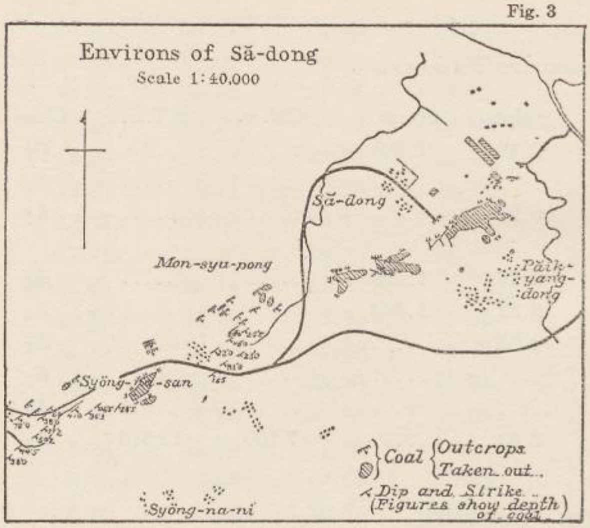
SOUTHERN SECTION

The southern section lies to the south-east of Phyöng-yang on the other side of the Tai-dong-gang river and consists of a low, hilly range less than

60 m. high, running from east-north-east to west-south-west. The total length of the section is as much as 13 km., while the breadth is only 2-3 km. The coal is now only mined in the environs of Să-dong (Fig. 3), the mines in Syö-pho and Mu-ro-san having been abandoned. The coal-bearing formation is covered by alluvium on both sides of the narrow belt indicated above, but its presence below has been proved by borings at Mi-in-dong, about 2 km. south-east of Să-dong, where shale and sandstone with coal two to five feet thick have been found at a depth of from fifty to eighty feet. The strike of the coal-bearing formation is generally N. 60° to 70° E. and the dip south-south-east at steeper angles, i.e., 60° to 70° in the south-east and 40° to 50° in the east.

Numerous outcrops of coal are found in the section and many coal-seams appear to be interbedded in it, but their mutual relations have not yet been well studied. From the results of borings and the examination of outcrops, it is known that seven seams probably exist in Să-dong, the third, fourth and fifth seams being mined at present. From Să-dong the coal continues westward to Mon-syu-pong, the length being estimated at 10,000 feet. The coal varies very much in thickness, in places widening to 60 feet and in places thinning out to a few inches, but the average aggregate thickness is about 15 to 20 feet. In Chyung-sand-dong, which is probably separated from Mon-syhong by a fault, three coal-seams nearly four feet thick run towards the south-west to Syö-pho, where they sink under the alluvial plain. The length is estimated to be 4,000 feet. They have been worked, but mining on them is now abandoned. In Mu-ro-san, rising south of Phyöng-yang, coal-seams which are considered to be continuations of those of Syö-pho, were formerly worked. They run towards the south-west, are about 2,000 feet in length, and are found along the cutting on the railway. Two seams are known, each being nearly three feet thick.

Fig. 3



As the thickness is very variable and basement limestone is often found underground, the calculation of the coal contents is based on depths above 500 feet for the sake of accuracy. On this basis the amount is roughly 2,500,000 tons each, for actual and probable reserves.

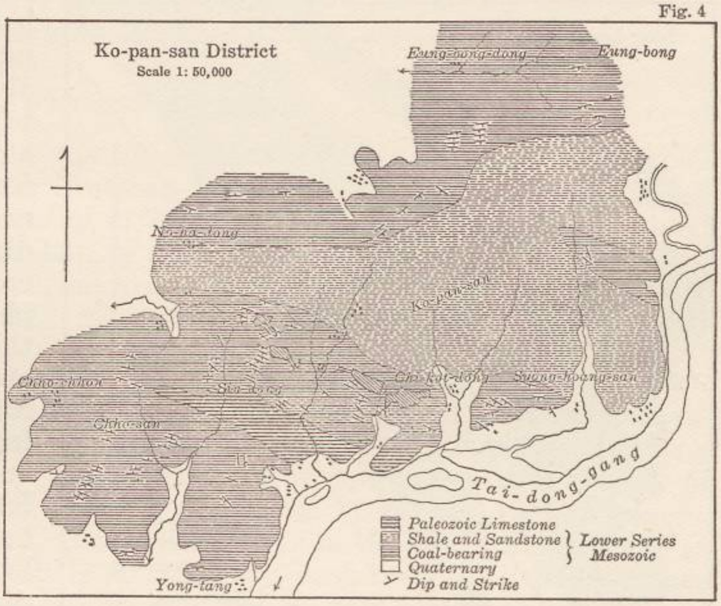
EASTERN SECTION

The eastern section is the most important, and is divided into the three districts of Ko-pan-san, Pong-hoang-dong and Ko-bi-ni and the district along the Nam-gang.

The Ko-pan-san district (Fig. 4). This district lies to the north of the Tai-dong-gang or Peuk-gang near the point where its main tributary, the

Nam-gang, enters. It forms an undulatory, hilly land sloping to the west, being generally higher in the east with peaks 100 to 150 m. high. It is bounded on the south and east by the river and its tributary, and on the west it sinks to the plain of the Tai-dong-gang. In the northern part it is covered by the upper series and beyond the Palæozoic forms rather high land. The Palæozoic is also found cropping out in the field. The length of the district is about 8,400 feet in a north-south and 12,000 feet in an east-west direction. The coal-bearing formation consists of quartzose sandstone and shale, with lenticular limestone near the basement complex. In the south-west portion of Ko-pan-san the formation is generally much disturbed, but its general strike is north-west or west-north-west, dip north or south with rather steep angles. On the north of Ko-pan-san it is east or east-north-east, with the dip towards the south, but near Eung-bong-dong the formation is much disturbed and folded.

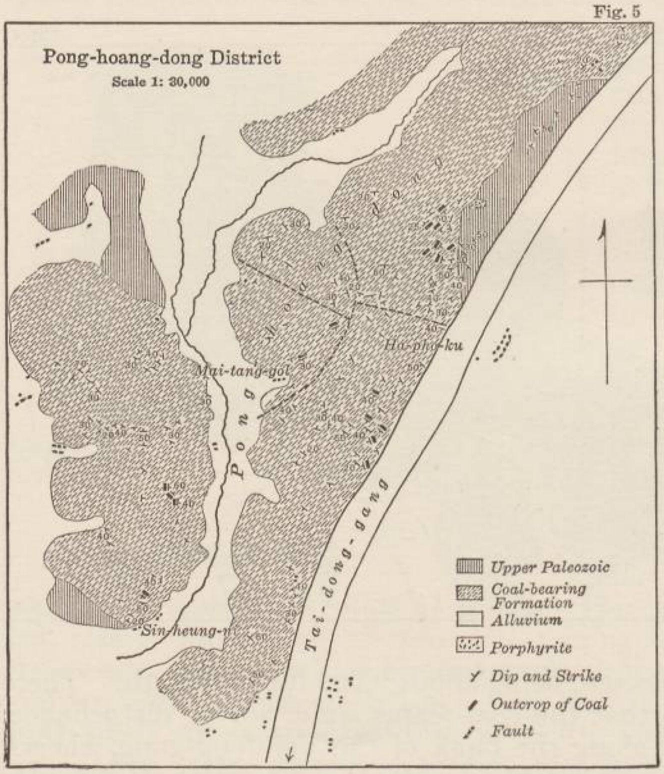
Fig. 4



The coal in the northern part may be traced for about 9,600 feet along the northern foot of Mount Ko-pan-san from Eung-bong to No-ha-dong; the strata occur in a monoclinal fold, dipping south-south-east, which, however, forms a syncline in the east. The coal-seams which crop out along the southern side of Mount Syöng-hoang-san run west-north-westward along the southern foot of Ko-pan-san to the north of Chho-san, being about 9,000 feet in length. There the formation is much folded, so that the coal-seams suffer severe disturbance. In the south the seams crop out along the bank of the Tai-dong-gang, whence they run west-north-westward to Chho-chhon with the dip north and south. The number and thicknesses of the coal-seams are not yet clearly known. In the middle portion of the district we can enumerate nine seams, of which probably the lowest two are now being worked. The thickness is very variable, the coal widening in places to 60 feet and in other places parting into thin seams, but the average aggregate thickness varies from 10 to 20 feet. For the same reason as in the southern section, the coal is believed not to lie more than 300 feet deep, with an average height of 100 feet above the level. The amount, computed on the above basis, is estimated at 4,000,000 tons for actual and 5,000,000 tons for probable reserves.

The Pong-hoang-dong district (Fig. 5). This district lies to the east of the Ko-pan-san district, from which it is separated by a plain drained by the tributaries of the Tai-dong-gang. A low, hilly range runs almost due north and south along the west bank of the Tai-dong-gang, the northern part of the range being the highest. West of it, across the valley of Mai-tang-gol, or to the north of Sin-heung-ni, stands a solitary hill elongated in a north-south direction. Palæozoic limestone, with sandstone, clayslate and hornstone, is found in a small area along the river. It also forms a part of the northern boundary of the field. The coal-bearing formation lies unconformably on the limestone and is composed of sandstone, shale and conglomerate, with coal-seams in the lower portion, as in Să-dong. The formation is greatly disturbed, and has a varied dip and strike. The eastern part of the district is cut by four faults which cross it about midway, the dips and strikes in each section so divided, being shown in Fig. 5. The number of coal-seams is not known but at least three seams appear to be interbedded. The thickness also is not known. One seam to the north of Ha-pho-ku has a maximum thickness of five feet. It forms an anticline near the top of a hill, with the dip N.W.-S.E. 25-40°. The coal cropping out south of Ha-pho-ku dips S.S.W. 40°, the thickness being said to be only one foot. A coal-seam north of Mai-tang-gol is at most three feet thick and dips S.W. 30°. In the western part, where the formation is also much disturbed, two coal-seams are known. The one in the north dips N.E. 30°-60°, its greatest thickness being three feet. The other in the south dips S.W. 50°, and has a maximum thickness of 12 feet. The average thickness of the coal-seams is not known, but probably varies from two to five feet. An extension of about 2,500 feet to the east and of about 1,000 feet to the west, with a vertical extension of about 300 feet, may be considered to contain coal, the reserves being very small.

Fig. 5



The Ko-bi-ni district. This district lies to the east of the Pong-hoang-dong district and is bounded on the east by the river. The coal-bearing formation strikes nearly east to west and dips S. 30°. One coal-seam, five to ten feet thick, is known and was formerly worked. The area underlain by coal is estimated to be 3,000 feet long. The coal reserve is estimated at about 3,000,000 tons.

The district along the Nan-gang. The coal-bearing series of the formation forms a belt about 16 km. long, separated by the river from the Ko-pan-san district in the west. The formation rests unconformably on Palæozoic limestone, several coal-seams lying near the basement limestone. The strike is generally west-north-west, dip N.N.E. 50°-60°; but in Sin-jyang an anticline is found. The coal-seams cropping out north-west of Sin-jyang have a thickness of from one foot to six feet. In the northern wing of the anticline, one seam is found. The coal seems to continue eastward along the strike, dipping north rather steeply. The two seams interbedded have a thickness of from one foot to three feet in general, but in Sim-chyu-uöl they become five feet thick; in Ko-tari-dong and Yong-chhyon six feet; and in Hoang-kyöng-dong over ten feet. The coal near Tho-tari was worked in 1906 under the name of the San-deung colliery, but after two years mining was abandoned. The dip of the formation is N.N.E. 45°-80°. There the thickness is from one foot to four feet. The coal reserve is estimated at about 15,000,000 tons.

WESTERN SECTION

In the western section coal was formerly mined near Pal-bong. The coal-bearing formation extends from Mun-san-dong, about 16 km. west of Phyöng-yang, south-westward to Sa-keui-ni in Kang-syö, and covers an area of about 10 km. in a north-south and 8 km. in an east-west direction. The geology is quite similar to that in the northern section, the coal-seams being found in shale below quartzose sandstone. The strike is generally east or north-east, and the dip N. or N.W. 30°-40°; but the strata are often disturbed.

North-west of Mun-san-dong three coal-seams are found and dip N. 30°. At Pal-bong, about 4 km. south-west of Mun-san-dong, two seams with thicknesses of two and six feet, respectively, are known. They run east, bending over an anticline with a nearly central axis and inclining at angles usually of 30°. To the north-north-west of An-syan-ni coal crops out in two places. Owing to the presence of a fault, the strike differs in the east and the west, as shown in the geological map (Plate 2). In the east the coal is nearly three feet and in the west nearly six feet thick. The Sa-keui-ni coal is bounded by gneiss. It is a lenticular mass and dips N.W. 40°. The length of the coal outcrops is estimated to be about 8 km. and the average thickness to be five to six feet. Estimated on these data the amount of coal will reach, roughly, 11,000,000 tons. It belongs to the anthracite variety and breaks up easily into powder.

SAM-KA-PHO COAL-FIELD, HOANG-HAI-DŌ

The Sam-ka-pho coal-field is situated about 16 km. north-west of Hoang-jyu, or about 12 km. north-north-east of Kyöm-i-pho. The coal-field lies to the west of the village and is a hilly tract separated by the drainage plain of the river of the same name. The coal-bearing Mesozoic rests on the limestone of the upper Palæozoic unconformably and consists of shale, sandstone and conglomerate, striking north-east in general. To the north of the river it forms a syncline, dipping S.E. 60° in the northern wing and N.W. 40° in the southern. To the south of the river it forms a monoclinal fold dipping N.W. 30°-50°. The coal found in Meuk-chhyön-ha-dong and Kon-jyu-dong on the north side of the river, is intercalated in shale. The thickness is nearly three feet, but it contains abundant shaly matter and the coal is of very inferior quality. After a short trial working, it was abandoned. The coal found in the hills on the south side of the river is also of very inferior quality. There are three coal-seams, the thickest one being two feet with partings. The result of technical analyses of coal is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Class
0.47	13.62	61.26	24.65	B_1
0.88	12.58	56.15	30.39	B_1

SA-RI-UÖN COAL-FIELD, HOANG-HAI-DŌ

The Sa-ri-uön coal-field is a small hilly district along the railway, about 5 km. south of Pong-san or 13 km. east of Sa-ri-uön. The basement limestone of the upper Palæozoic runs nearly east to west, dipping S. 20-50°. The coal-bearing formation has been deposited in a small basin in the limestone about 1 km. long, and consists of alternating strata of sandstone and shale. It strikes N. 20°-30° W. and dips N.E. 25°-40°. Five thin seams nearly 0.3-0.4 foot thick, and one nearly three feet thick, are interbedded in shale about 15 feet in vertical extension. The coal is of a black, lustrous bituminous variety and is non-caking. The result of technical analyses of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U
14.59	38.14	38.08	9.19	1.27	5,445	9,801
18.95	36.17	36.04	7.64	1.23	5,509	9,916
7.80	44.80	37.20	9.50	1.50		
18.86	34.75	37.35	9.04	1.65		

COAL-FIELDS NEAR THONG-JIN, KYÖNG-GEUI-DŌ

The Tai-myöng coal-field. Tai-myöng is situated about 8 km. south of Thong-jin. The coal-bearing formation consists of conglomerate, sandstone, shale and schalstein. It is often folded as well as faulted, but the general strike is north-south or N. 45° E., and the dip east or west with the inclination 40°-70°. One coal-seam with abundant thin partings is found, its thickness being only 0.3 to 2 feet. The coal is of a black, lustrous, anthracite variety. It is difficult to pick out the partings, so that the coal mined is mixed with shale. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Class
1.00	3.72	55.40	39.88	A_1

The Keum-pho coal-field. On a hill lying to the south of the highway leading to Keum-pho from Thong-sin and about 6 km. south-east of the latter place, there is an outcrop of coal which was formerly worked on a small scale. The coal-bearing formation consists of alternating strata of shale and sandstone, intruded by granite, and strikes north-west, dipping S.W. 30°. One coal-seam is found and can be followed about 180 feet along the strike. The thickness varies from 0.4 to 1.5 feet. The coal is similar to that of Phyöng-yang and, like it, easily breaks up into powder.

OTHER COAL-FIELDS

Pho-uön, South Chhyung-chhyöng-dō. Pho-uön is situated about 12 km. east-north-east of Kun-san on the northern bank of the Keum-gang. A small hill to the west of the village consists of clayslate with sandstone, and one coal-seam 0.8 to 1.2 feet thick is intercalated in the clayslate. The strike is north-north-east, dip W.N.W. 55°-65°. The coal is of the non-caking anthracite variety and is pitch black. It is very brittle and easily breaks up into powder. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
7.13	7.82	69.09	15.96	0.32	1.954	A_2

Kui-baboi, Neung-jyu, South Chyöl-la-dō. Kui-baboi is situated on the highway between Hoa-syun and Tong-pok, or about 12 km. north-east of Neung-jyu. Coal is intercalated in alternating strata of sandstone and clayslate, striking N. 70° W., and dipping N.N.E. 45°. It attains a thickness of nearly 30 feet with partings, but as no other outcrops have been found in the direction of the strike it probably thins rapidly both ways, forming a lenticular mass. The coal belongs to the non-caking anthracite variety and is very brittle, easily breaking up into powder. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
9.78	8.29	58.02	24.91	0.38	1.95	A_2

Mok-pho, South Chyöl-la-dō. A small area of coal-bearing formation is surrounded by porphyry which attains great development in the environs of Mok-pho. The coal-bearing formation is composed chiefly of clayslate with subordinate layers of sandstone and breccia, striking north-west with the dip S.W. 20°. Thin lenticular coal-seams are known to occur in the formation, but they are not important.

Coal is also known to occur at Syang-uön in South Phyöng-an-dō and Keum-chhyön in Hoang-hai-dō.

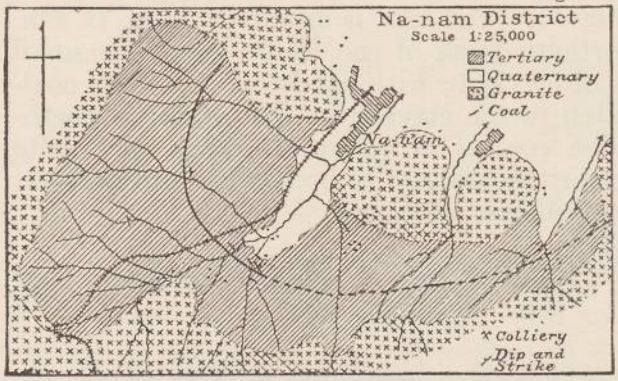
Coal Fields in the Tertiary

KYÖNG-SYÖNG COAL-FIELD, NORTH HAM-GYÖNG-DŌ

The Kyöng-syöng coal-field is divided into two districts, Na-nam and Săing-keui-ryöng. Na-nam and Săing-keui-ryöng are conveniently situated on the highway about 4 km. north and 6 km. south of Kyöng-syöng, respectively, the ports of Chhyöng-jin and Kyöng-syöng being connected by tramway. The production is insignificant. The basement complex is granite, on which the Tertiary has been deposited in small basins. The Tertiary forms a low hilly area less than 70 m. in height, made up of grey or dark grey shale and sandstone.

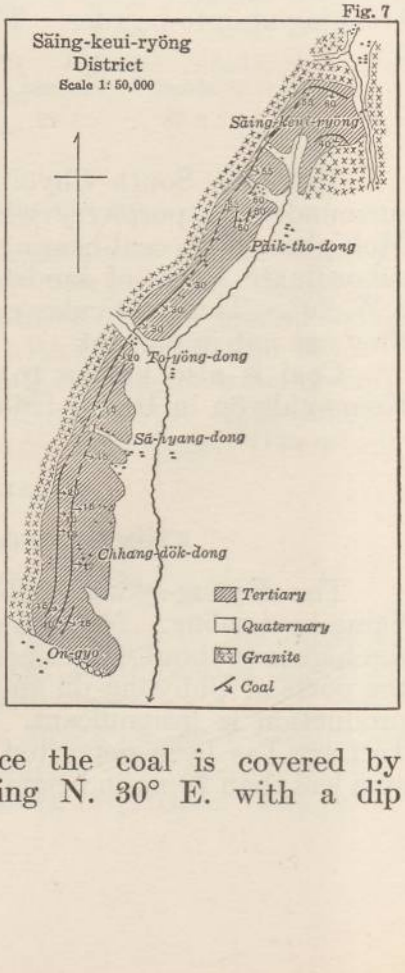
In the vicinity of Na-nam the Tertiary consists of a heavy, dark shale with sandstone in the form of a semicircle, with the town itself nearly at the centre. It dips toward the centre with an angle of 15° to 30°. The Tertiary of Săing-keui-ryöng consists of shale and sandstone and forms a narrow belt extending from Săing-keui-ryöng southwards to On-gyo. The general strike is north-south or north-north-east, dip E. 10°, but in the environs of Săing-keui-ryöng, or at the northern end of the basin, it bends to west-north-west, dipping south-south-west. The angle of inclination is low in the southern portion of the field, being only 10°, but to the north it becomes gradually higher, until at Săing-keui-ryöng it is 60°.

Fig. 6



The Na-nam district (Fig. 6). In the Na-nam basin the coal-seams crop out from the north-western corner to the eastern extremity, being, as has been said, semicircular in form and about 6,000 feet in length. In the north-western part the coal is nearly eight feet thick; the seam strikes N. 30° E. to north-south and dips E.S.E. 30°. The strike gradually bends eastward, and in the southern or middle part becomes N. 40° W. with a dip N.E. 20°. Here the coal attains its fullest development, being nearly twelve feet thick. Eastward the strike gradually changes from N. 60° E. to N. 80° E., dip N.N.W. 25°-30°, and the thickness of the seam gradually diminishes, until in the eastern part it is three feet or even two feet as it approaches the extreme eastern edge of the basin. The coal reserves are not large, being estimated at 1,100,000 tons only.

Fig. 7



The Săing-keui-ryöng district (Fig. 7). In Săing-keui-ryöng three coal-seams can be followed about 4 km. from north to south, dipping east. However, to the north they bend, dipping south-south-west, and generally become thicker and inclined more steeply towards the north. The lowest or western-most seam crops out near the granite. Near On-gyo at the southern extremity it has a thickness of four feet and strikes N. 30° E. with a dip E.S.E. 15°. Northwards, in Chhang-dök-dong, the strike is north-south, dip E. 10°-18°, and in Să-hyang-dong it slightly changes to the east. For some distance the coal is covered by alluvium, but it reappears farther north, striking N. 30° E. with a dip

E.S.E. 18°-30°. There the thickness is two to three feet. In Păik-tho-dong the thickness becomes four to six feet, and the inclination 50°. In Săing-keui-ryöng, or at the northern extremity, the strike bends to N. 70° W., dip S.S.W. 50°-60°. There the thickness is five feet, sometimes widening to twelve feet. The middle seam is two feet thick on an average and is exposed between On-gyo and To-yöng-dong. North of To-yöng-dong the coal-seam has been examined only in Păik-tho-dong. The upper seam, nearly two feet thick, crops out in On-gyo, Păik-tho-dong and south-east of Săing-keui-ryöng. The coal reserves have been estimated at about 5,500,000 tons.

The coal in Na-nam is blackish brown and has no lustre, while that in Săing-keui-ryöng is pitch black with a resinous lustre. It easily cleaves in layers. The result of technical analyses of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
11.50	46.94	32.24	9.32	0.58	1.31	5,280	9,504	D_2
9.79	44.46	31.52	14.23	3.83	1.41	4,950	8,910	D_2
9.37	47.93	32.27	10.43	0.58	1.34	5,060	9,108	D_2
9.61	43.84	31.95	14.60	4.44	1.43	4,620	8,316	D_2
13.60	40.04	32.94	13.42	1.11	1.39	4,400	7,920	D_2
12.31	45.99	32.74	8.96	3.85	....	5,940	10,692	D_2
14.79	44.39	33.44	7.39	0.18	....	6,160	11,088	D_2
15.16	42.91	36.50	5.43	0.28	1.29	6,380	11,484	D_2
17.25	42.09	36.67	3.99	0.16	....	5,940	11,592	D_2

Coal is also said to occur in Uön-syu-tai about 6 km. east of Kyöng-syöng.

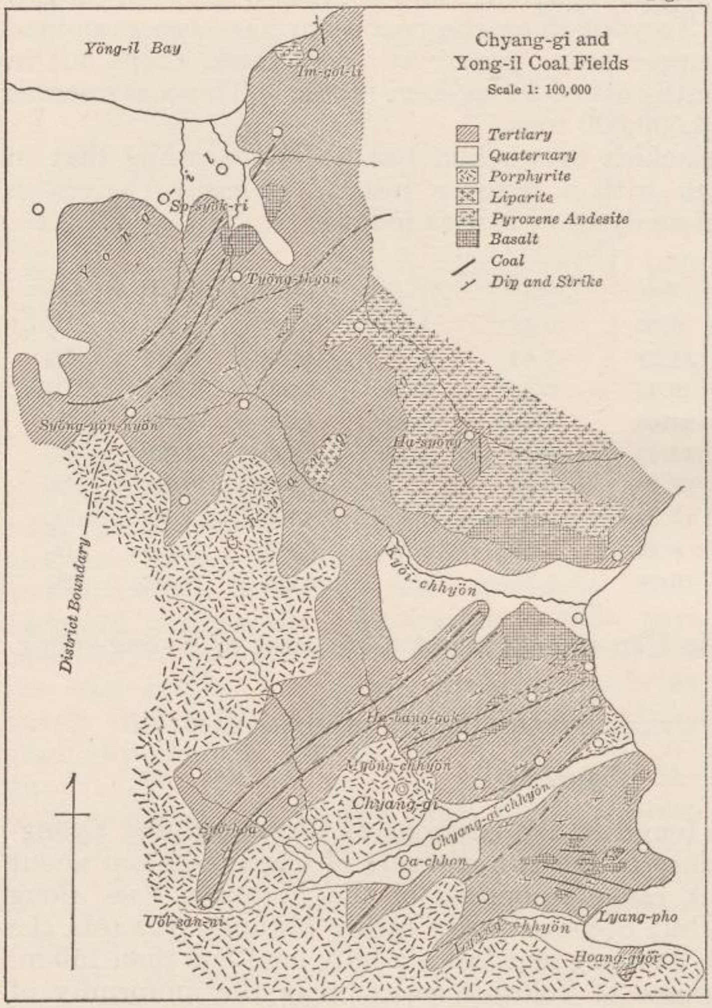
CHYANG-GI AND YÖNG-IL COAL-FIELDS, NORTH KYÖNG-SYANG-DŌ

(*Figure 8*)

Numerous coal-seams are found in the environs of Chyang-gi and Syöng-uön-nyöng, crossing the boundary of the two districts of Chyang-gi and about 8 km. north of Chyang-gi. A range composed of the Mesozoic rises along Yöng-il, or the Sea of Japan, but becomes lower rather abruptly towards the east, where it is covered by the Tertiary and forms a hilly land less than 150 m. in height. Solitary hills composed of volcanic rocks break the uniformity of the topography. The Tertiary consists chiefly of tuffs of various kinds with subordinate layers of sandstone, shale and conglomerate. The tuff imbeds fossil plants, and coal is found in the lower horizon.

The Chyang-gi coal-field (Fig. 8). The coal-bearing Tertiary extends from the coast westward to Uöl-san-ni and from the Kyöi-chhyön in the north to the Lyang-chhyön in the south, and covers an area of about 6 km. from east to west and 4 km. from north to south. The area is drained by the Chyang-gi-chhyön which divides conveniently the field into two sections. In the northern section the strike is N. 60°-70° E., dip N.N.W. 20° in the lower or south-eastern part, while it bends to north-east or to N. 30° E., with a dip W.N.W. 30° in the upper or north-western part. On the south side of the Chyang-gi-chhyön the strata seem to be much disturbed, but generally the strike is east-north-east with the dip N. 20° in the northern part, east by north with the dip S. 10°-20° in the central part, and west-north-west with the dip N. 20° in the southern part. South of Lyang-pho it is N. 70° E., dip N.N.W. 20°. In the west, as in Syö-hoa, the strike changes to N. 30° E., dip W.N.W. 30°. The relations are shown in Figs. 8 and 9.

Fig. 8



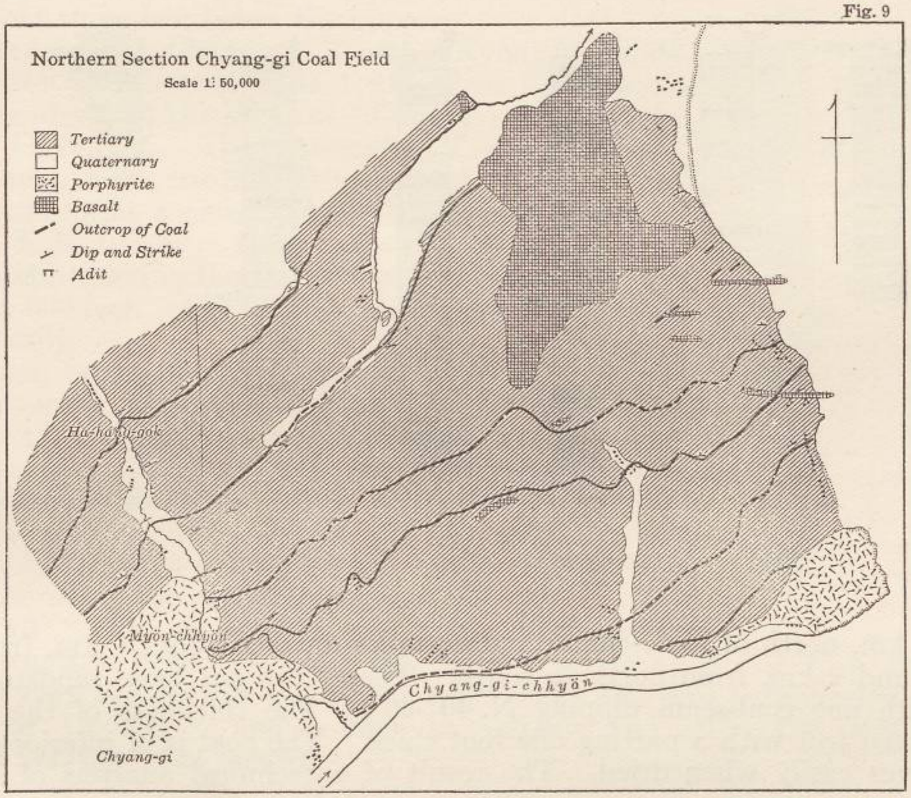
In the northern section there are numerous coal-seams which may be classified into six or seven groups. Among them eleven seams over two feet thick can be enumerated, their respective thicknesses and horizons being shown in Fig. 10. On the south side of the Chyang-gi-chhyön we have only examined two or three thin coal-seams of less than one foot. Their correlation with those in the northern section has not yet been studied. In Ha-syong, to the north of the Kyöi-chhyön, a small area of coal-bearing Tertiary crops out surrounded by pyroxene andesite. Two or three coal-seams, nearly two feet thick, are found in the formation. In a small area of the Tertiary in Hoang-gyoi, lying south-east of the Lyang-chhyön and bounded by porphyrite, one coal-seam nearly two feet thick is known to occur running N. 70° E. and dipping N.N.W. 20°.

The Yöng-il coal-field (Fig. 8). Numerous coal-seams in the Tertiary, north of the Syöng-uön-nyöng pass, run north-east with a dip N.W. 20°-30°. They may be divided into a lower and an upper group. Six seams, each over two feet thick, are known, as shown in Fig. 11. The strike is N. 20°-30° E. in Työng-thyön but southwards it bends gradually until, to the west of Syöng-uön-nyöng, it becomes N. 70° W. The dip also varies from west-north-west to north-north-east with angles of 20° to 30°. Northwards it approaches a north-south direction, and in Im-gol-li it dips W. 20° with a strike N. 10° E. Along the coast of Pang-nim-gol-li, to the north-east, a coal-seam nearly one foot thick is found.

The coal is a brownish black lignite, sometimes cleaving easily in thin leaves or breaking with conchoidal fracture. It often contains small quantities of pyrite, clay, amber, etc. The result of technical analyses of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
5.76	35.43	47.89	10.92	2.58	1.41	6,745	12,141	D_1
14.18	31.90	49.40	4.52	3.28	1.35	6,007	10,813	D_1
8.31	31.57	51.01	9.11	0.71	....	6,820	12,276	D_1
8.94	29.49	50.94	10.63	0.91	1.42	7,478	13,460	D_1

Fig. 9



As the coal is of inferior quality, we have taken into account in the estimate only coal-seams over three feet thick. The average height of the outcrops is 40 to 80 feet, and the length about 4 km. in the Chyang-gi coal-field and $3\frac{1}{3}$ km. in the Yŏng-il coal-field. The depth that has been taken in calculation is 500 feet below the level. From the above data we get the following figures for the coal reserves in these fields:

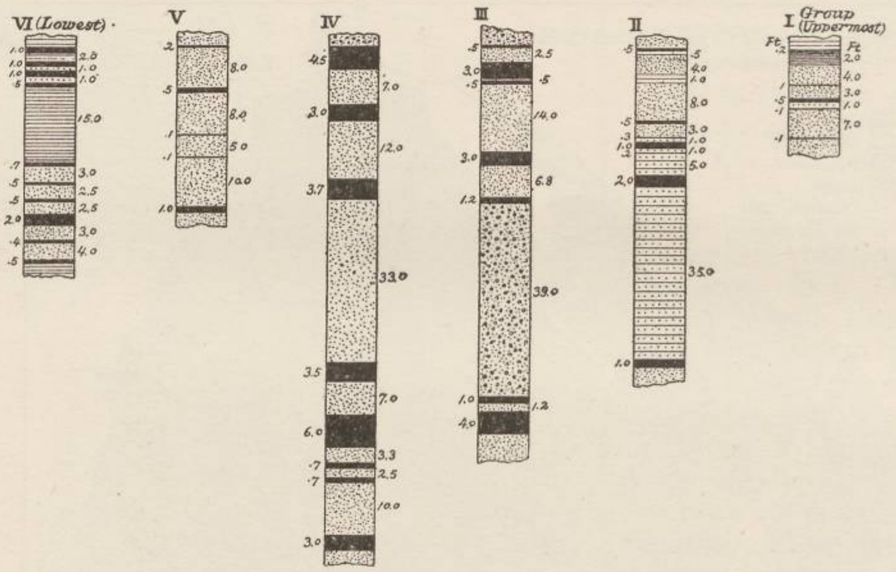
	Actual	Probable
Chyang-gi..	3,000,000	10,500,000
Yŏng-il..	1,400,000	5,500,000

OTHER COAL LOCALITIES

Environs of On-syöng, North Ham-gyöng-dō. Chyu-uön and Oa-dong lie adjacent to On-syöng on the south. The low, rolling hills near the villages consist of undulatory strata of loose shale and sandstone. Coal crops out in the three places, the thickness varying from three to six feet. It is mined by the farmers for domestic use.

O-no-chhon, Ham-heung, South Ham-gyöng-dō. O-no-chhon is situated about 12 km. north of Ham-heung. The wide valley of Chyang-phung-ni lies

Fig. 10



about 8 km. north of O-no-chhon and occupies an area about 4 km. from east to west and 2 km. from north to south. There crop out loose sandstone and shale with one coal-seam dipping N. 40°-60°. The thickness of the coal is eight to ten feet with a parting one foot thick. The coal is of inferior quality and cleaves easily when dried. The result of a technical analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Cal. p.	B.T.U.	Class
13.07	43.77	40.13	3.03	6,050	10,890	D_2

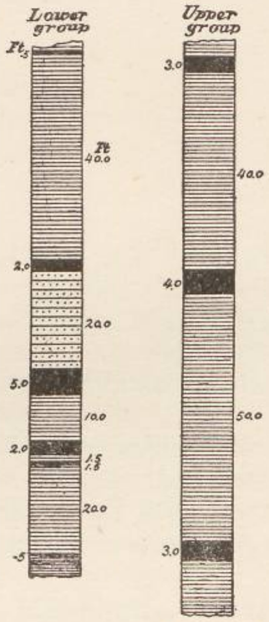
Ku-uön and Yöng-heung, South Ham-gyöng-dō. A large triangular plain lies to the east of the highway between Ko-uön and Yöng-heung. The hills rising from the plain consist of alternating strata of clay, sand and gravel with coal. The coal was mined for a short time at the foot of an isolated hill, called Chin-nyong-pong, near the Yong-heung-gang and also in the hills about 4 km. south-east of Ko-uön, and furnished fuel for domestic use and for salt pans. Chin-nyong-pong is composed mainly of dark green porphyrite, its eastern foot being covered with clay, sand and gravel, interbedding coal and dipping E. 30°.

The thickness of the coal is not known but is said to be several feet. The coal is of very inferior quality and crumbles when dry.

At the environs of Nai-dong-ni, about 4 km. south-east of Ko-uön, stand granite hills, on which lie clay, sand and pebble layers, almost horizontally stratified or slightly folded. A few beds of coal 0.5 foot thick or less are found in the formation. The coal is similar to that of Chin-nyong-pong. There are also many outcrops of coal in the hills about there, but they are not important.

Yong-hai, North Kyöng-syang-dō. In a small pass along the highway to the south of Yong-hai, two coal-seams are found in loose Tertiary shale in an almost horizontal position. The upper seam is one foot thick with a thin parting, and the lower two to three feet, lying about three feet below the upper.

Fig. 11



Syang-syö-li, Chang-gi, North Kyöng-syang-dō. Syang-syö-li is situated about 1 km. west of Phan-jin which lies about 20 km. north of Ul-san and about 32 km. south of Chyang-gi. The coal-bearing Tertiary bounded by the Jurassic, is quite similar to that of Chyang-gi and Yöng-li and forms a small basin. The strike is N. 60° W., dip N.E. 10°-20°. One coal-seam, six to eight feet thick, is imbedded in the formation, and can be followed for about 900 feet. The coal is of inferior quality and cleaves easily.

Ul-san, South Kyöng-syang-dō. The Tertiary lies on the Mesozoic between Pam-dong and Phyöng-chhyön, or about 8 km. north-east of Ul-san. It covers only a small area, $\frac{2}{3}$ km. long in an east-west direction and $\frac{1}{2}$ km. in a north-south direction. It is composed of tuff and shale, and strikes generally N. 20° E. with the dip W.N.W. 20°; in Yö-nam, however, near the northern end of the area, the strike changes to N. 30° W., dip W.S.W. 20°. Four coal-seams are found, their respective thicknesses, beginning with the uppermost, being 8, 1.5-3, 1, and 0.5 feet, and they can be followed about 1,800 feet. The coal is somewhat similar to that of Chyang-gi and is high in sulphur and ash. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
7.55	46.33	35.42	10.70	9.05	1.40	5,425	9,765	D_1

Coal is said to occur at Phung-myön-ni in Ham-heung, at Tök-yuh-ni in Kil-jyu and in the environs of Hoi-ryöng; in the districts of Pu-ryöng, Kyöng-uön, Kyöng-heung and Myöng-chhyön in North Ham-gyöng-do; and also at Thong-chhyön in Kang-uön-dō and at Heung-hai in North Kyöng-syang-dō.

THE COAL RESOURCES OF MANCHURIA

BY

KINOSUKE INOUYE

Director of the Imperial Geological Survey, Japan

(With three plates in the Atlas and fifteen figures in the text)

I—INTRODUCTION

Manchuria is closely related to Japan in both economical and scientific interests, but I regret to say a geological reconnaissance survey has only been carried out for the southern part. Since 1907, when the South Manchuria Railway Company was organized, the survey has been carried on especially by Mr. C. Kido, Superintendent of the Geological Experimental Station of the the company, to whom I am greatly indebted for valuable information. Though the northern part of the country is almost unexplored and little information as to its mineral resources is accessible, I have been able to compile this short paper on the coal of Manchuria. It is confessedly incomplete and imperfect, and is based chiefly on data obtained during the geological reconnaissance survey and furnished me by Mr. C. Kido.

Coal is the most important of the mineral resources in Manchuria, yet its production scarcely exceeds one and a half million tons a year, the production of other minerals being quite insignificant. Most of the coal-fields are worked by the Chinese in a primitive way and the number of mines is very great, so that to enumerate them all or to estimate the output is utterly impossible. A large mining plant is in position only in the Fu-shun coal-field, the only one that is being actively mined at present. The other coal-fields are not comparable with the Fu-shun field either in output or plant.

II—THE GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF COAL

The coal occurs in the Carboniferous and the Jurassic, as well as in the Tertiary. The Tertiary coal is at present the most important and the greater part of the coal in Manchuria is furnished by it, though its distribution is not extensive, being restricted to a narrow belt along the Fu-shun valley. Of the coal-bearing systems, the Carboniferous seems to be the most extensive. It is mostly found in the province of Hsing-king-shêng, while the Jurassic measures occur in scattered areas, chiefly in the province of Chi-lin-shêng. As to the coal-bearing formation in the province of Hei-lung-kiang-shêng, we have no reliable data on which to base a description.

The basement complex is a gneissic system, on which the so-called Takushan and Sinian formations have been deposited in rather small areas. The Carboniferous, the age of which has been proved by fossil flora, occupies small basins on the gneiss or older formations and is divided into the lower and the upper, the lower consisting of heavy limestone with marl, and the upper representing the Coal-Measures. The Coal-Measures are composed of sandstone and clayslate, with limestone and coal-seams in the lower, and thick sandstone with clayslate in the upper, part. In the central part of the province of Hsing-king-shêng the Coal-Measures spread in an east-west direction. Whether they were originally deposited over a wide area and subsequently separated by erosion, or were deposited in separate basins, as they now occur, it is difficult to decide, but it is evident that at least some of the areas were once joined. Small areas are also found in the south of the province of Hsing-king-shêng. In the province of Chi-lin-shêng the coal is found only near K'uan-chieh.

The coal-bearing Jurassic, the age of which has been established by fossil flora, is found chiefly in the province of Chi-lin-shêng. It rests directly on the gneiss, or older formations, occupying rather small areas. In the province of Hsing-king-shêng a few localities are known, their extent also being small. The formation consists of shale and sandstone, sometimes with conglomerate, the shale predominating in the upper and the sandstone in the lower part.

The coal-bearing Tertiary is found only in the Fu-shun valley. It lies directly on the gneiss and is intruded by basalt. Though the formation containing good coal covers an area of only 48 sq. km., yet its coal reserves are estimated to be large and are the most important now known in Manchuria. It consists of sandstone, conglomerate and shale in the lower, and shale in the upper, part. By fossils interbedded in the formation it has been proved to represent the Miocene.

The coal is of three kinds, anthracite, semi-anthracite and bituminous. The coal which is interbedded in the Carboniferous belongs to the anthracite or semi-anthracite variety, and that in the Mesozoic to the semi-anthracite or bituminous variety. It is used by Chinese as fuel for domestic use. The mines producing anthracite or semi-anthracite are very numerous, but are all worked on a small scale, the Pen-hsi-hu, the largest one, having an annual production of less than 100,000 tons. The Tertiary coal is of the bituminous variety and the equipment for mining it is the largest in Manchuria, its daily production exceeding 4,000 tons at present. Part of the output is consumed in Manchuria, but the coal is also exported to China, Corea and Japan.

III—THE PRODUCTION AND AMOUNT OF COAL

Except in the case of a few collieries, there are no statistical reports of the amount of coal produced; but the following figures are founded on fairly accurate reports and other sources of information.

We could get no information about the production of coal in the provinces of Chi-lin-shêng and Hei-lung-kiang-shêng; but it is highly probable that the production in these provinces does not reach a large amount.

Hsing-king-shêng	1,728,524	tons.	
Fu-shun	1,343,198	"	
Pen-hsi-hu	100,000	"	
Nuan-ti-t'ang	48,000	"	
Sai-ma-chi	40,000	"	
Yen-t'ai	39,326	"	
Wu-hu-tsui	30,000	"	
Shan-sung-kang	24,000	"	
Hsi-kou-tzŭ	24,000	"	
Niu-hsin-t'ai	20,000	"	
Other coal-fields	60,000	"	
Chi-lin-shêng	20,000	"	+ ?
Wu-lung-t'un	10,000	"	
Kang-yao	10,000	"	
Other coal-fields	?		
Hei-lung-kiang-shêng	270,000	"	+ ?
Cha-lei-no-êrh	150,000	"	
Other coal-fields	?		

Except in the case of a few important coal-fields in southern Manchuria, no detailed geological survey has yet been carried out through Manchuria, and probable figures for the amount of coal are only obtained by estimating the extent of the coal-fields, mostly in the south. Under these circumstances we cannot make any estimate of the total amount of coal in Manchuria, but only of the probable amount in southern Manchuria.

The amount of coal is shown as follows:

ACTUAL RESERVE

	Thickness	Area	Class	Metric Tons
Palæozoic—Hsing-king-shêng	....	$9\frac{3}{10}$ sq. km.	..	409,000,000
Yen-t'ai	Aggregate 18–25 ft.	$1\frac{1}{2}$ sq. km.	B_1	15,000,000
Pen-hsi-hu	" 40–45 ft.	$\frac{4}{5}$ sq. km.	B_2	16,000,000
Tertiary—Fu-shun	" 110–130 ft.	7 sq. km.	C	378,000,000
Totals	....	$9\frac{3}{10}$ sq. km.	..	409,000,000

District	Coal-Seams	Probable Reserves (Approximate estimate)			Possible Reserve
	Thickness	Area	Class of Coal	Metric Tons	
		sq. km.			
Palæozoic—Hsing-king-shêng . . .	. . . .	$47\frac{7}{10}$	. .	793,000,000	Large
Wu-hu-tsui	$3\frac{1}{2}$ to 4 ft.	2	B_2	3,000,000	Moderate
Mei-yao	6 ft.	$1\frac{1}{2}$	A_2B_1	3,500,000	Small
Yen-t'ai	Agg. 18 to 25 ft. .	3	B_1	25,000,000	Moderate
Pen-hai-hu	40 to 45 ft.	10	B_2	180,000,000	Moderate
Niu-hsin-t'ai	Agg. 20 ft.	3	A_2	25,000,000	Moderate
Tien-tzŭ-fu-kou	5 ft.	1	B_2	2,000,000	Small
Coal-fields east of Great Wall	4 to 10 ft.	$4\frac{1}{10}$	B_2	10,000,000	Moderate
Coal-fields west of Chin-chou	$3\frac{1}{2}$ to 12 ft.	$12\frac{2}{5}$	B_2	43,000,000	Moderate
Mesozoic—Fang-niu-kou	4 to 5 ft.	$\frac{3}{5}$	C	1,000,000	Small
Sha-ho-tzŭ	8 to 15 ft.	$\frac{1}{2}$	C	2,500,000	Small
Tertiary—Fu-shun	110 to 130 ft.	$9\frac{3}{5}$	C	498,000,000	Large
Other Coal-fields	. . . .	. . . .	. .	. . . .	Moderate
Chi-lin-shêng	. . . .	$3\frac{1}{2}$	. .	7,000,000	Large
Shih-pei-ling	4 to 5 ft.	1	C	1,000,000	Small
Wu-lung-t'un	$5\frac{1}{2}$ to 6 ft.	2	C	5,000,000	Moderate
Hou-shih-ling	5 ft.	$\frac{1}{2}$	C	1,000,000	Small
Other Coal-fields	. . . .	. . . .	. .	. . . .	Large
Totals	. . . .	$51\frac{1}{5}$	. .	800,000,000	Large

Manchuria is said to be rich in mineral resources, but at present coal alone is produced on what approaches a large scale. Though the amount of coal known is not large, it will suffice not only to meet the demand in the country, but also to supply the oriental coal market for several hundreds of years. And we have reason to believe that new fields will be discovered and that coal under deeper cover will be uncovered or proved to exist, especially in northern Manchuria. Thus it is obvious that we shall not be able to reach a definite conclusion about the coal resources in Manchuria, until further exploration and closer examination have been carried out.

IV—DESCRIPTION OF THE COAL-FIELDS

Hsing-king-shêng

Coal-fields in the Carboniferous

The Carboniferous is found scattered in rather small areas in a long belt running from the South Manchurian railway route between Liao-yang-chou and Fêng-t'ien (Moukden) eastward to the Ya-lu-kiang, where it forms basins on the older formations. In the southern part of the province, as in F'u-chou and Chin-chou, in the Liao-tung peninsula, it covers only smaller areas, while in the western part of Chin-chou it extends farther south-westward, to the province of Chih-li-shêng, occupying tolerably wide areas.

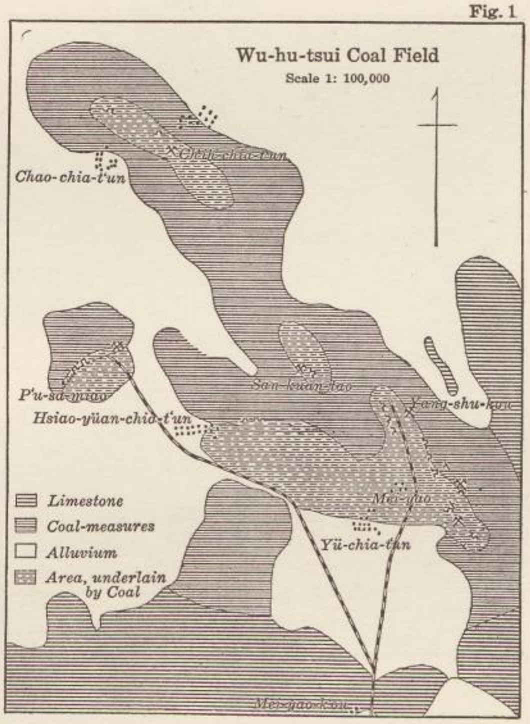
I—THE COAL-FIELDS IN THE SOUTHERN PART OF THE PROVINCE

Three coal-fields are known in the southern part of the province, namely, the Wu-hu-tsui, Cha-tsu-yao and Mei-yao coal-fields.

Wu-hu-tsui Coal-Field

The Wu-hu-tsui coal-field (Fig. 1) is conveniently situated about 6 km. from the sea-coast, and lies about 48 km. south of F'u-chou and about 40 km. west of P'u-lan-tien station, being reached by waggon road from both towns.

Fig. 1



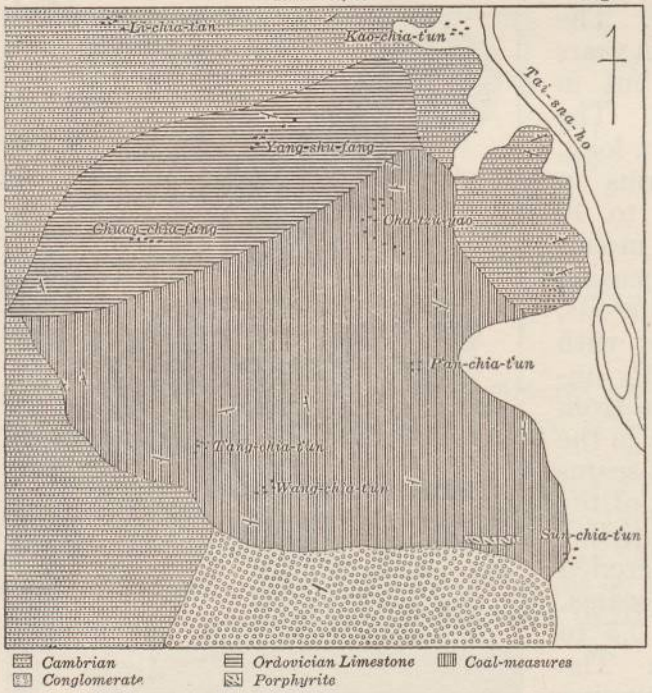
This coal-field is said to have been opened in the eighteenth century. The annual production of coal, until ten years ago, was less than 1,500 tons, but in 1910 it increased to 30,000 tons. The field is a narrow basin about 6 km. long, with a breadth of 3½ km. and forms an undulatory plateau generally 30 to 40 m. high, bounded by limestone mountains on three sides. The coal-bearing formation, known as the Carboniferous, consists of shale and sandstone with limestone, and is, in general, slightly undulatory, though two synclines run from north-west to south-east and unite in the south-eastern part. Three coal-seams are interbedded in the upper part of the formation, but those near the anticline in the middle part are already eroded away. The two upper coal-seams, being less than one foot or only 0.5 to 0.6 foot thick, are not important. The lowest seam has a thickness varying from two to over ten feet, or averaging three to five feet, and is workable. The coal above the drainage level or 30 to 150 feet below the outcrops, is of inferior quality and has long been mined, only a little remaining for the future. Thus future mining must be in the synclinal basins of the central part, where much water will make mining difficult. It does not seem probable, therefore, that any large quantity can be raised in the field, probably not more than 3,000,000 tons. The coal is black and lustrous, and belongs to the non-caking semi-anthracite variety. It is very brittle, giving only 10 to 20% lump. The results of technical analyses of it are as follows:

Moist	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
3.49	7.33	77.76	11.42	1.23	1.450	.....	.....	A_2
6.46	18.20	65.08	10.26	0.65	1.528	5,280c	9,504	B_2
15.27	23.09	49.94	11.70	0.66	1.581	.....	.....	B_2
7.44	22.40	61.31	8.86	0.62	1.582	5,500	9,900	B_2
16.93	25.84	46.06	11.17	0.50	1.564	.....	.....	B_2
15.99	22.96	49.23	11.82	0.90	1.562	.....	.....	B_2

Wa-fang-tien Coal-Field

The Wa-fang-tien coal-field (Fig. 2) is conveniently situated about 4 km. east of Wa-fang-tien station. It forms a small basin, bounded on the north, south and west by hills nearly 190 m. high and on the east by the Tai-sha-ho river. The coal-bearing formation, considered as representing the Carboniferous, consists of shale and sandstone with limestone. It rests on the Cambrian formation and is covered in the south by a conglomerate of unknown age, and in the east by alluvium. The strike is variable, the strata being much folded as well as faulted, but in general it is north-west, and forms synclines and anticlines. The angle of inclination is moderate, being less than 20°. A great fault passing through the environs of P'an-chia-t'un, divides the coal-field into a northern and a southern section. Of the three coal-seams known at present, the upper one has a thickness of from one foot to four feet, while the thickness of the lower two varies from one foot to over ten feet, though they often thin out to only a few inches. The coal is mostly mined in the district south-east of Cha-tzŭ-yao, in the northern section, where the thickness of the seams is 2-4, 1-3, and 1-3 feet, respectively, and the strata dip towards the north. In Wang-chia-t'un the strata dip steeply to the south and the coal-seams there are very thin. West of Tang-chia-tun two coal-seams nearly one foot thick are found. The vertical intervals between these coal-seams are very narrow, being often only a few feet. As the area is small and the strata are much disturbed, the coal reserves in the field are

Wa-fang-tien Coal Field
Scale 1: 50,000
Fig. 2



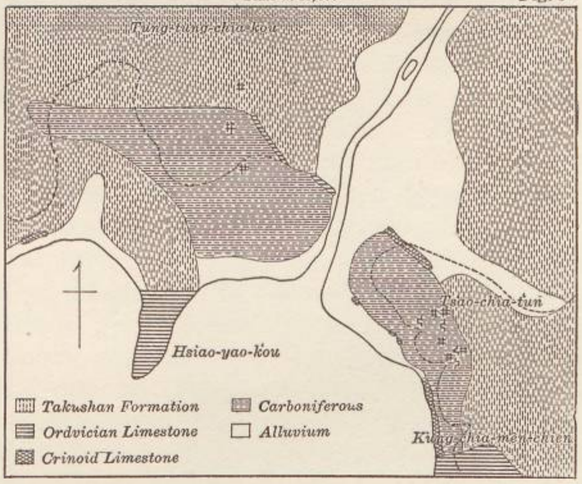
probably not large. The coal is very variable in quality, differing in different localities and seams. It belongs sometimes to the bituminous variety and sometimes to the semi-anthracite. It disintegrates into powder and often contains partings, which are difficult to pick out. The results of technical analyses are as follows:

Moist	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class	
1.71	32.51	53.78	12.00	3.69	1.409	6,380c	11,484	C.	Slightly caking
1.270	12.440	79.290	7.000	.662	1.498	6,710	12,078	B_1	Non-caking
3.43	23.61	34.68	38.280	.549	1.614	4,400	7,920	B_2	Non-caking
3.34	35.74	37.47	23.45	0.92	1.463	.....	.....	B_3	Non-caking
1.54	34.82	54.74	8.90	2.92	C. 14.09; H. 4.42; O. 8.39	.....	.....	C	

Mei-yao Coal-Field

The Mei-yao coal-field (Fig. 3) is situated in Mei-yao near K'ung-chia-mên, on the northern coast of Hsiao-yao-k'ou, about 23 km. east-south-east of Chin-chou. The daily production at present is nearly twelve tons. The basement complex is quartzite and limestone of the Takushan formation. Thick limestone, probably of Ordovician age, is found in the southern part and dips S.S.W. 30°-40°. The coal-bearing formation consists of shale and sandstone with limestone and is said to represent the Carboniferous. The strike is north-west in the northern part, but swings to north in the southern part, dipping W. 30°. Three coal-seams are known to occur and extend not less than 1 km. in length. The thickness of the coal-seams is variable, being generally less than three feet, though the lowest seam attains a thickness of twelve feet, owing probably to local development. The average aggregate thickness may be estimated to be six feet. As the area is quite limited, the quantity of coal cannot be large, the estimated amount being roughly 3,500,000 tons. The coal belongs to the semi-anthracite variety and is non-caking. It is black, lustrous, and brittle, and easily breaks into powder. The results of technical analyses of it are as follows:

Mei-yao Coal Field
Scale 1: 50,000
Fig. 3



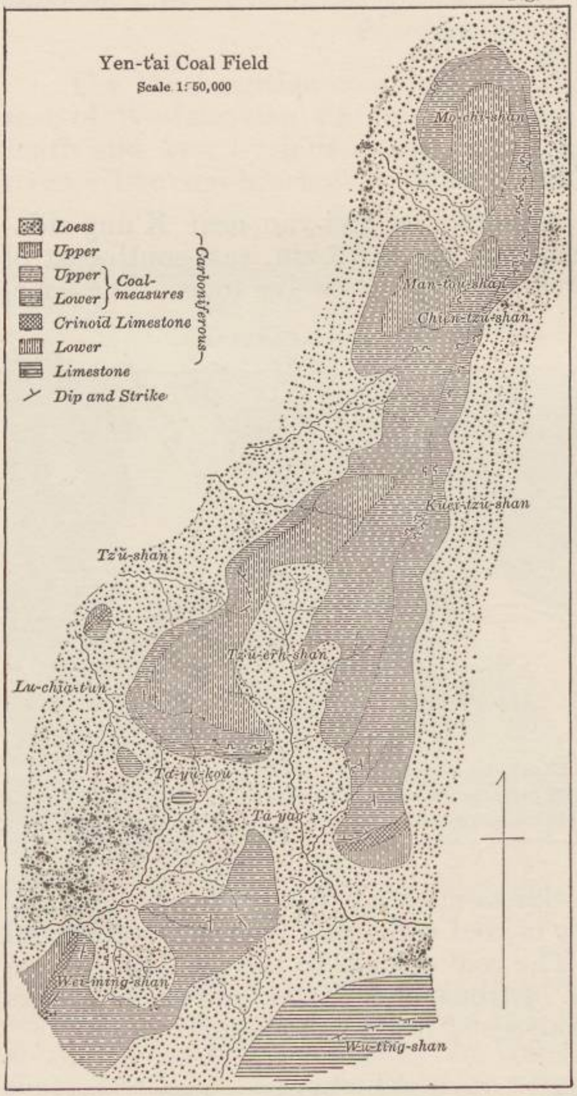
Moist.	Vol. mat.	Fixed C.	Ash.	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
5.78	13.33	74.57	6.32	0.62	1.418	7,613c	13,703	B_1
4.43	9.90	80.97	4.70	0.76	1.442	7,653	13,775	A_2

II—COAL-FIELDS LYING EAST OF LIAO-YANG-CHOU AND FÊNG-TIEN

In the region lying east of Liao-yang-chou and Fêng-tien there are numerous coal-fields, probably more than twenty, which have been deposited in basins on the older formations. They are conveniently divided by the Great Wall into two groups.

A—THE COAL-FIELDS TO THE WEST OF THE GREAT WALL

Fig. 4



In these coal-fields are included those of the central part of the province, the Yen-t'ai and Pen-hsi-hu coal-field being the most noted. They are almost regularly arranged in an east-west line, on which line, prolonged, also lie the coal-fields on the east of the Great Wall. Whether they have been deposited in separate basins on the older gneiss or the Sinian formation, or as continuous strata and separated by later erosion, is not yet clearly determined, but it is certain that some coal-fields, now disconnected, were originally continuous. These coal-fields may, for the sake of convenience, be subdivided into the Yen-t'ai coal-field, the Pen-hsi-hu and the K'an-ch'ang districts, and Hsiao-shieh coal-field.

Yen-t'ai Coal-Field

The Yen-t'ai coal-field (Fig. 4) is situated about 26 km. north-east of Liao-yang-chou or about 12 km. east of Yen-t'ai station on the South Manchurian Railway, from which a branch line leads to the coal-field. The coal-field is said to have been opened in the Tang dynasty, and in recent years it has been worked by a Russian company. After the Russo-Japanese war it was transferred to the South Manchuria Railway Company. The monthly production of coal is nearly 3,000 tons, the annual production in 1910 and 1911 being 27,728 and 39,326 tons, respectively. The field is an undulatory, hilly tract rising on the east to the mountains of the Sinian formation. On the north stands the isolated conical mountain Mo-ch'i-shan, to the south of which rise the hills, such as Chien-tzŭ-shan, Man-t'ou-shan and Kuei-tzŭ-shan, gradually diminishing southwards to Ta-yao and again rising farther south to Wu-ting-shan of the Sinian formation. On the west stands Tz'ŭ-êrh-shan from which the land falls away to the undulatory loess plateau. In the south no prominent hill is to be observed, though the coal-bearing formation can still be followed.

The coal-field is about $5\frac{1}{2}$ km. long in a north-south direction, and $1\frac{1}{2}$ km. wide, and may be conveniently divided into two sections The northern section includes the hilly range from Mo-ch'i-shan in the north to Ta-yü-kou in the south and forms synclinal strata. The southern section is limited in area, lying south of Ta-yü-kou. The horse-shoe shaped Wei-ming-shan seems to represent a syncline, which probably is the continuation of that in the northern section. The basement complex is heavy limestone of the Sinian formation. The Carboniferous is divided into the Lower Carboniferous Coal-Measures and the Upper Carboniferous. The Coal-Measures rest on alternating strata of shale and sandstone with limestone of the Lower Carboniferous, and are covered by sandstone with shale of the Upper Carboniferous. Wu-ting-shan in the south consists of limestone of the Sinian formation and is separated from the Coal-Measures by a large fault. The mountainous land in the north-west as well as in the east is composed of limestone and hornstone of the Sinian formation. The Coal-Measures consist of shale and sandstone with crinoidal limestone in the lowest horizon and may be subdivided into the lower and the upper. The lower Coal-Measures are composed of shale with sandstone, and thirteen coal-seams are known to be interbedded in the shale. Among these coal-seams three are important, each having a thickness of about five feet. Heavy loess covers the foot of the hills, so that the outcrops of the coal-seams can be examined only here and there. The upper Coal-Measures are composed of alternating strata of shale and sandstone, the latter being thicker than the former. Three coal-seams are known to occur, only one, two to five feet thick, being workable. In the southern section the upper Coal-Measures have been entirely eroded away. The strike is nearly north-south in general, though the beds are folded to form a syncline in the middle, as above stated. The angle of inclination is variable; it is rather steep near the outcrops, and becomes lower as it nears the synclinal axis, until at last it attains a nearly horizontal position. Of sixteen coal-seams, two in the upper and four in the lower Coal-Measures are generally workable, their average thickness in the upper being 0.7 and 2.5 feet and that in the lower 2.2-4.5, 2., 5-6 and 5 feet, respectively. The aggregate thickness of the coal-seams of over one foot, is probably not less than 25 feet in the northern section and 18 feet in the southern section. The area underlain by coal is estimated to be 4 sq. km. From the data above given we get the amount of 40,000,000 tons for actual and probable coal reserves. The coal belongs mostly to the semi-anthracite variety and is very brittle, giving only 20 to 30% lump. The results of technical analyses of the coal are as follows:

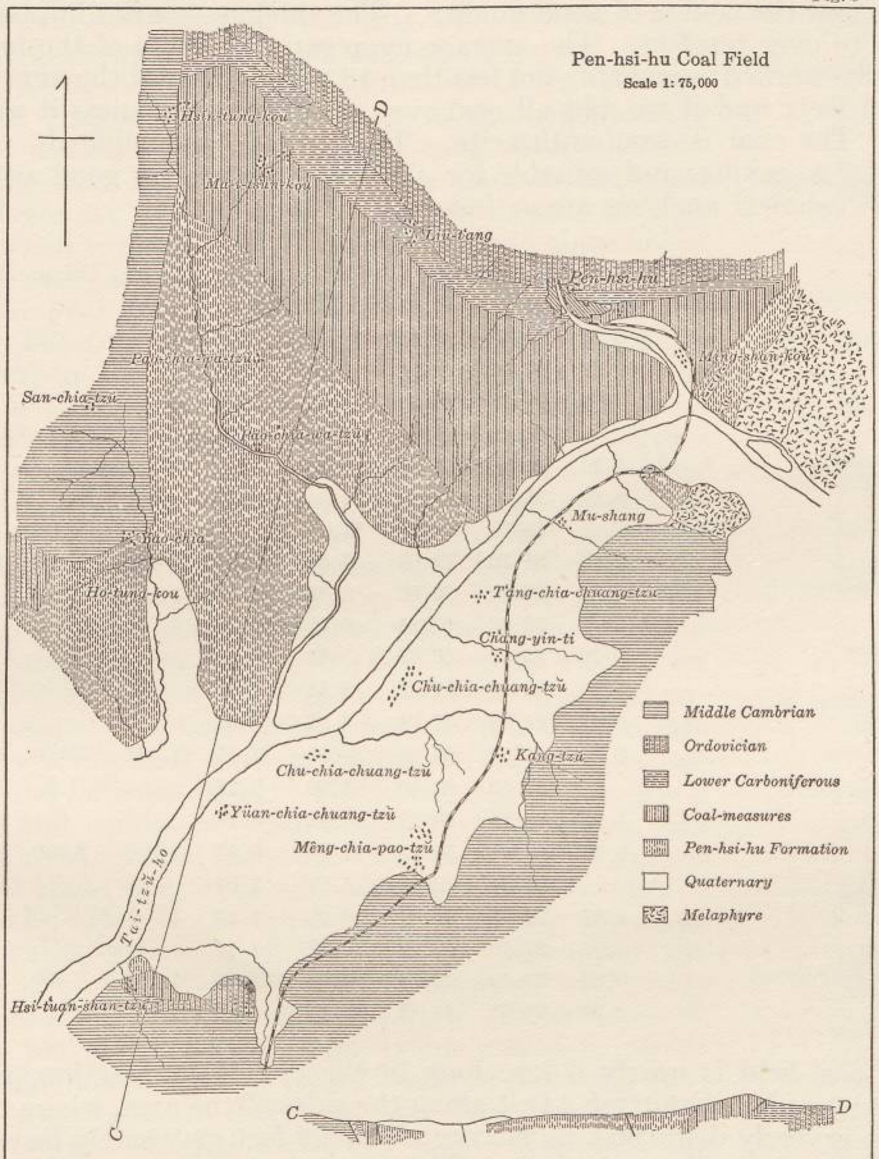
	Moist.	Vol. mat.	Fixed C.	Ash.	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
First Seam (uppermost)........	1.41	10.84	25.57	62.18	0.47	1.430			
Second Seam....................	0.89	14.03	71.29	13.79	0.48	1.414	.....	.....	B_1
" "	1.14	11.34	79.62	7.90	0.51	1.318	6,270c	11,286	A_2
Third Seam....................	0.86	13.10	72.42	13.62	0.52	1.435	.....	.....	B_1
" "	0.85	13.88	75.70	9.57	0.42	1.411	.....	.....	"
" "	0.90	14.19	74.97	9.94	0.41	1.390	.....	.....	"
" "	1.04	11.79	67.63	19.56	0.45	1.438	.....	.....	"
" "	1.65	10.89	80.62	6.84	0.49	1.362	6,050	10,890	A_2
Seventh Seam..................	1.12	13.55	72.65	12.68	1.59	1.394	.....	.....	B_1
" "	1.43	14.46	74.26	9.85	1.05	1.401	.....	.....	"
" "	1.60	11.96	74.49	11.95	0.68	1.307	.....	.....	"
Ninth Seam....................	2.59	8.14	72.47	16.80	5.59	1.471	.....	.....	A_2
" "	0.77	12.11	82.73	4.39	0.81	1.323	6,710	12,078	B_1
Twelfth Seam..................	3.01	10.16	74.23	12.60	3.10	.....	.....	.....	"
Thirteenth Seam................	3.58	8.33	85.14	2.95	0.67	.....	.....	.....	A_2
Fourteenth Seam...............	0.80	14.00	75.74	9.46	0.53	1.443	.....	.....	B_1
" "	4.19	11.87	75.20	8.74	2.42	.....	.....	.....	"
Fifteenth Seam.................	0.92	10.60	75.36	13.12	4.33	1.388	5,830	10,493	"
Sixteenth Seam (Lowest).......	0.76	10.77	77.65	10.82	0.98	1.337	6,490	11,682	A_2
" " "	0.61	10.61	61.22	27.56	1.67	1.662	5,830	10,493	B_1
" " "	1.32	10.44	80.02	8.21	3.05	1.432	.....	.....	A_2
" " "	0.95	14.08	62.48	22.49	5.22	1.418	5,720	10,296	B_1
" " "	0.90	10.50	84.48	4.12	2.12	1.342	6,600	11,880	A_2
" " "	1.96	12.84	65.46	19.74	0.44	1.506	5,830	10,493	B_1
" " "	0.78	11.70	56.04	31.48	2.11	1.445	5,940	10,692	"

Pen-hsi-hu District

The Pen-shi-hu coal-field (Figs. 5 and 6). This coal-field is situated about 65 km. east of Liao-yang. The railway passes the eastern part of the coal-field, transportation facilities being thus easily available. The field was opened several hundred years ago, and it is said that mining was actively carried on from 1820 to 1850. The total yield of coal since its opening does not exceed 3,000,000 tons. The daily production in recent date is about 300 tons, and it is said to be capable of yielding 500,000 or 600,000 tons a year in future without any difficulty. The coal-field forms an undulatory plateau about 600 m. high, running from north-north-west to south-south-east, and is bounded on the south-east by the Tai-tzŭ-ho river. The middle Cambrian formation forms the western part of the field and also the southern part beyond the Tai-tzŭ-ho. It consists of clayslate, sandstone, quartzite and limestone. Thick Ordovician limestone is found in the north of the field. The coal-bearing formation has been proved by its contained flora to represent the Permo-Carboniferous and overlies these formations. It is covered by a thick complex, consisting of shale, sandstone and conglomerate, which is probably Permian, though no unconformability is noticed between them. The coal-bearing formation is divided into a lower, a middle, and an upper series. The upper series is chiefly composed of sandstone with shale, and the lower of shale, sandstone and limestone.

The Coal-Measures represent the middle series, consisting of shale and sandstone with crinoidal limestone in the lowest horizon. It interbeds sixteen coal-seams. The total thickness of the formation, as measured, reaches 550 feet. Small faults are very abundant and there are some larger ones of 40 to 60 feet vertical displacement, the eastern and western ends of the field being cut off by

Fig. 5



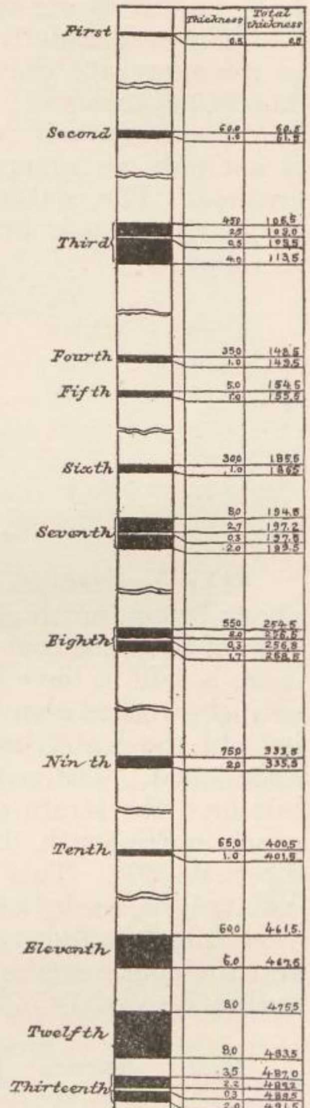
them. The strike is generally north-west or west-north-west, but near the larger faults to the east and west it bends strongly to the east or north-east. The angle of inclination is variable, being generally 20° to 30°, but increasing to 50° to 60° or even to vertical at both extremities of the field, near the faults. Outcrops of the Coal-Measures are also found at the south and south-west. In the former the strata incline steeply north-north-west, while in the latter they strike north-north-west, dipping almost vertically. Among the sixteen seams, shown in Fig. 6, nine may be workable. The third, seventh, eighth and twelfth are the seams chiefly worked at present. They are much disturbed and crushed near the faults at both extremities but towards the middle part they attain their full thickness and the coal is of good quality. The thickness varies in places, often widening to over ten feet. The average aggregate thickness of the four seams now chiefly worked is probably not less than 18.5 feet; that of the nine workable seams, 40 feet; and if we add all coal over one foot in thickness it will exceed 45 feet. The coal is semi-anthracite. It is brittle, and difficult to get in lumps. It is caking, and suitable for the manufacture of good coke. The results of technical analyses are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash.	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
First Seam	0.64	21.39	61.57	16.40	0.65	.....	.....	.....	B_2
Second Seam	0.81	23.55	57.62	18.02	0.65	.....	.....	.....	"
" "	....	21.77	72.11	6.12	....	.....	.....	.....	"
" "	0.56	23.38	69.00	7.06	0.48	.....	.....	.....	"
" "	....	21.48	65.92	12.60	1.45	.....	.....	.....	"
" "	0.56	23.36	67.28	9.80	....	.....	.....	.....	"
Third Seam	0.79	25.70	62.69	10.55	0.57	.....	.....	.....	"
" "	....	19.79	69.17	11.04	....	.....	.....	.....	"
" "	0.69	21.70	72.03	5.58	0.45	1.319	7,260c	13,068	"
" "	0.66	22.06	70.80	6.48	1.11	.....	.....	.....	"
" "	....	24.02	69.45	6.53	0.70	.....	.....	.....	"
Fourth Seam	0.76	25.73	63.66	9.85	0.69	.....	.....	.....	"
Fifth Seam	1.16	22.97	67.73	8.14	1.78	.....	.....	.....	"
Seventh Seam	0.91	23.58	67.04	8.47	0.58	.....	.....	.....	"
" "	0.72	21.57	63.31	8.40	1.15	1.341	7,150	12,870	"
" "	....	22.50	64.40	13.10	2.26	.....	.....	.....	"
Eighth Seam	1.01	16.64	69.23	13.12	0.70	.....	.....	.....	"
" "	0.71	19.34	68.37	11.58	0.61	1.389	6,930	12,474	"
" "	....	24.00	70.37	5.63	1.09	.....	.....	.....	"
Ninth Seam	1.07	22.65	65.99	10.29	1.26	.....	.....	.....	"
Twelfth Seam	....	27.10	63.02	9.88	1.14	.....	.....	.....	"
" "	0.84	22.49	72.33	4.34	2.95	1.319	7,150	.....	"
" "	1.21	24.31	47.48	27.00	0.95	1.562	.....	.....	"

The coal-field is nearly 6 km. long in the east-west direction, and 6,000 to 9,000 feet wide. Omitting a belt along the sides of the area, where the strata have been severely disturbed, a distance of 15,000 feet may safely be considered as imbedding workable coal-seams. The vertical extension is difficult to estimate, but considering the average inclination of the strata to be 23°, about 6,000 feet of the seams may be workable. As the least aggregate thickness of nine coal-seams is 40 feet, and that of all coal-seams above one foot is 45, the quantity of coal in the area will amount to 15,000,000 tons for actual reserves and, roughly, 180,000,000 tons for probable reserves.

In T'uan-tzŭ-shan near Mêng-chia station, lying next to Pen-hsi-hu station on the south, the coal is worked on a small scale. In Hung-ch'i-hsün, about 11 km. south-east of Shih-ch'iao-tzŭ station, lying next to Pen-hsi-hu station on the north, coal of a bituminous caking variety is mined on a small scale, the production being 2 tons a day.

Fig. 6



Scale 1:400

Coal

The Niu-hsin-t'ai coal-field (Fig. 7). This coal-field is situated about 20 km. east of Pen-hsi-hu and lies in the district of Pen-hsi-hsien on the south of the Tai-tzŭ-ho. The coal is mined at present in the neighbouring villages of Hsiao-nan-kou, Lao-mei-tung, Hung-lien-kou and Wang-kuan-kou. Of these mines those in the latter two villages are most worked. The field is said to have been opened several hundred years ago, and since about 1660 the coal has been continuously mined, rather actively about the year 1876, when the yield was nearly 360 tons a day. The total amount taken out since its opening is estimated to be 1,236,000 tons, and the production at present is nearly 60 tons a day or 20,000 tons a year. The coal-field is bounded by mountains of Ordovician limestone, except on the north-west, where the drainage plain of the Tai-tzŭ-ho covers a somewhat large area. It is a semi-circular plateau, and is subdivided into three sections. The coal-bearing formation, deposited on the basin of the Ordovician limestone, consists of sandstone and shale. The stratigraphical as well as palæontological evidence tends to prove that this field and the Pen-hsi-hu coal-field were formerly continuous, but later were separated by erosion. The coal-bearing formation is divided into the lower series and Coal-Measures, crinoidal limestone being found between them. The lower series is composed of shale and sandstone with two beds of limestone, and occupies a wide area in the south-east. The Coal-Measures consist of shale, sandstone and conglomerate. Sandstone is especially thick in the upper part overlying the coal-seams, while shale is thick in the lower part where the coal-seams are interbedded. The number of coal-seams is not yet known with certainty, but is estimated to be at least ten, only three or four being mined in recent years. The lower series is folded near Ta-nan-kou, running in a north-south direction, and there many faults are met with. On the north-east and south-west, the strata dip towards the centre of the field at steep angles. The Coal-Measures generally dip to the centre of the field, though in a part of Hsiao-nan-kou local disturbances are noticed. The dip angle is often variable, being 20° to 30° at Hung-lien-kou, where the coal is rather actively mined, as above stated. The number of coal-seams differs in different places, and the thickness varies within a wide range, for example, in the environs of Shang-niu-hsin-t'ai six seams are known, being 4-7, 1-2, 1-2, 2-5, 3-5, and 1-2 feet thick, respectively; at Sung-shu-ling 1-2, 1-4, 3-10, 2-4, 1-4, 1-2, 1-4, 4-10, 1-4 and 1 feet; at Hung-lien-kou 1-2, 3-4, 2-4, 2-3, 3, 3-9, 2.5, and 1 feet; and at Wang-kuan-kou 1-2, 3-4, 2-4, 2-3, 2, 2-7, 2-5, and 0.7-0.8 feet.

The area underlain by coal is nearly 3 sq. km., and a conservative estimate of the aggregate thickness is 20 feet. Thus the coal reserves are estimated at 25,000,000 tons.

The formation is intruded by dykes of volcanic rock, by which the coal is not only metamorphosed to natural coke but is also in many places badly crushed. The coal belongs to the anthracite variety and is non-caking. It is very brittle, easily breaking into powder. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph	Sp. gr.	Cal. p.	B.T.U.	Class
5.61	6.93	78.42	9.04	0.88	1.665	.....	.....	A_2
0.82	10.75	81.92	6.51	2.60	1.393	6,380c	11,486	"
1.19	7.16	73.71	17.94	2.07	1.493	5,720	10,296	"
0.42	7.63	76.11	15.84	3.14	1.457	5,390	9,702	"
2.11	8.89	69.54	19.46	0.14	1.592	3,850	6,930	"
5.61	6.93	78.42	9.04	0.88	1.665	.....	.....	"

The Yao-tzŭ-yü and Ch'ien-ch'ang-tzŭ coal-fields. Yao-tzŭ-yü is situated about 10 km. north of Niu-hsin-t'ai coal-field, and Ch'ien-ch'ang-tzŭ about 5 km. west of the same coal-field, the two areas lying adjacent to each other. The coal there is said to have been discovered in the seventeenth century and was rather actively worked about twenty years ago. On account of the difficulty of pumping out the water, mining afterwards declined, and the former field is now abandoned. The geology is quite similar to that of the Niu-hsin-t'ai coal-field, but here the strata are much disturbed. In Yao-tzŭ-yü the general strike is nearly north-south, dipping W. 20° and in Ch'ien-ch'ang-tzŭ N. 70° W., with the dip S.W. 30°. Two coal-seams are known to occur. They are very thin in Yao-tzŭ-yü, each being only 0.5-0.6 foot thick, but in Ch'ien-ch'ang-tzŭ they vary from one foot to 2.5 feet. The area underlain by coal is limited in extent and the coal reserves are probably small. The coal is of the non-caking semi-anthracite variety. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.30	27.05	56.83	15.82	2.71	1.349	6,600c	11,881	B_3
0.73	28.57	60.20	10.50	6.80	1.406	6,930	12,474	"
1.76	23.92	53.74	20.58	9.63	1.727	6,050	10,890	B_2

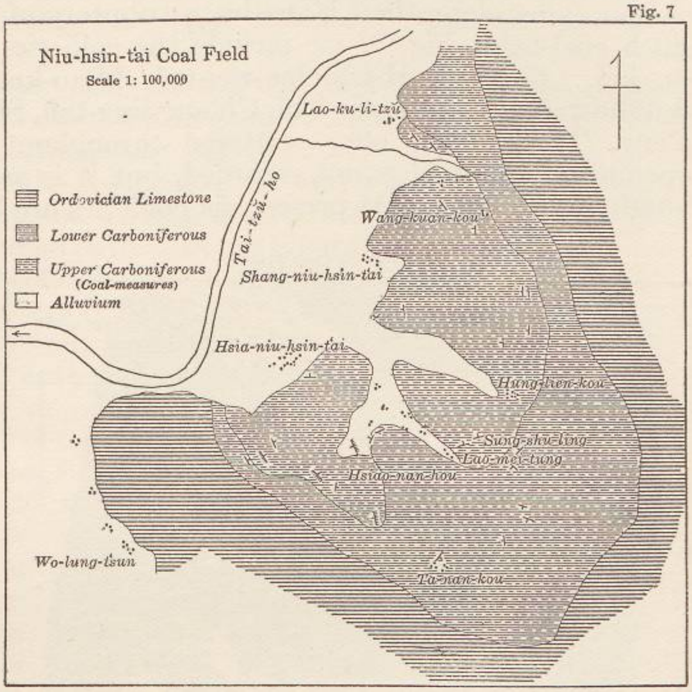
K'an-ch'ang District

In this district are included the scattered coal-fields west of K'an-ch'ang.

The T'ien-tzŭ-fu-kou coal-field. This coal-field is situated about 20 km. west of K'an-ch'ang, and the coal is mined in the villages of Ta-pao, K'ung-chia-pao-tzŭ, Ch'üan-chia-pao-tzŭ, etc., the mines in Ta-pao being the most active.

The coal is said to have been discovered about ninety years ago and yields nearly 30 tons of coal a day or 6,000 tons a year. The basement complex is a grey limestone, overlain by the coal-bearing formation which consists of brown sandstone in the lower, alternating strata of shale and sandstone in the middle, and brown conglomerate in the upper, part. The middle part represents the Coal-Measures in which Carboniferous flora are found. The strata strike north-west generally and dip S.W. 20°-30°. However, the strike bends nearly to the north, with the dip W. 20°, at the west end of the field. There are two important coal-seams, the thickness of the upper being nearly two feet and that of the lower 3.5 to 4 feet. As the area underlain by coal is rather small, the quantity of coal it contains cannot be large, being estimated at 2,000,000 tons. The coal belongs to the semi-anthracite variety and is brittle, being difficult to get in lumps. Some of the coal, as in the south-east or in Ta-pao, is non-caking, while other varieties, as in the north-west or in K'ung-chia-pao-tzŭ, is caking and fit for the manufacture of coke. The results of technical analyses are as follows:

Fig. 7



Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
1.30	11.17	70.31	17.22	0.38	1.539	6,050c	10,890	B_2
1.95	14.35	77.12	6.58	0.95	1.498	6,325	11,385	"

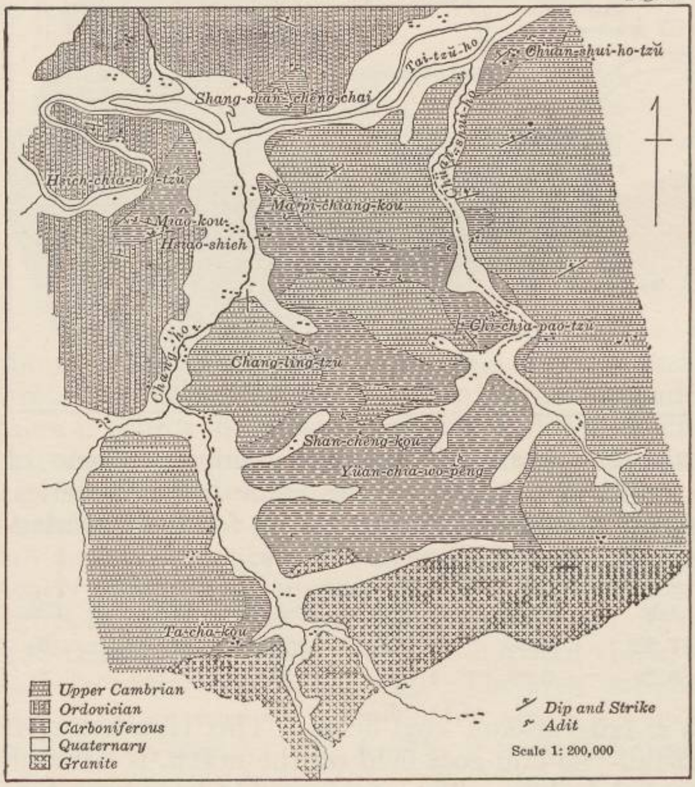
The Hou-huang-ti and Ts'ai-tzŭ-yao-kou coal-fields. The Hou-huang-ti coal-field, lying adjacent to Ts'ai-tzŭ-yao-kou coal-field on the north, is situated about 13 km. north-west of T'ien-tzŭ-fu-kou. The coal is said to have been first mined in 1888, and yields at present about 35 tons of coal a day. These two coal-fields are composed of strata continuous with those in the T'ien-tzu-fu-kou field. The strike of the coal-bearing formation is generally N. 30° E., dip N.W. 30°. One coal-seam, about two feet thick, has been examined, though two or three seams are said to occur. The area underlain by coal is quite limited, so that the amount of the coal reserve is probably small. The coal belongs to the semi-anthracite variety and is caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.70	24.03	72.52	2.75	1.39	1.286	8,470c	15,256	B_2

Hsiao-shieh Coal-Field

Hsiao-shieh is situated about half way between Pen-hsi-hu and K'an-ch'ang, lying along the Ch'ang-ho, a tributary of the Tai-tzŭ-ho. In the Hsiao-shieh coal-field (Fig. 8) we include the collieries in an area covering about 16 sq. km.; they are Hsieh-chia-wei-tzŭ, Miao-kou, Ma-p'i-chiang-kou, Ch'üan-shui-ho-tzŭ, Ch'i-chia-pao-tzŭ, Ch'ang-ling-tzŭ, Shan-ch'êng-kou, Yüan-chia-wo-p'eng, Ta-ch'a-kou, etc., scattered throughout the area. The date of the opening of the field is not recorded, but it is said to have been mined over a hundred years ago. At present six collieries are being worked on a small scale, yielding about 1,000 tons a year. The field is hilly with tolerably wide drainage plains along the Tai-tzŭ-ho and its two tributaries. The upper Cambrian is most widely distributed in the field, while the Ordovician is found in the north-western part. The Carboniferous is subdivided into three series, the lower, middle, and upper, and lies on the Cambrian and the Ordovician. The lower series consists of schalstein, shale and sandstone, and the middle represents the Coal-Measures, while the upper consists chiefly of sandstone with shale. The Coal-Measures are composed chiefly of sandstone with shale. Seven coal-seams are interbedded in sandstone, but their development is local, so that they are not all found throughout the field. The formation is severely disturbed by folding and faults. Granite is found in the southern part of the area.

Hsiao-shieh Coal Field Fig. 8



In the Hsieh-chia-wei-tzŭ colliery, which lies in the north-west of Hsiao-shieh, the formation dips S.S.W. 40°-70°, but in the Miao-kou colliery, lying adjacent to it on the south, it turns N. or N.W. 55°, forming a syncline. Of seven coal-seams found in these collieries, two have a thickness of one foot to 1.7; one is 3.6 feet thick, and the others are less than one foot.

In the Ma-p'i-chiang-kou colliery in the east of Hsiao-shieh three thin coal-seams, less than one foot thick, dip S.S.W. 70°-80°.

In the Shang-shan-ch'êng-chai colliery, which lies to the north of the Tai-tzŭ-ho, three thin coal-seams, less than one foot thick, run N. 45° W., dipping S.W. 10°-20°.

In the Ch'üan-shui-ho-tzŭ colliery, lying along the Tai-tzŭ-ho in the north-eastern corner of the field, five coal-seams, less than one foot thick, are found. The dip and strike are often variable, the strike being N. 60° E. and the dip N.W. 40° in general.

In the Ch'i-chia-pao-tzŭ colliery, on the Ch'üan-shui-ho, four coal-seams are found, the thickness being one to two feet in general. The strike is N. 30° W. or north-south, and the dip east at moderate angles.

In the middle of the field lie the collieries of Ch'ang-ling-tzŭ, Shan-ch'êng-kou and Yüan-chia-wo-p'êng. In the Ch'ang-ling-tzŭ colliery the dip is N.E. 45°, but eastward it changes to north-south. In the Shan-ch'êng-kou colliery the dip is nearly east, but towards the south-east it gradually bends to the south, and in the Yüan-chia-wo-p'êng colliery it is S.W. 18°. Five coal-seams are known to occur, their thickness being generally one to two feet.

The coal is of the non-caking anthracite variety. The results of technical analyses of it are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Miao-kou....................	2.15	6.55	61.21	30.09	0.56	1.490	6,417c	11,551	A_2
Ch'üan-shui-ho-tzŭ..........	1.01	23.26	71.62	4.11	1.87	1.350	9,032	16,258	B_2
" "	8.53	15.04	69.88	6.56	0.33	1.587	4,565	8,217	B_1
Ch'i-chia-pao-tzŭ............	8.74	1.72	80.71	8.83°	0.50	1.748	7,223	13,001	A_1
" "	1.74	8.51	85.44	4.30	0.50	1.435	.....	.....	A_2
Shan-ch'êng-kou.............	3.67	6.54	61.77	28.02	0.51	1.48	6,246	11,243	"
" "	2.64	7.01	85.58	4.77	0.51	1.442	.....	.....	"

B—THE COAL-FIELDS LYING ON THE EAST OF THE GREAT WALL

Numerous coal-fields are found arranged almost in a row in nearly an east-north-east, west-south-west direction.

Ssŭ-p'ing-chieh District

The Ssŭ-p'ing-chieh coal-field. Ssŭ-p'ing-chieh is inconveniently situated, lying about 34 km. east of K'an-ch'ang and about 20 km. south of P'ing-ting, shan. The coal was discovered in 1875 and at present nearly 10 tons a day are mined. The basement limestone is overlain by the coal-bearing formation in the south. The coal-bearing formation consists of shale and sandstone and is often folded as well as faulted, though it runs generally from north-west to south-east and dips S.W. 30°. There are two coal-seams, the upper being 1.3 feet thick and the lower four and sometimes five feet in thickness. The area is limited in extent and the amount of coal contained in it is probably small. The coal is brittle, and difficult to get in lumps. It is semi-anthracite and caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U	Class
0.90	28.30	64.91	5.89	2.85	1.316	7,590c	13,662	B_2

The Ma-chia-tzŭ coal-field. Ma-chia-tzŭ is situated about $1\frac{2}{3}$ km. west of Ssŭ-p'ing-chieh. The coal was discovered in 1897, but owing to the difficulty of keeping the pit free of water, mining was soon abandoned. The coal-bearing formation rests directly on the basement limestone, as in Ssŭ-p'ing-chieh. One coal-seam has been examined, its thickness being generally three feet. The coal is caking and fit for coke, as in Ssŭ-p'ing-chieh.

The Mu-lo-yü-tzŭ coal-field. Mu-lo-yü-tzŭ is situated about 28 km. east of P'ing-ting-shan and lies between Huai-jên and P'ing-ting-shan. The date of discovery is not known, but it is known that, after being closed for a time, the mine was reopened in 1879, only to be again abandoned. The coal-bearing formation consists of shale and sandstone, which overlie limestone. The geological age of the formation is not yet established, but from correlation with other coal-fields I assign the formation to the Carboniferous. The mode of occurrence of the coal has not yet been studied, as no outcrop has been observed in the field and the adits are all destroyed. The coal belongs to the semi-anthracite variety and is caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U.	Class
2.0	16.9	62.2	18.9	1.5	6,504c	11,707	B_2

In Mei-tung-kou, lying at about 6 km. south of Mu-lo-yü-tzŭ, one coal-seam two feet thick, increasing in places to five or six feet, has been worked for 30 years. The production is insignificant, the daily yield being estimated to be less than six tons.

T'ung-hua District

Coal is found in several places along the Hun-chiang on the north-east of T'ung-hua. It is anthracite, and is interbedded in sandstone and shale of the Carboniferous, underlain by limestone. The thickness of the coal varies from one foot to ten feet.

The San-ch'a-tzŭ coal-field. This is the most northerly of the coal-fields, and is conveniently located near the Hun-ho at a distance of about 80 km. north-east of T'ung-hua. The mine was opened in 1881, though the discovery of coal is said to have been much earlier. The coal-bearing formation consists of sandstone and shale, and strikes N. 45° E. dipping S.E. 20°. Two important coal-seams are found, the upper having a thickness of three or four feet, and the lower of two feet. The extension of the coal-seams along the strike has not yet been ascertained, but has been supposed to reach 2,000 feet. The coal reserves are estimated at about 3,000,000 tons. The coal is of bad quality, giving much ash.

The Liu-tao-kou coal-field. This coal-field is situated to the south of San-ch'a-tzŭ, being about 40 km. north-east of T'ung-hua. One coal-seam is found in sandstone, in what is perhaps the upper horizon of the coal-bearing formation, and runs from east-south-east to west-north-west, dipping N. 25°. The thickness is five or six feet, with thin partings. The extension along the strike has been estimated to be nearly 2,000 feet, and the coal reserves to be about 1,500,000 tons. The coal belongs to the semi-anthracite variety and is caking.

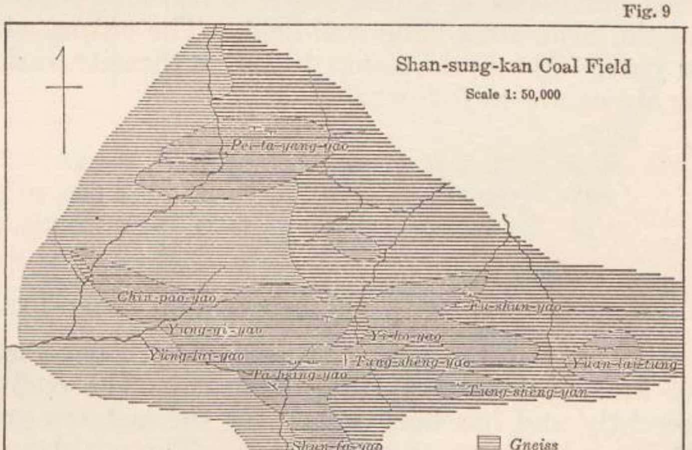
The T'ieh-ch'ang coal-field. This coal-field is located about 30 km. east-north-east of T'ung-hua and has been mined since 1885. The coal is mined at present on a small scale. The coal-bearing formation strikes nearly east-west, dipping N. 50°. Three coal-seams are found. The lowest one, which is worked at present, has a thickness of ten feet, while the other two are very thin and of rather inferior quality. The coal may be followed for about 4,000 feet and the coal reserves are estimated at about 4,000,000 tons. The coal is very brittle, yielding only 20% of lump coal. It is of the caking, semi-anthracite variety, fit for coke making. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
0.45	24.60	57.15	17.80	0.40	.....	6,050c	10,890	B_2
1.18	20.70	66.40	11.70	0.53	1.413	6,160	11,088	"
1.19	26.57	58.34	13.90	0.54	1.287	7,260	13,068	"
1.02	17.42	62.26	19.30	0.50	1.645	5,500	9,900	"
4.11	8.30	69.65	17.94	0.42	1.219	5,170	9,306	A_2
3.35	16.41	66.38	13.86	0.46	1.399	6,050	10,890	B_2

Shan-sung-kang Coal-Field

The Shan-sung-kang coal-field (Fig. 9) is situated about 65 km. south-east of Hai-lung-t'ing, and may be reached by wagon road. The coal-field was covered by thick forest till 1889, when it was cleared by immigrants for purposes of agriculture, as a result of which the coal was discovered. In 1896 four adits were opened and ten may be counted at present. The total production since its opening is estimated to be nearly 100,000 tons, and the yield in recent years has been 24,000 tons a year. The coal-field is an undulatory plateau, the somewhat isolated mountain in the east being exceptional. The basement complex is gneiss, consisting mainly of biotite gneiss with chlorite schist. It trends north-north-west, dipping east-north-east, and mostly covers the western half. Limestone, considered to be Ordovician, rests on the gneiss and forms many isolated basins, generally running east-west, though often variable. The coal-bearing formation, consisting of alternating strata of sandstone and shale, overlies the limestone unconformably. From its rather slight thickness, it is generally considered that the formation has suffered severe erosion since its deposition; the underlying limestone crops out here and there, where erosion has carried away the overlying Carboniferous. The dip and strike are often variable.

Fig. 9



There are three coal-seams, one of which is being worked. In the western part the strata form a rather regular syncline, running west-north-west, and lie directly on gneiss. The angle of inclination is very variable, being sometimes 35° near the outcrop and sometimes 60° underground. The thickness of the coal varies from one foot to ten feet, being generally six feet. In the eastern half, the structure is very complicated, the areas forming several isolated basins of irregular undulatory strata. Farther east three small isolated areas lie on the limestone. The coal-seams have been examined only near the synclinal basins, and have been found to be rather thin, that is, from one foot to six feet. A separate area in the north-west consists of two anticlines, where a coal-seam of two to three feet thick has been found. The extent of the western part, where coal is most actively worked, is 4,200 feet long and 1,200 to 2,400 feet wide, the quantity being estimated at 1,500,000 tons. The coal belongs to the semi-anthracite variety and is generally caking, fit for the manufacture of coke. It is so brittle that it is difficult in mining to get a large amount of lump coal. The results of technical analyses are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
	1.70	22.20	61.61	14.49	0.720	1.440	6,600c	11,880	B_2
	1.24	20.50	67.64	10.62	0.953	1.344	6,710	12,078	"
Yüan-lai-yao................	1.14	25.68	55.84	17.34	0.678	1.325	6,290	11,322	"
	2.05	30.31	55.86	11.78	1.024	1.299	6,490	11,682	B
Yi-ho-yao....................	1.50	30.94	57.36	10.20	0.875	1.288	6,600	11,880	"

The Pan-chieh-ho coal-field. This coal-field is situated about 60 km. east-north-east of Liu-ho-hsien in Hai-lung-fu, or about 26 km. west-south-west of the Shan-sung-kang coal-field. The output of late years has been 4,800 tons a year. The coal belongs to the anthracite variety. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
1.45	9.82	84.61	4.12	0.846	1.301	6,050c	10,890	A_2
3.39	6.31	71.78	18.52	0.720	1.469	4,180	7,526	"

Scattered Coal-Fields

The San-tao-yang-ch'a coal-field. San-tao-yang-ch'a is situated about 45 km. south-east of Huai-jên-hsien. The coal was discovered comparatively recently and has been mined for the last ten years. The production is small, being only about 18 tons a day. The coal-bearing formation covers a limited area and rests on thick limestone. It consists of sandstone and shale, and strikes N. 80° E. with the dip N. 12°-40°. One coal-seam, 1.6 feet thick, is known to occur. The coal belongs to the anthracite variety and is black with a semi-metallic lustre. It is very brittle and breaks easily into powder, yielding only one per cent. of lump coal. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U.	Class
1.5	5.0	76.4	16.1	1.0	7,163c	12,893	A_1

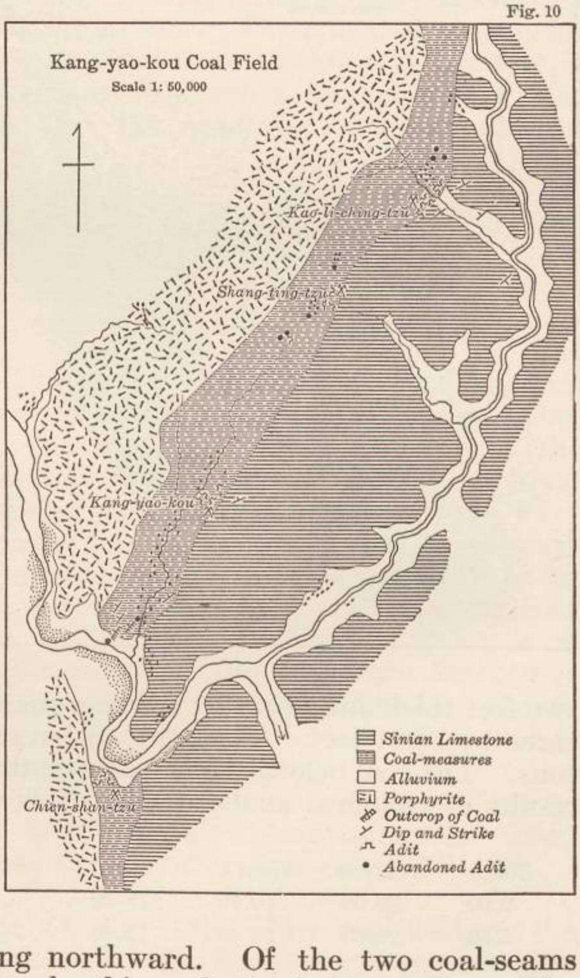
The Chia-p'i-kou coal-field. Chia-p'i-kou is situated about 15 km. north-east of Tung-kou. The coal was first mined in 1895 but work on it was soon abandoned. The coal-bearing formation consists of shale and sandstone of unknown age, though it is considered to represent the Carboniferous. The strike is N. 35° E. dipping N.W. 65°. The mode of the occurrence of the coal has not yet been studied.

The Yi-mo-shu coal-field. Yi-mo-shu is conveniently situated on the highway between Wang-ch'ing-pien-mên and Huai-jên, about 10 km. south of the former. The coal-bearing formation consists of Carboniferous shale and sandstone, containing one coal-seam four to five feet thick. The strike is N. 45° E. and the dip N.W. 35°. The area is quite limited in size.

III—THE COAL-FIELDS LYING WEST OF CHIN-CHOU

Many coal-fields are found west of Chin-chou and extend over the long terrain stretching from north to south near the Great Wall, the southern portion entering the province of Chih-li-shêng, which for the sake of convenience will be described here. The coal-bearing formation consists chiefly of sandstone and shale, with conglomerate in the upper part, and is underlain by heavy limestone. In the north-west it is cut generally by porphyrite, by which the formation is often disturbed and metamorphosed. The strike is generally north-east and the dip is N.W. 30°-40° or sometimes very steep.

Fig. 10

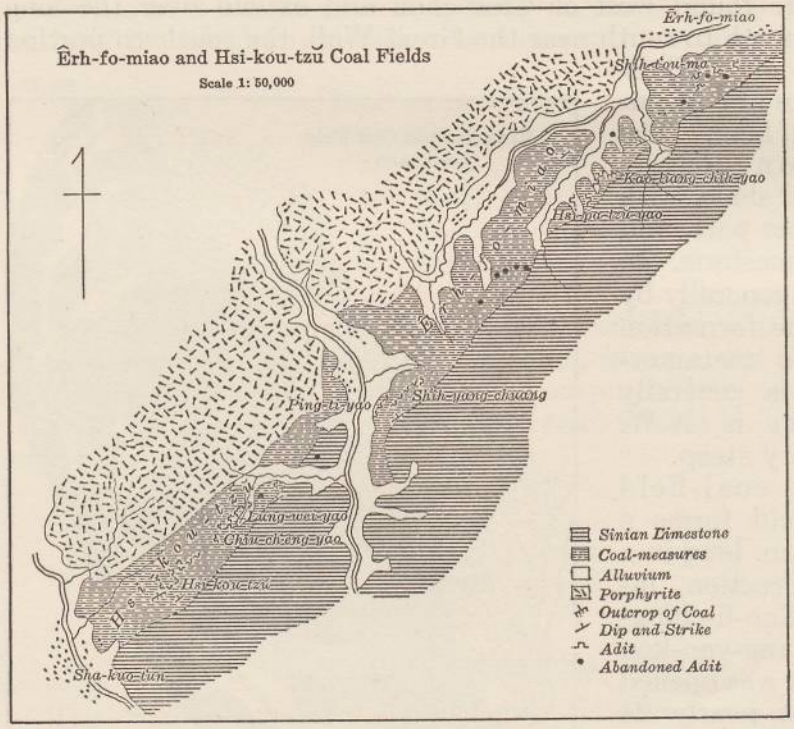


The Kang-yao-kou coal-field (Fig. 10). This coal-field forms a narrow basin about 6 km. long in a north-east-south-west direction, including the mines of Kao-li-ching-tzŭ, Shang-ting-tzŭ, Kang-yao-kou and Chien-shan-tzŭ. It was opened in 1860 and at present nearly 24 tons of coal are raised in a day. The greater part of the coal is supplied to the Chin-chou market, but a small portion is consumed locally as a substitute for wood and charcoal, and also as fuel for limekilns. The strike of the coal-bearing formation is generally N. 30°-50° E., dipping N.W. 30°-40°, but towards the north it bends nearly east, dipping northward. Of the two coal-seams known at present, the upper one is said to be thin and of inferior quality. The lower one is being worked, its thickness varying from two to seven feet. The coal reserves are estimated at about 2,500,000 tons. The coal is semi-anthracite and is non-caking. When the coal is much metamorphosed it changes to anthracite. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
3.20	12.50	63.50	20.80	9.85	1.59	6,198c	11,156	B_1
1.28	29.00	47.02	22.70	0.158	1.41	6,025	10,845	
5.80	21.60	49.80	22.80	3.179	1.34	.....	.....	B_2
6.25	22.50	56.05	15.20	6.869	1.35	6,756	12,159	"

The Êrh-fo-miao coal-field (Fig. 11). This coal-field, lying to the south-west of the Kang-yao-kou coal-field, is a narrow tract about 4 km. long and ½ km. wide, running from north-east to south-west. It embraces six collieries, that at Shih-yang-chuang being the largest, and P'ing-ti-yao next. The date of discovery is not recorded; but in 1860 some coal had already been mined, and the daily output at present is nearly 35 tons. The dip and strike of the coal-bearing formation are often variable, owing to local disturbances, though the formation generally runs N. 50° E. with the dip N.W. 30°. There are two coal-seams with varying thickness. Generally the upper one is two feet thick and of rather inferior quality, while the lower has a thickness of three to eight feet. Thus the coal reserves are estimated at about 3,500,000 tons. The coal belongs to the semi-anthracite variety and is non-caking. The results of technical analyses are as follows:

Fig. 11



Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
2.00	20.00	59.70	18.30	5.387	1.35	6,869c	12,364	B_2
5.30	24.90	56.40	13.40	2.423	1.39	5,670	10,116	"

The Hsi-kou-tzŭ coal-field (Fig. 11). This coal-field lies adjacent to the

Êrh-fo-miao coal-field on the south-west and occupies a belt about 3 km. in length. There are four collieries, the Hsi-kou-tzŭ being the largest. The field was opened a hundred years ago and at present yields 120 tons a day. The strike of the coal-bearing formation is N. 60° E., dipping N.W. 60°. Only one coal-seam, averaging four feet in thickness, is found. The coal reserves are thus estimated at about 1,700,000 tons. The coal is black, non-caking and contains much pyrite. It belongs to the semi-anthracite variety and easily breaks up into powder. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
8.12	15.2	47.78	28.90	11.68	1.53	7,279c	13,102	B_2
3.00	25.3	46.60	25.10	5.32	1.45	6,690	12,042	"

The Sha-kuo-t'un coal-field. This coal-field is situated at the south-west of the Hsi-kou-tzŭ coal-field, and occupies a narrow basin about 2 km. long. It was opened about forty-five years ago and eight collieries are at work, yielding the small amount of fifteen tons a day. The general strike of the coal-bearing formation is N. 40°-50° E. and the dip N.W. 40°-60°. Three or four coal-seams are said to occur, but only the lowest, with an average thickness of five feet, is being worked. The coal reserves will scarcely reach a million tons. The coal is semi-anthracite and is non-caking. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
5.32	12.1	52.38	30.2	2.18	1.7	5,957c	10,723	B_1
4.10	20.3	58.00	17.6	1.93	1.5	6,267	11,281	B_2
5.82	27.3	45.51	21.3	1.13	1.4	7,843	14,117	

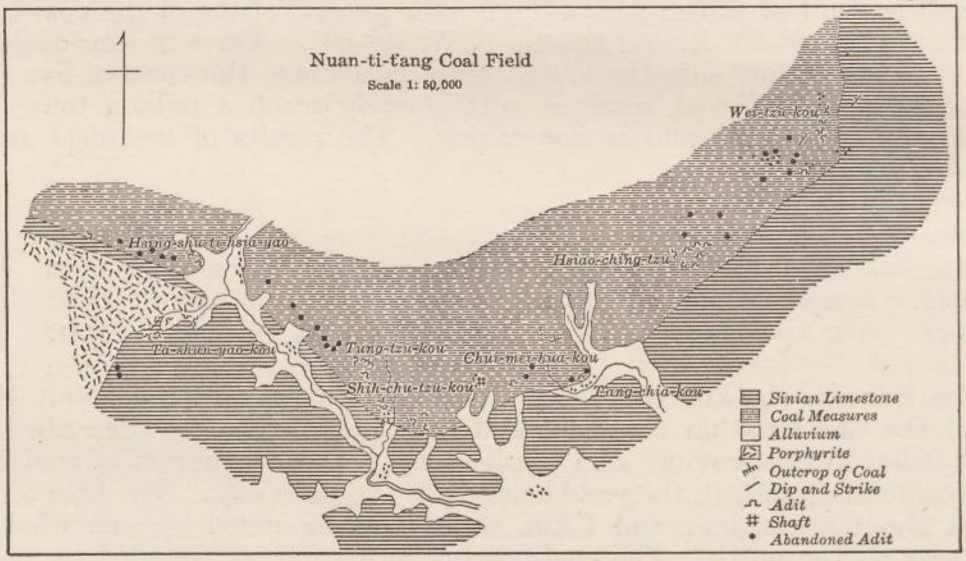
The Pai-tsao-shu-kou coal-field. This coal-field is situated about 10 km. west of the Sha-kuo-t'un coal-field and may be conveniently described here, though it lies in the province of Chih-li-shêng. The production of coal in the field is quite insignificant, the yield being only 12 tons a day. The field occupies an area about 2 km. long and 1 km. wide, being bounded by somewhat lofty mountains on the north. The coal-bearing formation, surrounded by porphyrite, consists of shale and sandstone with schalstein, and strikes north-east or N. 50° E. with the dip S.E. 50°-60° in the north, and north-west in the south, and forming a syncline nearly at the middle. The angle of inclination seems to be much lower underground, being 20° to 30° or less. One coal-seam nearly five feet thick is being worked. The coal reserves are small, being estimated at only about 800,000 tons. The coal belongs to the semi-anthracite variety and is non-caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
7.3	20.1	50.40	22.2	0.51	1.47	6,804c	12,247	B_2

The Nuan-ti-t'ang coal-field (Figs. 12 and 13). This coal-field, in the province of Chih-li-shêng, lies to the south of Pai-tsao-shu-kou and extends from Wei-tzŭ-kou, outside the Great Wall, to Ta-shun-yao, about 8 km. west of the same. The field was opened about one hundred and fifty years ago and six collieries are being worked, yielding 240 tons a day. The coal-bearing formation, as above stated, consists of shale and sandstone, with conglomerate in the upper horizon, and is underlain by thick limestone. The strike is generally N. 40° E. with the dip N.W. 40°, but towards the west it bends nearly to the east. Among six or seven coal-seams, now known, two or three seams may be workable, the thickness of each seam being four feet or more. The coal belongs to the semi-anthracite variety and is non-caking. The results of technical analyses are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
5.20	18.90	55.80	20.10	7.694	2.00	6,367c	11,461	B_2
17.60	25.30	45.80	11.30	4.375	1.44	8,463	15,233	"
13.47	21.53	41.30	23.70	1.932	1.56	6,256	11,261	"
9.25	23.75	47.30	19.70	0.359	1.40	.....	......	"

Fig. 12



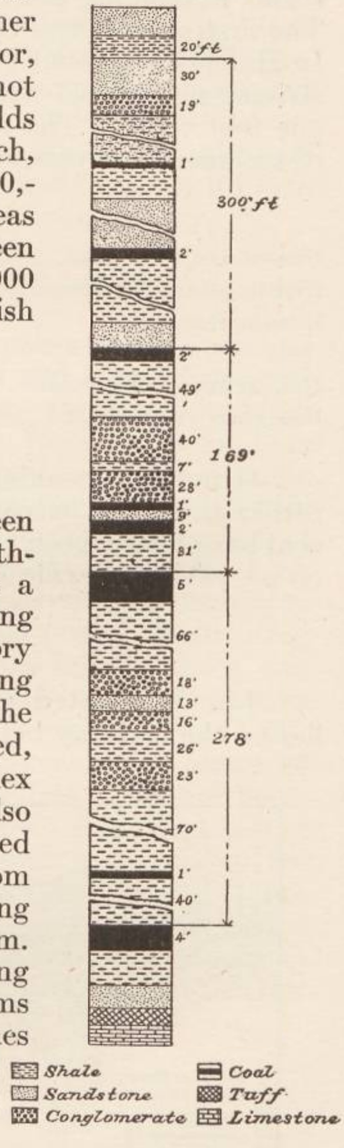
This coal-field is very actively worked at present and will continue to be on account of the large size of the field and the thickness of the seams. Its extension is about 8 km. long and a conservative estimate puts the aggregate thickness of the coal-seams at twelve feet. The coal reserves are thus estimated at about 30,000,000 tons.

The Hung-lo-hsien coal-field. This coal-field extends north-eastward from Kao-ling-t'sun, which is situated about 6 km. north-west of Hung-lo-hsien, and west-south-west of Chin-chou. It covers a terrain about 2 km. long. There are two collieries, yielding only about 90 tons a month. The strike of the coal-bearing formation is N. 30°-50° E. dipping N.W. 40°. There are two or three coal-seams. The upper seam has a thickness of three feet and more, while the lower is four feet thick, both intercalating thin partings. The coal reserves are estimated at about 3,500,000 tons. The coal belongs to the semi-anthracite variety and is non-caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
7.6	15.6	41.9	34.9	14.16	1.61	B_2

As the transportation facilities are not good, mining in the above coal-fields is not active. The total production in a year will not exceed 150,000 tons, the working methods being primitive. There are two or three coal-seams, now known, which dip often with rather steep angles. The quality of the coal is rather inferior, often containing abundant ash and sulphur. It is not now possible to estimate the amount of coal in the fields of this district, but it is probable that the reserves in each, except the Nuan-ti-t'ung field, will reach 1,000,000 to 5,000,000 tons, basing the calculation on the extent of the areas and the thickness of the coal-seams. Thus it will be seen that the total amount in the district will reach 40,000,000 tons, quite enough to supply the local demand and to furnish a surplus for export to distant towns or markets.

Fig. 13



COAL-FIELDS IN THE MESOZOIC

Sai-ma-chi Coal-Field

Sai-ma-chi is a small town on the highway between Fêng-huang-ch'êng and K'an-ch'ang, about 80 km. north-east of Fêng-huang-ch'êng. The coal-field (Fig. 14) is a narrow tract on the north and north-east of the town along the Pa-tao-ho and its tributaries, and forms undulatory hilly land about 100 to 250 m. high. The coal-bearing formation is composed chiefly of shale and sandstone in the lower horizon and conglomerate in the upper, and is bounded, both to the north and south, chiefly by a basement complex of quartzite and phyllite of the Takushan formation and also by limestone of the Sinian formation. It has been proved by fossil flora to represent the Jurassic and runs nearly from east to west. The coal-seams, interbedded in the alternating strata of shale and sandstone, seem to extend about 12 km. in length. At the middle part of the field the coal-bearing formation attains its greatest development, and five seams with full thickness occur, while towards the sides it becomes gradually thin, only two or three coal-seams being known. The total output of coal at present does not exceed 200 tons a day.

In the middle of the coal-field stands Mount P'ing-ting-shan, about 250 m. high, where the coal was first mined about fifty-five years ago. Five coal-seams, with thicknesses of 0.6-0.7, 2, 1.4, 2.6, and 0.6 feet, respectively, are interbedded in the strata at vertical intervals of 50 to 70 feet. In Hsiao-ku-shan-tzŭ on the west of P'ing-ting-shan, two coal-seams, corresponding to the second and third seams in P'ing-ting-shan, are observed, striking N. 35°-40° E. with the dip S.E 10°. The thickness is four to six feet, but the upper seam is of inferior quality and not worth working. In Li-shu-kou about 1 km. north-west of Sai-ma-chi, two coal-seams, corresponding to the third and fourth seams in P'ing-ting-shan, are found striking north-west with the dip S.W. 20°. The upper one is the thicker, but is only 0.7 to 3.0 feet thick and the lower is less than one foot, being 0.3 to 0.8 foot. In Nien-tzŭ-kou the coal-seams are all thin, only the first and fourth seams developing there. They run nearly from east to west, dipping S. 5°-10°. The first seam is less than one foot in thickness and the fourth is 1.2 feet thick. In Huang-kou, about 8 km. east of Nien-tzŭ-kou, the fourth seam only is known, striking nearly east-west with the dip S. 5°-10°. It is very thin, being less than one foot thick. The coal belongs to the semi-anthracite variety. The results of technical analyses are as follows:

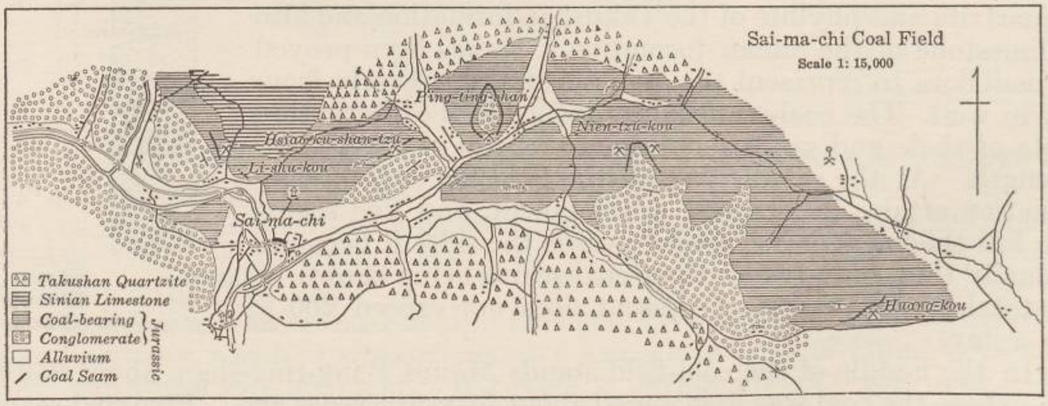
	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
Nien-tzŭ-kou, First Seam..........	1.51	27.82	57.28	13.39	0.87	B_2
P'ing-ting-shan, Third Seam........	1.26	21.89	69.27	7.58	0.58	"
Hsiao-ku-shan-tzŭ.................	1.39	29.21	59.08	10.32	0.60	"
	3.69	6.44	70.10	19.77	0.49	A_2
Nien-tzŭ-kou, Fourth Seam.........	1.41	27.04	54.86	16.69	0.95	B_2
Huang-kou, Fourth Seam...........	1.49	22.11	70.42	5.98	0.40	"

Generally speaking, the coal is of good quality, although the seams are rather thin, not exceeding five feet in thickness. As all the easily workable coal has already been taken out, future mining will be rather difficult and mining on an extensive scale is not to be expected.

I-lu Coal-Field

I-lu is situated about 4 km. east-south-east of Hsin-t'ai-tzŭ station and lies on the highway between Fêng-t'ien and T'ieh-ling. The coal is found in the

Fig. 14



hills to the south of the town and in Kuan-ti, about 3 km. east of the town. The daily production is said to be nine tons. The northern part of the hilly land is drained by a small stream running from east to west. The basement complex is phyllite and quartzite, probably of lower Cambrian age, and forms the northern mountain seen across the stream. Schalstein, of probably Mesozoic age, is found to the west of Kuan-ti, and porphyrite occupies the northern part of the field. The coal-bearing formation, consisting of shale and sandstone, overlies them and is covered by loess in the north. By correlation with other coal-fields in the north of Fêng-t'ing, the formation is considered to represent the Jurassic. At Kuan-ti the formation strikes west-north-west, dipping N.N.E. 30°. A coal-seam about two feet thick is intercalated in black shale. The coal found on the south of the town is accompanied by porphyrite, by the intrusion of which the strata have suffered contact metamorphism and have been much disturbed. The thickness of the seam, it is said, varies from one foot to eight feet. As the area underlain by coal is quite limited, the coal reserves are probably not large. The coal is black and easily breaks up into powder. It belongs to the bituminous variety and is of inferior quality.

Ta-t'ai-shan Coal-Field

The Ta-t'ai-shan coal-field is situated about 4 km. north-west of T'ieh-ling and occupies hilly land about 4 km. from north to south and 1 km. from east to west. It is said that the coal was first mined by Coreans about two hundred years ago, but that in a short time mining was prohibited. Since then no mining has been carried on. From time to time plans have been made for opening the field, but they have always failed. Recently it was reopened, and is yielding at present nearly 20 tons a day. The coal-bearing formation consists of shale and sandstone with conglomerate, imbedding fossil flora by which it has been proved to represent the Jurassic. The basement gneiss, intruded by prophyry and porphyrite, forms the eastern part of the field, the porphyry constituting the solitary Mount Ta-t'ai-shan. The coal-field is separated into northern and southern sections, about 2 km. apart, by a thick deposit of loess. The strike of the coal-bearing formation is nearly east or N. 75° E. dipping N. 5°-10°. Of the two coal-seams known at present, the upper one is reached at about 80 feet from the surface in the southern section and at about 40 feet in the northern, the difference being probably due to a fault between the two. The thickness of the upper seam is 1 to 1.8 feet with a thin parting. The lower seam, about ten to thirty feet below the upper, is three feet thick, also with a thin parting. Thus, it is not probable that the field contains a large amount of coal, unless other good thick seams below the known ones should be discovered. The coal belongs to the bituminous variety and burns easily with a long flame, being rather inferior in quality. The results of technical analyses are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.
Coal in northern section	10.56	29.68	46.54	13.20	1.52	1.430	6,787c	12,217
Coal in southern section......	17.90	22.30	62.80	7.00	3.55	1.218	7.207	12,973 Caking

Fang-niu-kou Coal-Field

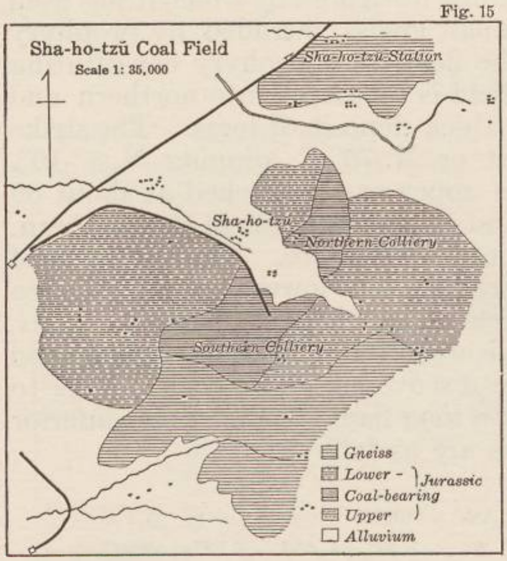
The Fang-niu-kou coal-field is situated about 12 km. north of K'ai-yüan, or 10 km. south-south-east of Ch'ang-t'u station, and occupies the western flank of the Yang-tzŭ-ling range, which has an average height of about 200 to 300 metres above the general level. It was opened about 160 years ago, and mined on a small scale, but has been abandoned since 1908. The field consists of hills rising about 50 to 60 m. above the general level, and trending from north-north-west to south-south-east and sloping towards the south and the west. The basement gneiss forms the eastern mountain, on which alternating strata of shale and sandstone with coal have been deposited. The extent of the coal-bearing area is estimated to be 6,000 feet in length and 1,200 feet in width. The coal-bearing formation is considered to be Mesozoic, as suggested by its geological relation with that of the Sha-ho-tzŭ coal-field. It strikes N. 20° W. and dips W.S.W. 20°-30°. Three coal-seams are known, their respective thicknesses, beginning with the upper one, being 1-2, 2-2.5, and 0.4-0.6 feet. Besides, a coal-seam 0.3-7 feet thick seems to occur, its correlation with the other seams having not yet been studied. The coal reserves seem to be small, being estimated at an amount less than a million tons. The coal belongs to the bituminous variety and is somewhat caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.
9.45	45.83	23.88	16.84	1.68	1.427	5,170c

Sha-ho-tzŭ Coal-Field

The Sha-ho-tzŭ coal-field (Fig. 15) is situated about 15 km. east of Ch'ang-t'u or 6 km. north-east of Ch'ang-t'u station, with which it is connected by a branch line of railway. It was opened about 120 years ago, and of late years has been managed by Russians. The annual production is nearly 7,000 to 8,000 tons. It lies on a hilly plateau, about 30-40 m. above the level of Ch'ang-t'u, fringing the western side of a gneiss formation and sloping towards the north-west. It is separated into the northern and southern sections by a thick loess deposit where a rivulet runs west-north-west. The coal-bearing formation consists of shale, sandstone and conglomerate, the lower part being chiefly sandstone and the upper chiefly shale, and has been proved by fossils to represent the Jurassic. Only a few outcrops are observed, so that it is difficult to ascertain the general strike of the formation, which, however, seems to be N. 30°-40° E. with the dip N.W. 10°. There are eight coal-seams, the thickness varying from 0.5 to 5 feet or, enumerated from the top downwards, 1, 1, 0.5, 5 (with a parting), 2 (with a parting), 2, 3 (with a parting), and 4-5 feet (with a parting), respectively. They have been all examined in the southern section, while in the northern, only the lower three are known, the upper part being already eroded away. The extension of the northern section is about 1,200

Fig. 15



feet long and 600 feet wide and that of the southern about 3,000 feet long and 1,800 feet wide. The coal reserves in the coal-field are probably not large, being estimated at about 2,000,000 tons. The coal belongs to the bituminous variety and is caking, fit for the manufacture of coke. The results of technical analyses of coal from two of the better seams are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Seventh Seam................	8.70	30.76	47.25	13.29	0.69	1.358	5,940c	10,692	C
Eighth Seam................	7.43	32.03	50.34	10.20	0.91	1.347	5,940	10,692	C

Ku-shan-tzŭ Coal-Field

The Ku-shan-tzŭ coal-field is situated about 28 km. south-east of Fa-k'u-mên. The coal-bearing formation crops out on the southern flank of a solitary porphyry mountain, Ma-chia-ku-shan, and is composed chiefly of sandy tuff, running N. 40° W. with the dip S.W. 30°. As to the coal-seams, nothing is known at present, but it is said that coal was mined about 25 years ago, but that mining was soon abandoned, owing to the very bad quality of the coal.

Pan-la-mên Coal-Field

The Pan-la-mên coal-field is situated about 16 km. south of Ssŭ-p'ing-chieh station on the railway between Ch'ang-t'u and Ch'ang-ch'un. Three coal seams are known to occur, their respective thicknesses being 1.5, 2 and ¾ feet. The coal belongs to the bituminous variety. The coal was formerly worked, but at present mining is abandoned.

COAL-FIELDS IN THE TERTIARY

Fu-shun Coal-Field

(*Plates II and III*)

Situation and history. The Fu-shun coal-field forms a long belt on the east of Fêng-tien, opposite Fu-shun. It is connected by a branch line with the main South Manchurian railway. To the north the area is drained by the Hun-ho, while a somewhat steep mountain range constitutes its southern boundary. At present mining is carried on at Ch'ien-chin-chai, Yang-pai-pao and Lao-hu-t'ai. Two shafts, Togō and Ōyama, were recently opened, by which the production was greatly increased. In area the coal-field covers 48 sq. km., being about 18 km. long in an east-west direction. There is no authentic record of the history of this coal-field, but it is said that the coal was used as fuel for a porcelain factory about 600 or 700 years ago, and for copper smelting in times as remote as 2,000 or even 3,000 years ago. In the eighteenth century mining was prohibited by the Government. In 1901, a concession was granted to the Chinese, by whom two companies were organized. In 1903, the greater part of the concession was transferred to the Russian company, and during the Russo-Japanese war the whole was delivered over to the management of the Russians.

In 1905, the coal-field was placed under the management of the officials of the Military Department of Japan. In 1907, the South Manchuria Railway Company was organized, and the coal-field was transferred to that company. The production of coal is not well recorded but that raised by Japanese has been as follows:

September 11th, 1905—March 31st, 1907........	229,947	tons.
1907 ending March 31st, 1908...	233,325	"
1908, ending March 31st, 1909...	490,720	"
1909, ending March 31st, 1910...	706,042	"
1910, ending March 31st, 1911...	898,482	"
1911, ending March 31st, 1912...	1,343,198	"

Topography and geology. The coal-field is a hilly plateau, abruptly sinking by cliffs to the Hun-ho, which bounds the field on the north. To the south it is bordered by a somewhat steep mountain range, which is intersected by the tributaries of the Hun-ho. The coal-field is divided into an eastern and a western section by a central highland, where the strata have been much contorted, and bent almost at right angles, so that it was formerly supposed that a great fault occurred there, with a horizontal displacement of 2,400 feet.

The basement complex is granite gneiss, on which the tuff, considered as lower Cambrian, has been deposited. In the eastern part of the coal-field, red and green tuffs with porphyrite sheets cover the gneiss unconformably. Tufaceous sandstone and shale lie on it and run from north-west to south-east, forming a syncline. These, together with red and green tuffs, are considered to be Mesozoic of unknown age. The Tertiary formation, in which the coal-seams are interbedded, was deposited on the "graben," running from east to west, in the gneiss and older formations, and generally dips N. 30°. By fossils discovered in the shale, the formation has been proved to belong to the Miocene. It may be divided into the lower and the main coal-bearing series. The lower coal-bearing series consists of tufaceous sandstone, conglomerate and shale, in which two coal-seams are interbedded. The series may be followed from the eastern corner of the coal-field westward to the east of Yang-pai-pao station. Farther westwards it is found in small areas to the south of Yang-pai-pao and Ch'ien-chin-chai stations. Generally the strike is west-north-west and the dip N.N.E. 30°-40°. The series reappears on the east of the Ku-ch'êng-tzŭ-ho, bending northward with the river, where it is covered by alluvium. The main coal-bearing series consists of shale with a thick coal-seam but no sandstone. The shale overlying the coal is very thick, being about 2,500 feet, measured by outcrops. The series attains full development at the middle of the field and no outcrop is found at the eastern corner. Basalt forms the southern part of the field, occurring as sheets, especially between the lower and the main coal-bearing series or in the lower coal-bearing series. The effects of contact metamorphism are seen in the shale and coal-seams in the lower coal-bearing series, which it often covers, but not in the main coal-bearing series. Thus it will be seen that the intrusion of the basalt was later than the deposition of the lower, and before the deposition of the main, coal-bearing series. The strike of the formation is nearly east-west, dip N. 25°-45°. Faults are very frequently met with but there is none large enough to make mining difficult. A broad fold is found between Yang-pai-pao and Lao-hu-t'ai, by which the strata seem to have been shifted about 2,400 feet, as above stated. The formation forms a monocline dipping northward, but to both sides it bends northwards, from which fact we can infer that the lateral pressure acted from south to north. The dip angle is steep at the north or near the outcrops, but southward it becomes gradually lower, being nearly 25°.

Coal-seams in the lower coal-bearing series. There are two coal-seams in the lower coal-bearing series. The lower seam lies near the basement gneiss and is rather thin, being only two feet thick. The upper one lies several feet above the lower, but by the intrusion of basalt the vertical interval between the two often reaches several tens of feet. It has a maximum thickness of 20 feet, or an average of 10 feet. The quality is rather like that of the main coal-bearing series. Westwards it contains only thin partings, but is often cut and metamorphosed by basalt, so that mining on a large scale is not to be expected. On the east of the Tung-chou-ho, a coal-seam two feet thick is interbedded in shale and sandstone, with basalt sheets in the lower and upper part, and dips north-north-west. At the hill south of Ta-ying-tzŭ the upper seam, with tuff in the lower and basalt in the upper part, is found, striking N. 85° E. with the dip N. 50°. The thickness is nearly ten feet with many partings, and the good portion, only one foot thick, is mined by Chinese mining methods. A lower seam is not known here. At the south of Hsin-t'un a lower seam several feet thick crops out, striking N. 70° W. with the dip N.N.E. 40°, but the partings are thicker than the coal. This was formerly mined by Russians. At the saddle, south of Wan-ta-wu, an outcrop of coal twenty feet thick with many partings, was mined by Russians. About ten feet below the upper, a lower seam crops out, the thickness of which is not known. To the south and south-east of Lao-hu-t'ai the upper seam was once mined, and several abandoned adits are now found scattered here and there. On the south-west of Yang-pai-pao, abandoned adits are found, and near the river the lower seam crops out, with a basalt sheet forming both walls. On the south of Ch'ien-chin-shai the lower coal-bearing series is found in patches, and an upper seam nearly ten feet thick strikes N. 70° E. with the dip N.N.W. 40°, the hanging wall being basalt and the foot wall tufaceous shale. The lower seam crops out in a small area to the south of the summit of Ch'ien-chin-t'ai, lying near the basement gneiss. At Shê-wo, south-west of Ku-ch'êng-tzŭ, abandoned adits are found scattered where the strata bend to the north. Here the thickness is twenty feet with thin partings, basalt resting on coal. The strata then turn northwards and dip beneath the alluvium.

The main coal-seam. The roof of the main coal-seam is brownish grey shale, rather lacking in slaty structure, and the foot wall is also shale, often becoming sandy and intercalating thin coal-seams.

In the Ch'ien-chin-chai section, no outcrop of coal is seen, but underground the dip angle is 23° or 24°. The thickness is over 200 feet where it is thickest and 130 feet where thinnest. The number of partings is very large, nearly a hundred having been counted, though they are all thin, with a total thickness of twenty feet. The quality is almost the same throughout the whole seam.

At Yang-pai-pao, near the large fold, small folds and faults are abundant, but westwards or at a distance from the great fold, they become less numerous, showing the position of the centre of disturbance. Near the folding, the thickness shrinks to 75 feet, but is generally between 115 and 130 feet. The strike is nearly east-west and the dip N. 33° or 34°, sometimes N. 45° near the foot wall. At Lao-hu-t'ai east of the great fold, the strike is N. 75°-77° W. in the roof and N. 80°-86° W. in the foot wall. Foldings and faults are not so frequent as above. The dip is 25° to 37° in the roof and sometimes 42° in the foot wall, and has a tendency to become low deeper down. The thickness varies from 112 to 137 feet, with partings which have an aggregate maximum thickness of 70 feet. Still farther eastwards the main seam may be followed, and abandoned adits are found south of Wan-ta-wu. From there to Lung-pu-t'un across Hsin-t'un the seam is covered by alluvium, but on the hill south of Lung-pu-t'un an outcrop of several thin seams with sandstone partings is found. The horizon of the coal-seam has not been well studied, but seems to correspond to a coal-seam below the main coal-seam or to a part of the same. At Ta-ying-tzŭ the same outcrop is found, but eastwards across the Tung-chou-ho we have not sufficient data to regard it as the continuation of the main coal-seam. Somewhat thick sandstone partings are first met with in Lao-hu-t'ai and become gradually thicker to the east. There is no evidence to suggest a tectonic disturbance east of Lao-hu-t'ai that affected the thickness of the coal suddenly. Thus it will be seen that the main coal-seam becomes gradually thinner the farther we go from Lao-hu-t'ai, while the partings gradually swell, so that in the environs of Ta-ying-chŭ-tzü the coal at last shrinks to a thin seam, and in the region east of Hsin-t'un large mining operations are not to be expected.

No outcrop of coal is observed west of Ch'in-chin-chai, as the formation is overlaid by the alluvium; but drillings have proved that coal exists underground, where there is no change in its thickness. From the results of drillings it has been found that the strike changes to north-west at the eastern end of Ku-ch'êng-tzŭ and gradually bends north-eastwards, the strata forming a syncline.

Quantity. The area between Ch'ien-chin-chai and Yang-pai-pao underlain by coal is 9.6 sq. km. in which over half the area, or 5 sq. km., is actually proved by borings or shafts to contain coal, and a conservative estimate of its thickness is 130 feet. The dip angle is 26° on the average. From these grounds we get an amount in the district of 282,000,000 tons for actual and 260,000,000 tons for probable reserves. The area between Lao-hu-t'ai and Ta-ying-tzŭ underlain by coal is 7 sq. km., in which an area about 2 sq. km. is actually proved by borings to contain coal, and the average dip angle is 27°. The thickness becomes somewhat less, being 110 feet on the average. Thus the quantity of coal in the area will amount to 96,395,000 tons for actual and 238,000,000 tons for probable reserves. The area of 1 sq. km. east of Hsin-t'un is not included. The coal-seams in the lower coal-bearing series have also not yet been calculated.

Quality. The coal is pitch black in colour and lustrous. It belongs to the bituminous variety and is somewhat caking. The results of chemical and technical analyses are as follows:

MAIN COAL-SEAM

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Ch'ien-chin-chai	9.55	38.28	40.49	11.68	1.35	1.339	5,830c	10,494	C
"	9.80	40.31	44.63	5.26	0.81	1.307	6,270	11,286	C
"	9.21	41.84	40.03	8.92	1.29	1.359	5,830	10,494	C
"	7.56	40.33	46.63	5.48	2.30	1.325	6,380	11,484	C
"	8.99	38.78	49.24	2.99	0.61	1.274	6,380	11,484	C
"	9.16	41.49	45.93	3.42	1.16	1.298	6,380	11,484	C
"	8.67	41.43	46.88	3.02	0.61	1.300	6,380	11,484	C
"	7.93	41.97	46.25	3.85	0.90	1.285	6,380	11,484	C
"	8.81	40.06	47.07	4.06	0.75	1.305	6,490	11,682	C
"	8.06	39.70	46.42	5.82	0.55	1.327	6,325	11,385	C
"	8.28	38.37	40.63	12.72	1.02	1.357	5,830	10,494	C
"	6.20	43.86	40.20	9.74	1.13	1.371	6,380	11,484	C
"	6.70	43.52	46.45	3.33	0.86	1.294	6,820	12,276	C
"	6.03	45.93	43.43	4.61	1.30	1.225	6,710	12,078	C
"	8.07	35.48	51.45	5.00	0.78	1.302	6,490	11,682	C
"	7.15	42.86	45.16	4.83	0.74	1.308	6,600	11,880	C
"	7.19	40.10	50.21	2.50	0.50	1.303	6,380	11,484	
"	4.60	48.68	43.60	3.12	0.75	1.249	7,040	12,672	
"	5.18	44.90	48.48	1.44	0.71	1.229	6,710	12,078	
Ōyama	3.24	46.09	48.63	2.04	0.68	1.233	7,700	13,860	
Tōgo	2.26	48.76	43.04	5.94	1.74	1.254	7,123	12,821	
"	4.88	41.59	49.02	4.52	0.83	1.298	7,029	12,652	
"	6.25	48.42	40.63	4.70	0.58	1.342	6,843	12,317	
"	3.42	43.96	48.51	4.11	0.84	1.257	7,332	13,198	
Yang-pai-pao	6.11	41.33	46.32	6.24	3.02	1.302	6,820	12,276	C
"	6.77	38.96	50.43	3.84	0.59	1.282	6,380	11,484	C
"	6.02	38.56	52.40	3.02	0.58	1.318	7,710	12,078	C
"	4.98	39.59	52.03	3.40	0.48	1.261	6,820	12,276	C
"	6.18	38.37	53.13	2.32	0.34	1.279	6,930	12,474	C
Lao-hu-t'ai	7.30	39.80	40.67	12.23	1.35	1.286	6,270	11,286	C
"	6.75	44.70	44.25	4.30	0.90	1.241	7,040	12,672	C
"	7.90	40.20	44.25	7.65	4.14	1.350	6,490	11,682	C
"	6.90	39.85	50.12	3.13	0.86	1.256	7,150	12,870	C
"	7.95	40.80	47.00	4.25	0.75	1.270	6,820	12,276	C
"	7.70	39.90	48.80	3.60	0.82	1.218	7,095	12,771	C
"	6.70	40.08	48.69	4.53	1.55	1.303	6,930	12,474	C
"	5.50	40.40	50.32	3.78	0.90	1.281	7,040	12,672	C
"	6.15	40.03	48.77	5.05	0.74	1.312	6,930	12,474	C
"	6.25	39.90	50.25	3.60	0.75	1.266	6,875	12,375	C
"	5.75	41.80	48.62	3.83	0.90	1.280	7,230	13,014	C
"	7.80	38.53	50.57	3.10	0.60	1.242	7,040	12,672	C
"	7.40	37.85	50.67	4.08	0.58	1.281	6,710	12,078	C
"	7.65	38.70	50.02	3.63	0.65	1.286	6,930	12,474	C
"	7.21	38.11	50.50	4.18	0.77	1.281	6,820	12,276	C

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Lao-hu-t'ai	7.42	39.39	50.21	2.98	0.78	1.291	6,930	12,474	C
"	7.32	36.92	44.46	11.30	1.15	1.346	6,160	11,088	C
"	7.80	34.90	43.30	14.00	0.87	1.414	5,830	10,494	C
"	7.45	38.30	50.20	4.05	0.79	1.269	7,040	12,672	C
"	8.77	36.95	48.60	5.68	0.91	1.282	6,710	12,078	C
"	6.71	41.87	47.20	4.22	1.73	1.274	7,150	12,870	C
"	8.34	38.96	50.13	2.57	0.86	1.271	7,150	12,870	C
"	7.24	38.68	50.06	4.02	1.42	1.265	6,930	12,474	C
"	7.83	35.79	53.83	2.55	0.93	1.394	5,940	10,692	C
"	7.00	39.95	49.72	3.33	0.55	1.280	7,260	13,068	C
"	7.13	35.57	54.37	2.93	0.39	1.271	7,150	12,870	C
"	7.77	39.43	50.28	2.52	0.46	1.243	7,150	12,870	C
"	7.82	40.25	44.65	7.28	0.93	1.255	6,490	11,682	C
"	5.53	39.96	47.16	7.35	0.98	1.283	6,380	11,484	C
"	6.19	42.95	47.49	3.37	0.57	1.253	7,040	12,672	C
"	7.47	39.54	45.12	8.87	0.80	1.284	6,600	11,880	C
"	6.01	41.10	49.87	3.02	0.61	1.262	7,150	12,870	C
"	6.80	42.08	45.76	5.36	0.81	1.285	7,480	13,464	C
"	7.52	37.96	51.49	3.03	0.47	1.248	7,150	12,870	C
"	6.33	39.38	50.58	3.71	0.70	1.294	6,930	12,474	C
"	5.99	41.87	46.58	5.56	0.55	1.299	6,270	11,286	
"	5.97	39.56	50.19	4.28	0.90	1.277	6,600	11,880	C
"	6.85	38.69	48.34	6.12	0.41	1.287	6,270	11,286	C
"	5.76	33.78	51.12	9.34	0.34	1.248	6,160	11,088	C

	C	H	N	O	S	Moist.	Ash
Ch'ien-chin-chai	66.075	5.712	2.307	13.191	0.739	7.146	4.830
"	68.243	5.654	1.972	13.942	0.503	7.186	2.500
"	71.093	6.554	1.999	11.881	0.753	4.600	3.120
"	73.306	6.173	1.147	12.050	0.706	5.178	1.440
Yang-pai-pao	70.936	5.596	2.092	10.181	0.590	6.765	3.840
"	71.962	6.118	1.838	10.467	0.579	6.016	3.020
"	72.955	6.052	1.541	10.499	0.575	4.978	3.400
"	74.718	5.747	1.233	9.465	0.338	6.179	2.320
Lao-hu-t'ai	67.972	5.878	2.235	11.811	0.554	5.990	5.560
"	69.530	5.773	1.905	11.651	0.895	5.966	4.280
"	69.151	5.859	1.181	10.423	0.414	6.852	6.120
"	69.356	5.059	1.100	9.045	0.342	5.758	9.340

COAL IN THE LOWER COAL-BEARING SERIES

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Yang-pai-pao	5.53	39.12	46.21	9.14	3.16	1.315	6,710c	12,078	C
Ta-ying-chü-tzŭ	3.14	37.91	48.77	10.18	0.52	1.364	6,930	12,474	C
Ku-ch'êng-tzŭ	10.24	35.54	45.02	9.20	1.05	1.349	6,050	10,890	C

Shih-mên-chai Coal-Field

The Shih-mên-chai coal-field is situated east of the Fu-shun coal-field and embraces the two small villages of T'u-kou-tzŭ and Shih-mên-chai. The geology and topography are quite similar to those of the Fu-shun coal-field, only the area is very narrow and quite small as compared with that of Fu-shun. The basement complex is gneiss, overlain by the coal-bearing formation, which, from the study of its fossil flora, is considered to be Miocene. Basalt sheets are seen in the lower part of the formation. One important coal-seam may be followed from the bank opposite Hsia-chang-tang to Shih-mên-chai, across T'u-kou-tzŭ, striking N. 75° E. with the dip N. 50°, rarely N. 60°. The coal is thin, being two feet thick, with a parting of 0.7-0.8 foot in T'u-kou-tzŭ, and four feet, with many partings, in Shih-mên-chai. The number of coal-seams is not certainly known, but it is generally true that no large coal-seam is found such as occurs in the Fu-shun coal-field, so that the quantity will not reach a large amount. However, the Tertiary formation seems to extend to Ying-p'an and further exploitation will be necessary. The coal belongs to the bituminous variety and is caking. The results of technical analyses are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
T'u-kou-tzŭ................	5.66	32.40	36.93	25.01	0.87	1.518	5,170c	9,306	C
Shih-mên-chai..............	4.14	36.01	39.62	20.23	0.30	1.485	5,720	10,296	C

Chi-lin-shêng

Coal in the Carboniferous

The region along the Hui-fa-ho, a tributary of the Sungari between K'uan-chieh and Hui-fa-ch'êng, is famous for coal, and is said to be worked on a small scale. The basement complex is gneiss and metamorphosed rocks, on which the coal-bearing formation, considered as Carboniferous and consisting of sandstone with shale, has been deposited. A coal-seam in the T'ien-ho colliery, lying about 13 km. west of K'uan-ch'êng, has a thickness of three to five feet. The coal is of a rather inferior quality. It is said that the field extends about 15 km. in an east-west direction.

COAL-FIELDS IN THE JURASSIC

Ch'ang-ch'un Coal-Field

Under the name Ch'ang-ch'un coal-field, we include the two collieries of T'ao-chia-t'un and Shih-pei-ling, lying south-south-east and south-east of Ch'ang-ch'un, and also Ta-ting-tzŭ and Hsiao-ho-t'ai lying between these two. They were formerly worked on a small scale but are now abandoned, except the Ta-ting-tzŭ colliery. The coal-field occupies the western plateau, fringing the gneiss mountain at the east and sloping westward to the plain. The coal-bearing formation consists of shale and sandstone and imbeds fossil flora, which shows that the formation represents the Jurassic. The dip of the formation is N.W. 20°-30° in Shih-pei-ling, west-north-west in T'ao-chia-t'un and Hsiao-ho-t'ai and east-south-east at Ta-ting-tzŭ, forming a syncline. It is mostly covered with loam. Porphyrite and liparite are found in the north, intruding the formation. The tram-line connects the collieries with the main railway. As the coal-field is rather limited in extent and the coal is rather thin, the amount of the latter is probably not large, being estimated at about 1,000,000 tons.

The T'ao-chia-t'un colliery. This colliery is situated about 26 km. south-south-east of K'uan-ch'êng-tzŭ station. It lies in a hilly plateau cut by small valleys running from east to west. The coal-bearing formation consists chiefly of heavy white sandstone in the lower, alternating strata of shale and sandstone with coal-seams in the middle, and chiefly shale in the upper, part. Fossil flora has been discovered in shale in a coal-seam, which proves it to belong to the Oolitic. The strike of the coal-bearing formation is north-east in the south, but bends to north-north-east with the dip west-north-west. The angle of inclination is nearly 30° near the outcrops, but underground it diminishes to 12° to 20°. Two coal-seams are known to occur. The lower one is two to five feet thick with a thin parting of 0.6-0.7 foot but becomes thin on both sides. It was worked by the Russians before the war. The upper seam, located about 250 feet above the lower one, is about one foot thick and is not important. The coal belongs to the bituminous variety and is caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
9.22	31.88	58.90	9.34	0.87	1.482	C

The Ta-ting-tzŭ colliery. This colliery is situated between the two collieries, T'ao-chia-t'un and Shih-pei-ling, or about 3 km. south-east of Ch'ang-ch'un or 1 km. from T'ao-chia-t'un. It was opened about 50 years ago, and is now worked on a small scale. One coal-seam is known to occur, its thickness varying from two to five feet. The coal is of the non-caking bituminous variety, the results of technical analyses being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
10.23	31.31	54.00	4.46	0.86	.....	C
8.50	34.68	50.04	6.78	0.71	1.548	C

The Hsiao-ho-t'ai colliery. This colliery is situated about 5 km. south-west of the Shih-pei-ling colliery. The coal-bearing formation, consisting of shale, sandstone and conglomerate, is intruded by liparite and covered by loess. Owing to faults the strike is often variable, but is generally north-north-east, dip west-south-west, with steep angles.

The Shih-pei-ling colliery. This colliery is situated about 13 km. north-north-east of T'ao-chia-t'un or about 17 km. south-east of K'uan-ch'êng-tzŭ station. The coal-bearing formation is composed of shale and sandstone, interbedding two coal-seams. It is bounded on the south-east by porphyrite and liparite. The strike of the formation is north-east or north-north-east and the dip N.W. 20°-30°. The thickness of the coal-seams is variable, being greatest in the middle of the field and thinning out towards both ends. Where thickest the upper seam attains a thickness of 3.5 feet and the lower one of seven feet with a parting of two feet. The vertical interval between these two seams is about thirty feet. The relation of the coal-seams of the collieries has not yet been determined, but the coal-seam in T'ao-chia-t'un seems to correspond to the lower one in Shih-pei-ling. The coal is similar to that of T'ao-chia-t'un, and is sometimes caking and sometimes non-caking. The results of technical analyses are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.	Class
Upper Seam	3.11	36.83	54.76	5.30	0.55	1.314	6,710c	12,078	C—Caking.
Lower Seam......	10.61	38.21	35.84	15.34	0.53	1.478	4,950	8,910	C—Non-caking

Huo-shih-ling Coal-Field

The Huo-shih-ling coal-field is situated about 80 km. north-east of Ch'ang-ch'un or about 4 km. north of Ying-ch'êng-tzŭ station. There are two collieries, Huo-shih-ling and Ma-chia-kou, the former lying about 3 km. south-west of the latter. The coal is now mined on a small scale in the Huo-shih-ling colliery. The coal-bearing formation consists of shale and sandstone with conglomerate and coal-seams, and is intruded by porphyrite and liparite. By the fossils interbedded in the shale the formation has been proved to represent the Jurassic. The strike is north-west, with the dip N.E. 30°-40° in the north-eastern part at the Ma-chia-kou colliery, while in the south-western part, at the Huo-shih-ling colliery, it is west-north-west, dip S.S.W. 20°-30°.

The Huo-shih-ling colliery. Two coal-seams are known to occur, though they have not yet been closely examined. The upper seam is only one to two feet thick and is not important. The lower seam, lying about 200 feet below the upper, is often variable in its thickness, being ten feet where thickest. The coal reserves are small, being estimated to be less than 1,000,000 tons. The coal is of the non-caking bituminous variety, the results of technical analyses being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal. p.	B.T.U.	Class
15.79	32.43	51.78	7.75	0.96	5,162c	9,292	C
12.78	34.86	52.36	5.22	1.11	4,790	8,622	C

The Ma-chia-kou colliery. There is no outcrop that can be examined at present, but it is said that one thick coal-seam was formerly worked. The coal is similar to that of the Huo-shih-ling colliery.

Wu-lung-t'un Coal-Field

The Wu-lung-t'un coal-field, also known as the Chiao-ho or La-fa-ho coal-field, is situated about 130 km. east-south-east of Chi-lin or 13 km. east-south-east of Chiao-ho-chieh. It was opened about thirty years ago, and yields from forty to sixty tons a day. The total amount raised since its opening has been estimated to be 122,000 tons. It covers a hilly terrain, trending north-south. The coal-bearing formation is considered to represent the Jurassic and consists of shale and sandstone. The strike is N. 10° W., dipping W. 10°. The thickness of the coal-seam is about 6.5 feet with thin partings, the true thickness of the coal thus diminishing to 5.5 to 6 feet. The area underlain by coal is not large, the coal reserves being estimated at about 5,000,000 tons. The coal belongs to the bituminous variety and is non-caking. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.
10.11	25.95	45.96	17.98	0.44	1.408	5,198c	9,356

OTHER COAL-FIELDS

Coal-fields in the Kirin (Chi-lin) district. The Kang-yao coal-field is situated about 65 km. north-north-east of Kirin. It is said that the mine was opened about a hundred years ago, and at present it yields nearly 10,000 tons a year. Nine coal-seams are said to exist, the fourth, which is the best in quality as well as the thickest, is the one now worked.

In Chu-chia-ling about 20 km. east-north-east of Kirin, and at Wu-chia-shao, lying to the south-east of Kirin, coal is known to occur.

Coal-fields in the Ning-ku-t'a district. The Wu-hu-lin coal-field is situated about 100 km. north-east of Ning-ku-t'a. The coal-bearing formation represents the Jurassic, and one coal-seam, two to three feet thick, is said to be interbedded in the formation. The daily output of the Hsiao-pei-kou colliery at present is nearly fifteen tons.

Coal is said to be found in the villages of Yang-shu-lin-tzŭ and Fo-yeh-kou, situated about 23 km. south-east of Ning-ku-t'a. In the latter locality an area 9 km. long and 2 km. wide contains coal-seams which have not yet been exploited.

Coal-fields in the Chü-tzŭ-chieh district. The Lao-t'ou-êrh-kou coal-field is situated about 24 km. west of Chü-tzŭ-chieh. The coal-bearing formation consists of alternating strata of sandstone and shale and is said to represent the Jurassic. The strike is N. 10° E., dipping E. 40°-45°. Only one coal-seam is known, 2.5 to 4 feet thick; however, two or three coal-seams are said to lie far below. As the area now known is quite limited in extent, the amount of coal is probably small. The result of a technical analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal. p.	B.T.U.
8.96	26.50	56.23	8.31	0.47	1.375	5,841c	10,514

The Chuan-hsin-hu and T'u-shan-tzŭ coal-fields, lying adjacent to each other near a hill, are situated about 70 km. south-west of Chü-tzŭ-chieh. There is one coal-seam which has a thickness of five to seven feet. It was formerly worked, but the quality is rather inferior.

In Kang-yao-kou, north of Chü-tzŭ-chieh, a thin coal seam, one to two feet thick, is found.

Other scattered coal-fields. In Hsiao-ying-tzŭ, Hsih-t'ou-shao, Kao-têngsh'ang and Hsi-kou-k'ou along the Ta-sha-ho, south of Tun-hua and south-east of K'uan-chieh, coal is known to occur. Thick sandstone with shale dips almost east with an angle of 30°-40°. One seam about two feet in thickness is known.

Tsêng-shan-tung is situated about 13 km. west of Hoi-ryöng in Corea. There is one coal-seam seven feet thick, the quality of which is good. Hung-shan-tung is situated about 10 km. south-west of Hoi-ryöng, or about 4 km. south-west of the Tsêng-shan-tung. One coal-seam found there is nearly six feet thick. It is said that the coal-seams of the above two localities are parts of the same continuous bed. The coal-seam found in Pai-t'u-tung, which lies about 4 km. west of Tsêng-shan-tung beyond a hill, is quite similar to that in Tsêng-shan-tung.

Some of the following localities, where coal is known to occur, were formerly worked but are now abandoned:

Cha-tzŭ-wo, about 28 km. south of Nung-an-hsien; Mo-li-ch'ing, about 12 km. north-west of Yi-t'ung-chou; Hsing-shui-ch'üan-tzŭ at the south of Ch'ang-ch'un; Kung-tung-tzŭ, south-south-east of Ch'ang-ch'un; Hai-ch'ing-kou on the west of the Wu-lung-t'un coal-field; Sung-shan-chieh, east of Kirin; Na-êrh-hung-shan, about 265 km. south-south-east of Kirin; and Ta-huang-kou about 30 km. south of Tun-hua.

Hei-lung-kiang-shêng

In this province there are numerous coal-fields, or at least it is reported that coal occurs throughout the province. However, no reliable information about these fields is available, and it is therefore impossible to describe them or even to give their exact localities. Other localities, which I have indicated on the annexed map, are the following:

Cha-han-ao-la, where coal was once worked. It lies to the south-west of Man-chou-li station, the distance being said to be between 20 km. and 40 km. It is said that the coal-field covers a large area, of which the south-eastern part, about 3 km. long, is the best. One coal-seam is said to have been discovered in 1910. It strikes north-south. The coal is eight to ten feet thick and lies about thirty feet below the surface. It is of the bituminous variety.

The Cha-lei-no-êrh coal-field lies south of Cha-lei-no-êrh station, and a concession there was granted to the Russian company in 1901. Since then three shafts have been sunk and a fourth is now being opened. The daily yield of coal at present is 700 to 800 tons, and when the production from the fourth pit is added it will be increased to 1,500 tons a day without difficulty. The dip of the coal-bearing formation is said to be S.E. 10°. There are two known coal-seams, the upper being 25 (?) feet thick and the lower 4.5 feet. The coal is of the bituminous variety and is non-caking and brittle. The results of technical analyses of it are as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.
2.63	45.97	43.60	7.80	0.25
10.46	38.13	40.71	10.70	0.20

In the environs of Mên-t'ou-ho, about 200 km. south of Hu-lun-pei-êrh, coal is said to occur. The Kan-ho coal-field lies south of Mo-êrh-ken. It is said that the coal raised since its opening in 1904 amounts to about 26,000 tons, but owing to difficulties of transportation it is now intended to construct a railway to the bank of the Nên-ho.

The coal found in Ta-p'ing-shan, north-west of Tsitsihar, is of good quality and abundant.

Coal at Wu-tao-ling-tzŭ, about 7 km. west of Kan-ching-tzŭ-t'ai, is worked on a small scale.

Coal found about 13 km. south of Chêng-chi-ssŭ-han, is worked on a small scale.

Coal in Ching-jin-shêng-chên, about 65 km. north-west of Tsitsihar, is of good quality and occurs in a nearly horizontal bed.

Coal in Sung-shu-kou, about 20 km. north of Ai-hun, is of good quality.

In Yü-ch'ing-hsien coal is known to occur in several places. The Ma-an-shan coal-field lies at the northern and southern foot of Mount Chin-shêng-shan, which is about 100 km. east of Yü-ch'ing-hsien. It was opened in 1888, at the southern foot and afterward at the northern foot of the mountain. Owing to difficulties of transportation mining has been abandoned. The coal is of the anthracite variety.

THE COAL RESOURCES OF JAPAN

BY

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Director of the Imperial Geological Survey of Japan

(*With 4 maps in the Atlas and 30 figures in the text*)

CONTENTS

I—INTRODUCTION

Coal is by far the most important mineral product of Japan, but the rapid growth of the coal-mining industry is a feature of quite recent years. Up to thirty years ago, coal was mined by old and primitive methods and the output was, consequently, insignificant. Although coal-mining in Japan may be traced back to tolerably remote times, the surveying of the coal-fields and of other mineral districts, geologically, was long neglected, and it was owing to the recent development of the mining industry that a detailed survey of the country was instituted; even yet the exploration and examination of the coal-fields have not been thorough, and it is, in many cases, impossible to calculate the actual amount of the coal reserves.

After the Restoration of Meiji (1868) a systematic geological survey was inaugurated. It was commenced in 1872 by the local Government of Hokkaidō, under the superintendence of Mr. B. J. Lyman. For four years the survey was carried on in important coal-fields in Hokkaidō, then an uninhabited district, difficult of access. In 1889, the Imperial Geological Survey was established, to carry out a systematic geological survey of the country. Since then the geological surveying of the more important coal-fields has been undertaken by the geologists of the Survey. The Chikuhō and Ōmine coal-fields, and others, were surveyed by Mr. T. Suzuki; the Miike and Jōban coal-fields by Mr. S. Ōtsuka; the Amakusa coal-field by Mr. N. Kanehara; the Onoda coal-field by Mr. S. Noda; the Karatsu and Sasebo coal-fields by Mr. Y. Ōtsuki, etc. Many years have elapsed since the greater part of the first survey was finished, and it will be necessary to resurvey in order to gain a more thorough knowledge of the geological structure, now rendered so important by the development of modern mining, and to obtain accurate data for estimating the actual amount of coal in each portion of the fields. The Survey is now carrying out this work in Hokkaidō, and a detailed survey of the Uryū-rumoi coal-field has been undertaken by Mr. S. Yamane. Recently the Ishikari coal-fields were surveyed by Mr. Y. Ōinouye, the geologist of the Sapporo Mine Inspection Office, to whom I am indebted for the calculation of the amount of coal in that district. In 1903 Messrs. C. Kido and S. Matsuda, the geologists of the Bureau of Mines, undertook a detailed survey of the Chikuhō coal-field, though afterwards a part was specially surveyed by the engineers of the collieries. After the annexation of Taiwan, the coal-field there attracted attention and a survey of it was made thirteen years ago. Recently a resurvey was undertaken, and it is now in progress, under the superintendence of Mr. K. Fukutomi, the inspector of the Taiwan Government, to whom I am indebted for valuable assistance in calculating the amount of coal in Taiwan. During the years 1906, 1907, and 1908 the coal-fields of Karafuto were surveyed, under the superintendence of Mr. S. Kawasaki, the geologist of the Karafuto Government, by Mr. K. Nishiwada, the geologist of the Bureau of Mines, and Mr. Y. Ōtsuki, the geologist of the Survey.

The results of their survey have been published in the bulletins and explanatory texts of the Survey and also in other publications of the Government or of societies, some of which are difficult of access.

These surveys have not been complete enough to make it possible to calculate the actual reserves of coal in Japan, except in the case of a few districts; but they afford data for a fairly accurate conception of the geological structure of the coal-fields and serve as a basis from which to calculate the probable amount of coal. Some of the coal-fields were surveyed long ago, while others were only roughly measured. The coal-fields of Honshū, Kyūshū and Shikoku attracted attention thirty or forty years ago, so that there is scarcely a possibility of discovering large, new fields in that region. The object of future study will, therefore, be to ascertain the existence of coal under the deeper cover, where no detailed exploitation or examination has yet been carried out, and to make clear the mode of its occurrence. As for Karafuto and Hokkaidō, one part of the coal-fields has been surveyed roughly, while the other part remains untouched and there is great probability that new coal-fields may be found there, or that concealed continuations of known seams will be discovered.

I am indebted to the Director of the Bureau of Mines and to the officials of the Mine Inspection Offices, who kindly permitted me to make use of the maps and sections of the collieries in the calculation of the amount of coal; also to the directors of some mining companies, who kindly furnished me valuable information.

II—THE DEVELOPMENT OF THE COAL-MINING INDUSTRY

There is no authentic record of the early history of the coal-mining industry in Japan; but it is said that in Kyūshū, coal has been mined for local domestic use for several hundred years. Before the Restoration of Meiji, coal was only used as a substitute for wood and charcoal for household use in the country districts, as fuel for salt pans, and for export or for the coaling of foreign steamers. The industry at that time was carried on in a very primitive way and the production was insignificant, though large coal-fields, such as those of Chikuhō, Miike, Karatsu and Takashima in Kyūshū, Jōban in Honshū and Kayanuma and Shiranuka in Hokkaidō, had been opened. After the Restoration of Meiji came the opportunity for development, and in the year of the Restoration the first shaft in Japan was sunk at the Takashima colliery by a foreign engineer. Six years later the Takashima and Miike collieries, in which various improvements had been introduced by foreign engineers, were transferrred to the Imperial Government. After that time various attempts to promote coal-mining were made, especially in the Chikuhō coal-field, but there was no remarkable development, merely a gradual increase in production year by year. The five years from 1886 to 1893 form an epoch in the coal-mining industry in Japan; large mining plants were set up in several coal-fields, railways for transportation were planned and harbour improvements were gradually introduced. After the Sino-Japanese war, mining became very active, and the production increased very rapidly during the next year. The Russo-Japanese war also forms an epoch in the coal-mining industry. In 1906, the year next after that war, coal was mined with extreme activity and various improvements and large mining plants were introduced, under competent management, by collieries in the larger coal-fields, so that the production greatly increased. This rapid increase in the production in recent years has been caused by the sudden growth of industries, the development of means of communication and the expansion of the export trade.

III—THE PRODUCTION OF COAL

The early records of the production of coal are not now accessible; but there is no doubt that the production before the Restoration of Meiji was insignificant. Seven years after the Restoration, statistics of Japanese mineral production were first tabulated by the Government. The average yearly production for each five years' period since 1874 and for each of the last five years was as follows:

1874	209,515 tons
1879	864,218 "
1884	1,148,829 "
1889	2,407,245 "
1894	4,305,426 "
1899	6,804,279 "
1904	10,854,726 "
1907	14,010,074 "
1908	15,062,613 "
1909	15,330,650 "
1910	16,012,998 "
1911	17,887,580 "

Since 1895 the Chikuhō coal-field has contributed over one-half of the total production, and the coal-fields of Miike, Jōban, Ishikari and Karatsu from ten to fifteen per cent. each; the other minor coal-fields having yielded only a small amount. The coal produced in these fields is mostly bituminous, semi-anthracite and lignite furnishing only about one or one and a half per cent. each, of the total production.

IV—THE IMPORT AND EXPORT OF COAL

The import of coal into Japan has been small, save in a few exceptional years, and will be small in future, though imports from China will probably increase. It must not be forgotten, however, that this gradual increase in the amount of coal imported is due to the general development of the coal-mining industry along the Pacific coast, especially in China. The average yearly import of coal, for each five year period since 1869 and for each of the last five years, has been as follows:

1869	7,169 tons
1874	9,005 "
1879	25,705 "
1884	4,907 "
1889	7,297 "
1894	40,739 "
1899	58,193 "
1904	631,725 "
1907	35,855 "
1908	63,406 "
1909	133,791 "
1910	195,855 "
1911	297,502 "

Some coal was exported before the Restoration of Meiji, though the amount was insignificant; in the year of the Restoration (1868) it was only 17,000 tons, but the increase in succeeding years was comparatively rapid, and in 1888 it reached over one million tons. Owing to the rapid development of coal-mining, the export trade greatly increased, and, eight years later, in the year next after the Sino-Japanese war, it exceeded two million tons, and in another four years was over three million tons. The trade culminated in 1903, when the export amounted to 3,502,081 tons. In 1905 and 1906 there was a great decrease, on account of general depression in the mining industries, the amounts exported being 2,574,061 tons and 2,501,961 tons, respectively. Since 1900, the export has been almost stationary, in spite of the increasing demand for coal in the oriental market. This seems to be due mainly to the development of coal-mining in neighbouring countries. The average yearly export for each period of five years since 1869 and for each of the last five years, was as follows:

1869	33,750	tons
1874	118,516	"
1879	197,328	"
1884	527,630	"
1889	1,071,887	"
1894	1,729,628	"
1899	2,553,237	"
1904	2,944,460	"
1907	3,018,882	"
1908	2,960,400	"
1909	2,927,946	"
1910	2,874,309	"
1911	3,354,280	"

The coal exported is exclusively bituminous, of the higher grades. The consumption of coal in Japan has been calculated to be as follows:

1874	100,004	tons
1879	692,595	"
1884	626,106	"
1889	1,342,655	"
1894	2,616,537	"
1899	4,309,235	"
1904	8,541,991	"
1907	11,027,049	"
1908	12,165,619	"
1909	12,536,495	"
1910	13,334,544	"
1911	14,830,802	"

V—THE CENTRE OF THE COAL-MINING INDUSTRY

The centre of the coal-mining industry is in northern Kyūshū, where the coal-fields contain good coal, and furnish over two-thirds of the total production. Recently, the coal-fields of Hokkaidō have attracted attention and large mining plants are now projected for several new fields, while at the same time efforts are being made to improve transportation facilities by land and sea. Chikuhō, the richest and most important coal-field, is now at its maximum development, and the Miike coal-field, with the completion of its harbour, is rapidly increasing its output, ranking second in production, though still far below the Chikuhō field. The greatest future development, it is expected, will take place in Hokkaidō. Only about one and a half million tons of coal have been raised there annually, in recent years, as many productive coal-fields have not yet been opened, owing to the lack of railway transportation and harbours suitable for shipment. In the Jōban coal-field and in the coal-fields of the province of Hizen, borings are necessary to determine the mode of occurrence of deeply covered coal, upon which the future of mining there depends. Owing to the cold climate, which makes shipment difficult for from four to six months in the year, and to the lack of transportation facilities, the coal mines in Karafuto will, in the near future, find it very difficult to compete with those in Hokkaidō and Kyūshū. The other coal-fields are small in area and contain coal of inferior quality; they will, therefore, not affect the coal-mining industry in Japan. Under these circumstances the districts near Wakamatsu and Moji, where the coal of the Chikuhō coal-field is shipped, have rapidly increased both in population and wealth. Other large shipping ports in Kyūshū are Karatsu, Nagasaki, and Miike. The coal in Hokkaidō is chiefly transported to Otaru and Mororan for shipment. The Jōban coal-field is connected by railway with Tōkyō, and most of its coal is taken to that port.

VI—THE GEOGRAPHICAL AND GEOLOGICAL DISTRIBUTION OF COAL

(*Plate 1*)

Geographical Distribution

Coal occurs everywhere throughout Japan, from the northern end of Karafuto to southernmost Taiwan. Northern Kyūshū, the centre of the coal-mining industry, embraces extensive and important productive coal-fields, such as Chikuhō, Miike, Karatsu and Takashima, which are very favourably situated for the shipment of coal, being near the coast and connected with it by short railways. Central Hokkaidō also has large coal-fields, in which gradual development is taking place and where transportation facilities are being rapidly improved. Another important coal-field lies near the western coast of Hokkaidō, and there are several unexplored coal-fields in other parts of the island. The coal-fields of northern Kyūshū have long had the benefit of investments by large capitalists and have commanded the services of eminent mining engineers. The coal-fields of Hokkaidō, on the contrary, have been neglected; until recent years they have been worked by only one large company, and a few smaller ones, or by private individuals, and the capital invested in them is small compared with that invested in Kyūshū. This lack of interest is due mainly to the absence of transportation facilities, and to the great distance of the field from the market. Moreover, the region of the coal-fields is uninhabited, is covered by thick forests and has not yet been thoroughly examined geologically. Very recently conditions have changed somewhat and more attention is being paid to these fields by experienced coal miners and capitalists.

Considering the area of the coal-fields, the thickness of the seams and the suitability of the coal for fuel, the coal-mining industry of Hokkaidō has a future of great promise and it is probable that its product will soon come into competition with that of Kyūshū.

In area Honshū ranks first among the coal-fields, extending, as it does, from the northern end of north-eastern Honshū to the western end of Chūgoku; but in quantity and quality of coal, it ranks far below Kyūshū and Hokkaidō. The Jōban coal-field in north-eastern Honshū, on the Pacific coast, is first in importance, and the Onoda coal-field in the south-eastern part of Honshū, on the Inland Sea, is next. Lying near a market and being easily accessible by land and sea, they have long been worked.

Shikoku has no well-known coal-fields and none that is worked at present, only thin seams of inferior quality occurring there.

Karafuto, especially in the central part, is said to contain considerable areas underlain by coal, but for the same reasons as in Hokkaidō and from climatic disadvantages, the development of the field is difficult. Mining was tried for two years by the local Government, but is suspended at present.

In Taiwan the one productive coal-field is found in the northern part. Though the coal-seams are relatively thin, the coal, which is of rather inferior quality, has long been mined on a small scale, as transportation is very convenient and no other coal is found in the neighbourhood. The distribution of the coal is shown in the map (Plate 1 in the Atlas).

Geological Distribution

Coal is widely distributed throughout the Empire in the younger geological formations. The oldest coal occurs in the Mesozoic. The Triassic in the province of Bitchū and the Rhætic in the province of Nagato are known to contain coal. The Nagato coal, occurring in a very convenient position near the sea-coast, is being worked at present, and was mined years ago on a small scale. The Mesozoic—probably Jurassic—of Chūgoku and of the provinces of Echizen, Tamba, Tango and Nagato, in central Japan, also contains coal, though of less importance. The coal is mined here and there on a small scale, even the largest coal-field, Ōmine, in the province of Nagato, yielding only a fair amount of coal. The coal in the Cretaceous of middle Shikoku is inferior in quality and unimportant. The geological age of the Amakusa coal-field, in the province of Higo, has not been determined, but, as it is generally considered to be Cretaceous, I so refer it. The Kumano coal-field has long been considered to represent the Cretaceous, but Messrs. H. Hirose and Y. Ōtsuki, by a study of its fossils, have proved the formation to be of Tertiary age. Generally the coal-bearing beds of the Mesozoic are found scattered in rather small patches on the older complex in central Honshū, Chūgoku, Shikoku and Kyūshū, these patches being restricted in their distribution, except in a few cases.

The coal-bearing Mesozoic consists of shale and sandstone with conglomerate. Repeated foldings or severe contortions and the frequent occurrence of faults testify to the severe disturbance which the formation has suffered. The formation has also been disrupted in various places by the intrusion of igneous rocks, accompanied by alteration of the coal.

The richest and most important coal deposits are found in the Tertiary, in the lower series of which the coal is of much greater importance than in the upper.

The lower series is composed of shale, sandstone and conglomerate, sometimes with tuff, and contains a large amount of coal. It has been subjected to tectonic disturbance, foldings and faults, though these are not so severe as in the Mesozoic. The intrusions of volcanic rocks are many in some places, and there the coal has suffered contact metamorphism. The coal-fields of Kyūshū and Hokkaidō are the most extensive and valuable. The Jōban coal-field ranks next, and the Taiwan and the Onoda coal-fields in the province of Nagato, third. The coal-fields of Karafuto are considered to be extensive, though they have not yet been opened. The correlation of the coal-bearing formations of different districts has not yet been absolutely determined, though the formations themselves are commonly accepted as belonging to the Miocene.

Recently Prof. M. Yokoyama announced that one fossil, found in the Miike coal-field, represents the Eocene. The lowest coal-bearing bed in Hokkaidō and Karafuto, lies very near the Cretaceous, with a conglomerate layer between them, no unconformity being observed between the two formations. From these facts the inference seems to be that the formation represents the oldest Tertiary or even the uppermost Cretaceous.

In Honshū, Kyūshū and Shikoku, the coal-bearing formation lies directly and unconformably on the much older complex, so that their stratigraphical relation to the older rocks is of little value in fixing their age. Though fossil flora and fauna have been found in the formation, they are not sufficient to determine its geological age; that they tend, however, to prove that the series represents the Miocene is now generally accepted. In the present state of our knowledge it is impossible to correlate the coal-seams of the different coal-fields which are considered to be of the same age and to determine in that way the geological age of the formation; therefore, until further investigation shall have proved accurately the horizon of the coal-bearing series, I accept the current theory and refer all these to the Miocene.

The upper series is composed of loose sandstone and shale with conglomerate and tuff, or, in other words, of layers of clay, sand and pebbles with volcanic ash. It is gently undulating and but little disturbed, and is affected by small faults only. The productive coal-fields lie in north-eastern Honshū and central Japan, and include: the field along the Mogami-gawa, in the province of Uzen; that in the environs of Sendai, in the province of Rikuzen; the Nōbi field, in the province of Owari and Mino, and others. The geological age of the upper series is not certainly known, but the stratigraphical and petrographical relations of the strata, together with faunal evidence, tend to prove that the series belongs to the Pliocene.

As to the geological horizons of some of the coal-fields of less importance, it has not been determined yet whether they belong to the lower or the upper series. In most cases the relation of the upper series to surrounding formations is quite unknown and no fossil evidence bearing on its age has yet been discovered.

Thus it will appear that I refer to the Miocene the important coals upon which the coal-mining industry of Japan depends. The Mesozoic as well as the Pliocene coal is, in quality and quantity, far below that of the Miocene and is worked only on a small scale.

VII—THE QUALITY AND USE OF COAL

The coals of Japan are of three kinds: semi-anthracite, bituminous and lignite. The semi-anthracite occurs mostly in the Mesozoic, very rarely in the Tertiary. The natural coke and anthracite are local variations, resulting from contact metamorphism, and are commonly used as fuel for limekilns, as material for briquettes, used especially by warships, also for domestic use and other purposes. The coal which occurs in the Miocene is mostly bituminous, while the Pliocene coal is exclusively lignite. The Miocene coal is chiefly used by manufactories, steamers, and railways. What is known in the market as Japanese coal is bituminous coal of this kind. The lignite is used locally as fuel for small factories, chiefly in the silk or cotton industries, also for salt pans, and as a substitute for wood and charcoal in domestic use.

VIII—THE AMOUNT OF COAL

Except in a few cases, the existence of deep seams, under a heavy cover, has not yet been proved by borings or in any other way, so that it is not possible, in most cases, to tell the actual reserves of coal. However, in cases where few or no borings have been made, but in which the outcrops of coal-seams, more than 2.5 feet in thickness, have actually been examined for some distance, the coal, to depths of from 300 to 500 feet below the surface level, according to the conditions of geological structure, has been calculated as actual reserves. The figures given below for the actual reserves are very conservative in every case. As the geological survey of the coal-fields has been only roughly carried out, the estimate of the amount of coal in most of the fields is based on incomplete data or deduced from the geological structure of contiguous areas. The depth is limited to 4,000 feet below the surface level, but, for geological reasons, a depth far less than that, say 1,000 to 2,000 feet, has often been used in the estimate. The coal reserves thus calculated are as follows:

ACTUAL RESERVE

Coal-Field	Thickness	Area	Class of Coal	Metric Tons	
Mesozoic	2–13 ft.	1.4 sq.km.	..	4,500,000	
Ōmine	3–12 "	0.4 "	A_2	....	1,000,000
Amakusa	4–6 "	1.4 "	A_2	....	3,500,000
Tertiary	1–170 "	156.1 "	..	964,300,000	
1. Karafuto	3–70 "	3 "	..	17,500,000	
Central	3–27 "	3 "	C	17,500,000	
Northern	3–6 "	1.5 "	..	....	3,500,000
Middle	22–27 "	1.5 "	..	....	14,000,000

ACTUAL RESERVE—*Continued*

Coal-Field	Thickness	Area	Class of Coal	Metric Tons	
2. Hokkaidō	2–170 ft.	34 sq. km.	..	335,800,000	
Ishikari	6–170 "	25.3 "	C	307,600,000	
Ashpet	30–115 "	5 "	..	86,000,000	
(1)	100–115 "	0.5 "	..	....	21,000,000
(2)	30–65 "	4.5 "	..	....	65,000,000
Otaushinai	37–170 "	1.4 "	..	63,000,000	
(1)	170 "	0.5 "	..	....	33,000,000
(2)	100–105 "	0.6 ""	..	....	25,000,000
(3)	37–47 "	0.3 "	..	....	5,000,000
Naie-bibai	10–115 "	1.2 "	..	23,800,000	
(1)	110–115 "	0.4 "	..	....	18,000,000
(2)	20–25 "	0.5 "	..	....	4,500,000
(3)	10–12 "	0.3 "	..	....	1,300,000
Ikushumpet	10–35 "	3.9 "	..	19,800,000	
(1)	30–35 "	0.3 "	..	....	3,800,000
(2)	10–13 "	3.6 "	..	....	16,000,000
Poronai	9–24 "	5.3 "	..	30,000,000	
(1)	18–24 "	2.3 "	..	....	18,000,000
(2)	9–13 "	3 "	..	....	12,000,000
Yūparo	16–35 "	8.5 "	..	85,000,000	
(1)	28–35 "	5.5 "	..	....	65,000,000
(2)	16–18 "	3 "	..	....	20,000,000
Kayanuma	20–22 "	0.8 "	C		6,500,000
Uryū-rumoi	5–58 "	1.9 "	C	13,200,000	
U. Poronit	30–58 "	0.4 "	..	7,000,000	
(1)	50–58 "	0.2 "	..	....	4,200,000
(2)	30–36 "	0.2 "	..	....	2,800,000
L. Poronit	7–25 "	0.5 "	..	2,500,000	
(1)	7–10 "	0.4 "	..	....	1,500,000
(2)	20–25 "	0.1 "	..	....	1,000,000
Rurum	15–17 "	0.2 "	..	....	1,300,000
Opirash	4–15 "	0.3 "	..	....	1,400,000
Ōwada	5 "	0.5 "	..	....	1,000,000
Kushiro	2–5 "	6 "	..	8,500,000	
Bep.-Os	2–3 "	3.3 "	..	....	3,000,000
Harutori	5 "	2.7 "	..	....	5,500,000
3. Honshū	1.5–14 "	31.9 "	..	69,500,000	
Jōban	2–14 "	14 "	D_1	43,500,000	
Northern	2–2.5 "	1 "	..	....	1,000,000
Middle	10–14 "	7 "	..	....	34,000,000
Southern	3–5 "	6 "	..	....	8,500,000
Aburato	4–6 "	0.5 "	C	....	1,000,000

Actual Reserve—*Continued*

Coal-Field	Thickness	Area	Class of Coal	Metric Tons	
Nōbi	2.5–4 ft.	11 sq. km.	D_2	....	13,000,000
Kumano	2–3 "	1 "	A_1	....	1,000,000
Onoda	3–12 "	4.4 "	D_1	10,000,000	
Funaki	3–5 "	1.5 "	..	....	2,500,000
Onoda	3–5 "	0.5 "	..	....	1,000,000
Ube	4–12 "	2.4 "	..	6,500,000	
(1)	4–5 "	1.5 "	..	....	3,000,000
(2)	7–9 "	0.3 "	..	....	1,000,000
(3)	10–12 "	0.6 "	..	....	2,500,000
Matsuye	2.5 "	1 "	D_1	....	1,000,000
4. Kyūshū	3–50 "	87.2 "	..	541,500,000	
Chikuhō	4–33 "	62.2 "	C	405,500,000	
(1) Kokura	4–6 "	0.7 "	..	....	1,500,000
(2) Ongagawa	4–33 "	57 "	..	387,500,000	
Onga	10–18 "	6.5 "	..	....	33,000,000
Kurate-tagawa	4–25 "	32.7 "	..	141,000,000	
(1)	5–13 "	10 "	..	....	25,000,000
(2)	16–25 "	7.5 "	..	....	46,000,000
(3)	12–20 "	11 "	..	....	60,000,000
(4)	4–12 "	4.2 "	..	....	10,000,000
Kurate-kaho	8–33 "	8.4 "	..	144,000,000	
(1)	8–10 "	2 "	..	....	9,000,000
(2)	10–15 "	5.4 "	..	....	29,000,000
(3)	22–23 "	1.0 "	..	....	106,000,000
Kaho	12–32 "	9.4 "	..	69,500,000	
(1)	27–32 "	2 "	..	....	24,000,000
(2)	16–26 "	2.8 "	..	....	21,000,000
(3)	12–19 "	1.8 "	..	....	9,000,000
(4)	15–18 "	1.3 "	..	....	8,000,000
(5)	13–15 "	1.5 "	..	....	7,500,000
(3) Munakata	7–8 "	0.5 "	..	....	1,500,000
(4) Fukuoka	8–10 "	4 "	..	....	15,000,000
Miike	12–18 "	10 "	C	....	60,000,000
Karatsu	3–12 "	8 "	C	17,000,000	
(1)	6–12 "	5 "	..	....	13,000,000
(2)	3–4 "	3 "	..	....	4,000,000
Sakito	15–16 "	2.5 "	C	....	16,000,000
Matsushima	12–14 "	2 "	C	....	10,000,000
Takashima	15–50 "	2.5 "	C	33,000,000	
Takashima	37–50 "	1.5 "	..	....	25,000,000
Kōyagi	15–20 "	1 "	..	....	8,000,000
Totals	....	157.5 sq. km.	......	....	968,800,000

PROBABLE RESERVES

Coal-Field	Thickness	Area	Class of Coal	Metric Tons		Possible Reserve
Mesozoic....................	2–13 ft.	17.6 sq. km.	..	47,000,000	....	Moderate
Ōmine....................	3–12 "	6 "	A_2	19,000,000	....	Moderate
(1)....................	3–7 "	4 "	..	....	8,000,000	
(2)....................	12 "	2 "	..	....	11,000,000	
Amakusa................	4–6 "	8 "	A_2	....	15,000,000	Moderate
Ōno....................	11–13 "	1 "	C	....	5,000,000	Small
Umezako................	2–3 "	0.8 "	A_2	....	1,000,000	Small
Maizuru................	5–10 "	1.3 "	B_1	....	5,000,000	Small
Tsubuta................	8–10 "	0.5 "	A_1	....	2,000,000	Small
Other Coal-Fields.........	....	....	.....	....	....	Small
Tertiary....................	1–170 "	1613.2 "	..	6,955,200,000	....	Considerable
1. Karafuto............	3–70 "	174.5 "	..	1,345,000,000	....	Large
Central..............	3–40 "	132 "	C	885,000,000	....	Large
Northern (1).......	3–6 "	40 "	..	....	70,000,000	
Middle (2)......	22–27 "	34 "	..	....	320,000,000	
(3)......	6–12 "	18 "	..	....	45,000,000	
Southern (4)......	25–40 "	40 "	..	....	450,000,000	
Notoro..............	10–70 "	42.5 "	C	460,000,000	....	Large
(1)................	10–15 "	30 "	..	....	167,000,000	
(2)................	35–40 "	2.5 "	..	....	35,000,000	
(3)................	65–70 "	10 "	..	....	258,000,000	
Other Coal-Fields.....	....	....	.....	....	....	Large
2. Hokkaidō.............	2–170 "	271.5 "	..	2,339,200,000	....	Large
Ishikari..............	6–170 "	145.4 "	C	1,791,500,000	....	Large
Ashpet............	30–115 "	50.8 "	..	968,000,000		
(1)..............	100–115 "	5.8 "	..	....	258,000,000	
(2)..............	30–65 "	45 "	..	....	710,000,000	
Otaushinai.........	37–170 "	3 "	..	106,000,000		
(1)..............	170 "	0.4 "	..	....	26,000,000	
(2)..............	100–105 "	1.5 "	..	....	62,000,000	
(3)..............	37–47 "	1.1 "	..	....	18,000,000	
Naie-bibai.........	10–115 "	9.8 "	..	146,500,000		
(1)..............	110–115 "	1.8 "	..	....	80,000,000	
(2)..............	20–25 "	6.5 "	..	....	60,000,000	
(3)..............	10–12 "	1.5 "	..	....	6,500,000	
Ikushumpet........	10–35 "	6.8 "	..	50,000,000		
(1)..............	30–35 "	2.3 "	..	....	30,000,000	
(2)..............	10–13 "	4.5 "	..	....	20,000,000	
Poronai............	9–24 "	28 "	..	151,000,000		
(1)..............	18–24 "	11 "	..	....	86,000,000	
(2)..............	9–13 "	17 "	..	....	65,000,000	

Probable Reserves—*Continued*

Coal-Field	Thickness	Area	Class of Coal	Metric Tons		Possible Reserve
Yūparo	16–35 ft.	37 sq. km.	..	345,000,000		
(1)	28–35 "	20 "	..	...	230,000,000	
(2)	16–19 "	17 "	..	...	115,000,000	
Pōpet	6–8 "	10 "	..	...	25,000,000	
Kayanuma	20–22 "	2.5 "	C	...	25,000,000	Moderate
Uryū-rumoi	5–58 "	36 "	C	250,000,000	...	Large
U. Poronit	30–58 "	6 "	..	105,000,000		
(1)	50–58 "	2.5 "	..	...	55,000,000	
(2)	30–36 "	3.5 "	..	...	50,000,000	
L. Poronit	7–25 "	9.5 "	..	46,000,000		
(1)	7–10 "	7.5 "	..	...	28,000,000	
(2)	20–25 "	2 "	..	...	18,000,000	
Rurum	15–17 "	8 "	..	...	50,000,000	
Opirash	4–15 "	10.5 "	..	45,000,000		
(1)	4–6 "	4.2 "	..	...	10,000,000	
(2)	13–15 "	6.3 "	..	...	35,000,000	
Ōwada	5 "	2 "	..	...	4,000,000	
Haporo	5–6.5 "	15 "	D_1	...	35,000,000	Large
Horonobu	6–36 "	24 "	D_1	170,000,000	...	Large
(1)	30–36 "	5 "	..	...	70,000,000	
(2)	13–18 "	15 "	..	...	90,000,000	
(3)	6–7 "	4 "	..	...	10,000,000	
Sōya	12–25 "	25 "	D_1	...	13,000,000	Large
Kushiro	2–5 "	12.1 "	C	15,700,000	...	Moderate
Komb	3 "	0.6 "	..	...	700,000	
Bep-Ōs	2–3 "	6.5 "	..	...	5,000,000	
Harutori	5 "	5 "	..	...	10,000,000	
Shitakara	5 "	2 "	C	...	4,000,000	Moderate
Shakupet	6 "	2 "	..	...	5,000,000	Large
Uraporo	18 "	2 "	..	...	15,000,000	Large
Hitaka	6–7 "	5.5 "	D_1	...	15,000,000	Large
Other Coal-Fields	...	...	...	...	...	Large
3. Honshū	1.5–14 "	257.9 "	..	512,000,000	...	Large
Jōban	2–14 "	122 "	D_1	306,000,000	...	Large
Northern	2–2.5 "	18 "	..	...	17,000,000	
Middle	10–14 "	45 "	..	...	200,000,000	
Southern	3–5 "	59 "	..	...	89,000,000	
Aburato	4–6 "	5 "	C	...	10,000,000	Moderate
Nōbi	2.5–4 "	26 "	D_2	...	30,000,000	Moderate
Kumano	2–3 "	4 "	A_1	...	4,000,000	Moderate
Onoda	3–12 "	37.5 "	D_1	85,500,000	...	Moderate
Funaki	3–5 "	14 "	..	...	25,000,000	

Probable Reserves—*Continued*

Coal-Field	Thickness	Area	Class of Coal	Metric Tons		Possible Reserve
Onoda	3–5 ft.	10 sq. km.	..	....	15,000,000	
Ube	4–12 "	13.5 "	..	45,500,000		
(1)	4–5 "	2 "	..	....	3,500,000	
(2)	7–9 "	10 "	..	....	35,000,000	
(3)	10–12 "	1.5 "	..	....	7,000,000	
Kuji	3–3.5 "	2.5 "	D_2	....	3,500,000	Small
Kado	4 "	2.5 "	D_2	....	4,000,000	Small
Monji	2–2.5 "	4 "	D_2	....	3,500,000	Small
Sanbongi	2–4 "	2 "	D_2	....	2,500,000	Small
Sendai	2–2.5"	5 "	D_2	....	4,000,000	Small
Nanukaichi	8–9 "	2.5 "	A_1	....	9,500,000	Small
Ōanigawa	6–7 "	2 "	A_2, B_2	....	6,000,000	Small
Mogamigawa	2.5–3 "	17 "	D_2	....	20,000,000	Moderate
Shirakawa	2–2.5 "	7.5 "	D_1	....	6,000,000	Moderate
Nishijō	2–2.5 "	4.5 "	C	....	4,000,000	Moderate
Takasaki	1.5 "	7 "	D_2	....	4,500,000	Moderate
Suzuka	2–4 "	3 "	D_1, D_2	....	4,500,000	Moderate
Matsuye	2.5 "	3 "	D_1	....	3,000,000	Small
Okayama	4 "	0.9 "	D_2	....	1,500,000	Small
Other Coal-Fields	....	....	..	....	....	Moderate
4. Kyūshū	3–50 "	539.3 "	..	2,374,000,000	....	Large
Chikuhō	4–33 "	220.3 "	C	1,255,000,000	....	Large
(1) Kokura	4–6 "	2.5 "	..	....	6,000,000	
(2) Ongagawa	4–33 "	209.3 "	..	1,217,500,000		
Onga	10–18 "	42.5 "	..	....	200,000,000	
Kuratetagawa	4–25 "	107.5 "	..	450,000,000		
(1)	5–13 "	68 "	..	....	230,000,000	
(2)	16–25 "	8 "	..	....	60,000,000	
(3)	12–20 "	20 "	..	....	110,000,000	
(4)	4–12 "	11.5 "	..	....	50,000,000	
Kuratekaho	8–33 "	50.5 "	..	429,000,000		
(1)	8–10 "	7 "	..	....	25,000,000	
(2)	10–15 "	20.5 "	..	....	114,000,000	
(3)	22–33 "	23 "	..	....	290,000,000	
Kaho	6–32 "	17.8 "	..	138,500,000		
(1)	27–32 "	3.5 "	..	....	42,000,000	
(2)	16–26 "	5 "	..	....	50,000,000	
(3)	12–19 "	3 "	..	....	20,000,000	
(4)	15–18 "	2 "	..	....	12,000,000	
(5)	13–15 "	1.5 "	..	....	7,500,000	
(6)	6–7 "	2.8 "	..	....	7,000,000	

PROBABLE RESERVES—*Continued*

Coal-Field	Thickness	Area	Class of Coal	Metric Tons		Possible Reserve
(3) Munakata	7–8 ft.	0.5 sq.km.	..	....	1,500,000	
(4) Fukuoka	8–10 "	8 "	..	....	30,000,000	
Miike	10–18 "	130 "	C	....	700,000,000	Large
Karatsu	3–12 "	53 "	C	112,000,000	....	Large
(1)	6–12 "	20 "	..	....	67,000,000	
(2)	3–4 "	33 "	..	....	45,000,000	
Sasebo	1.5–3 "	110 "	C	....	90,000,000	Moderate
Sakito	15–16 "	6.5 "	C	....	40,000,000	Moderate
Matsushima	12–14 "	5 "	C	....	28,000,000	Moderate
Takashima	15–50 "	11 "	C	146,000,000	....	Moderate
Takashima	37–50 "	7.5 "	..	....	121,000,000	
Kōyagi	15–20 "	3.5 "	..	....	25,000,000	
Yaeyama	2–4 "	3.5 "	C	....	3,000,000	Small
Other Coal-Fields	....	....	.....	....	....	Small
5. Taiwan	1–4 "	370 "	..	385,000,000	....	Large
Taiwan	1–4 "	370 "	C	385,000,000	....	Large
(1)	1–1.5 "	133 "	..	....	68,000,000	
(2)	2–4 "	237 "	..	....	317,000,000	
Totals	....	1630.8 sq. km.	......	....	7,002,200,000	Considerable

Besides the coal-seams tabulated above, there are numerous outcrops of coal 2.5 feet and over in thickness, the continuity of which has not yet been established. The amount of coal represented by them has not been included, since it is intended that the estimate of the coal resources should be as accurate as possible and safely conservative.

As the length of the different coal-seams often differs widely throughout the field, it is impossible to define the area underlain by them, considered as an aggregate. Therefore, to make clear the method used in the calculation, the area underlain by each seam, with its average thickness, should be stated, but, in order to avoid complicated details, I have here given the total amount of coal contained in groups of seams, obtained by calculating each of them, together with the average area underlain by the different coal-seams.

IX—CONCLUSION

The coal-mining industry of Japan depends upon the bituminous coal. The industry has been most prosperous in northern Kyūshū and the mines there will be the most important in the future. The total output of coal in Japan ranges from 15,000,000 to 20,000,000 tons a year, rivalling that of China and India in amount. The increasing demand for coal in oriental countries is promoting the rapid growth of the coal-mining industry. Japan will continue to export coal as in the past, and the question of coal competition in the oriental market is likely to become a highly interesting one.

Japan contains large coal reserves; and the figures given above, though they do not represent the whole amount of coal, but only that of known areas, show a sufficiently large reserve to meet not only her own increasing demand, but also that of the present oriental market. Inasmuch as the coal-mining industry of the circum-Pacific countries other than Japan is also being rapidly developed, serious competition will soon be encountered. The chief factors determining the prosperity of the industry are the area of the productive coal-fields, the number and thickness of the workable seams, the suitability of the coal for fuel, the ease with which it can be mined, and the proximity of markets. As the coal reserves of China can meet the total coal consumption of the world for several centuries, so those of Japan will satisfy the demand for coal in the circum-Pacific countries for many hundreds of years. The investigation of the coal supply in circum-Pacific countries is highly interesting and necessary from the scientific as well as the economic point of view.

X—DESCRIPTION OF COAL-FIELDS

A—Coal in the Mesozoic

THE ŌMINE COAL-FIELD

The Ōmine coal-field (Fig. 1) is situated in the southern part of the province of Nagato near the western end of Honshū, and covers an area about 12 km. long, in a north-south, and 5 km., in an east-west, direction. It is connected with the Sanyō railway by a branch line about 20 km. in length. A mountain range, generally 300 to 400 m. in height, runs from north to south and forms the watershed of two rivers running south. No wide valleys are found in the field, so that the adits for mining have been opened mostly at or near the out-crops, which are all found on the mountain sides.

The coal is said to have been mined first in 1877. In 1904 a somewhat large mining plant was planned, together with a railway for transportation. Formerly the coal was mostly used as fuel in limekilns, but now the greater part is transported to Tokuyama, where it is manufactured into briquettes. The production of coal in 1909, 1910 and 1911, was 100,951, 100,262 and 72,354 tons, respectively, of which the Ōmine colliery yielded 95,292, 66,488 and 63,788 tons.

The coal-bearing formation consists of shale, sandstone and conglomerate, and is considered to be Mesozoic, perhaps Jurassic, in age. The underlying rocks, in the eastern part of the field, are in places oolitic limestone and in places crinoidal limestone, but their geological age has not yet been ascertained. Granite is found to the south of the field, while the formation is intruded by porphyrite as dykes and sheets, by the contact of which the coal is often changed to a natural coke. The coal is semi-anthracite, belonging to Class A_2. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.
3.66%	8.63%	64.70%	23.01%	0.58%

There are four groups of coal-seams, of which three lie to the east of the mountain range and one to the west of it, all running nearly parallel to each other, almost from north to south. The first group is the lowest geologically, and crops out in the south-eastern part of the field. To the north it is cut off by porphyrite and to the south by limestone, beyond which no outcrop is found, the total length being 1.2 km. The strike is N.10° E. or north-south, and the dip W. 30°-35°. Two workable seams have a variable thickness, the upper containing 2 feet and the lower 5 feet of workable coal. They seem to unite in the south near the limestone, where they are much disturbed and crushed. The thickness in places reaches 9 feet.

The second group lies to the west of the first and is cut off to the north by porphyrite dykes, and to the south by a granite mass, the total length being about 10 km. It is disturbed several times by faults and intruded by porphyrite dykes and sheets which dislocate and displace the coal-seams, though one seam can be traced the entire distance from north to south and another from the middle of the area to the south. The strike is nearly north in the north and N. 10°-25° E. in the south, and the dip W. 30°-40°. Two important seams in the group have a variable thickness, generally from 3 to 5 feet, sometimes 9 feet.

The third group, which is the most important, lies to the west of the second and crosses the mountain range in the north. It seems to become thin in the northern part and is cut off by the granite in the south, the total length being over 10 km. The strike is nearly north or north-north-west, in the north, but in the south it bends north-east, dipping W. or N.W. 30°. Three coal-seams run almost parallel to one another, the vertical interval between them being from 250 to 350 feet. The frequent occurrences of porphyrite dykes and sheets as well as numerous faults make mining difficult, especially in the middle portion (Fig. 2). The thickness of the coal-seams is variable: in the middle part of the field it is generally 2.5 feet for the upper, 7.5 feet for the middle, and 4.5 feet for the lower seam, or 8 to 10 feet for the combined workable coal. Southwards it becomes thicker, while to the north the partings gradually increase until the coal is not worth mining.

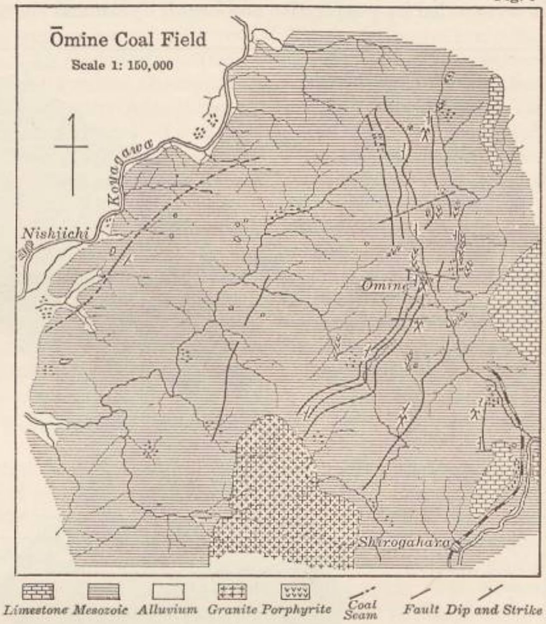
The fourth seam lies in the western part of the mountain range and can be followed for over 4 km. One seam, with a parting, runs almost from north to south, dipping west with a moderate angle. The thickness is very variable, being from 1.3 to 8 feet. Generally, when thick, the quality becomes inferior, and vice versa, so that the area underlain by workable coal is quite limited.

There is one seam in the north-western part of the field. It strikes north-east, dipping S.E. 25°. The thickness is 1.5 to 2 feet. The coal was formerly worked at outcrops.

Though the area is tolerably wide, the occurrence of many porphyrite dykes and sheets as well as numerous faults makes mining unprofitable, so that the amount produced will be rather smaller than might be expected.

The coal has been calculated for 1,000 feet below the surface, and the amount thus calculated will not reach a large figure, being 1,000,000 tons for actual and 19,000,000 tons for probable reserves. The coal was formerly mined in the southern part of the field, and to the east and south of Isa, a town east of the field.

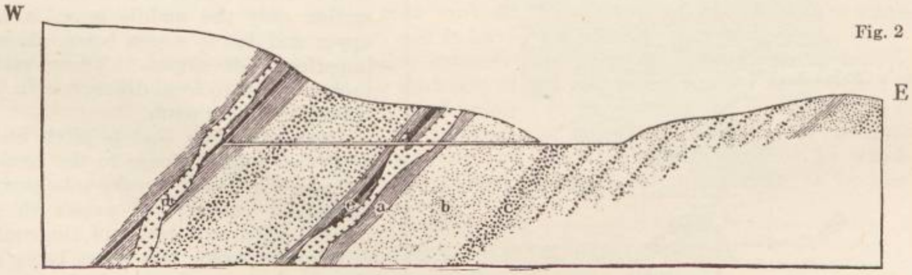
Fig. 1



THE AMAKUSA COAL-FIELD

Situation and history. In the western half of the Amakusa-shimoshima, which lies in the Sea of Amakusa, the coal extends from north to south, occupying a large area (Fig. 3). The coal is said to have been opened first in 1835, and worked on a small scale. From 1884, when pumping machinery was introduced, mining made rapid progress and after the Sino-Japanese war was especially active. Owing to mine water, the difficulty of deep

Fig. 2



Scale 1 6,000

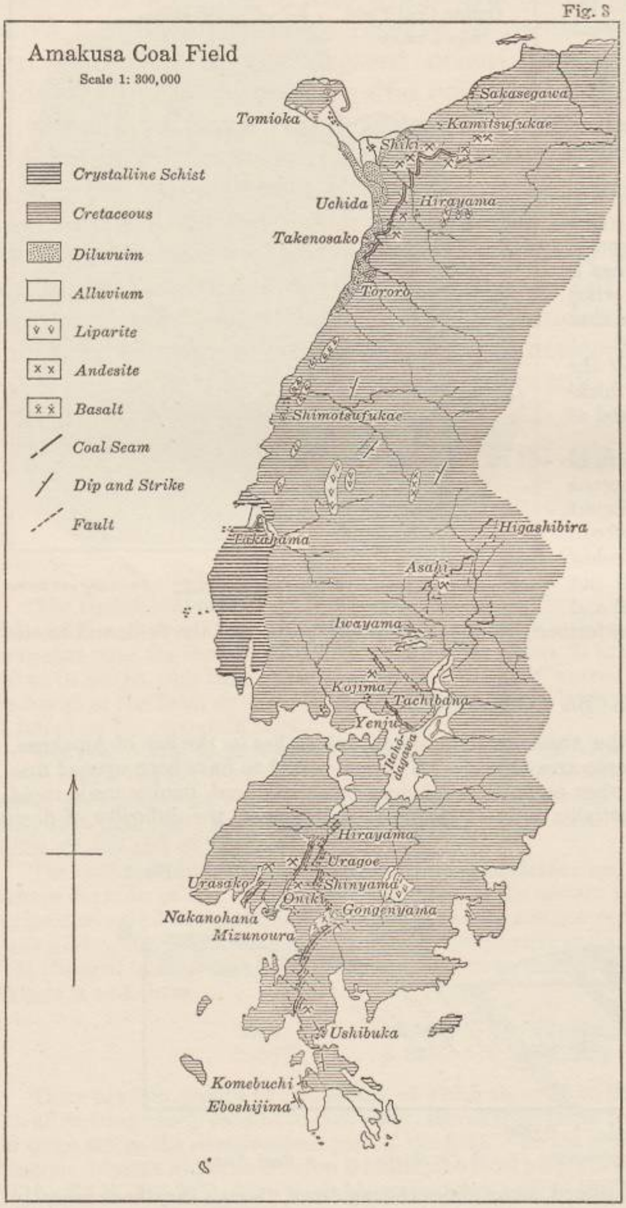
a *Shale* b *Sandstone* c *Conglomerate* d *Porphyrite* e *Coal Seam*

mining and the low price of coal, mining gradually declined, some mines closing down, though they have recently reopened. The average yearly production for each five-year period since 1879 and for each of the last five years has been as follows:

1879	14,080 tons	1907	72,577 tons
1884	24,627 "	1908	94,804 "
1889	58,932 "	1909	54,772 "
1894	40,653 "	1910	42,461 "
1899	44,444 "	1911	43,972 "
1904	41,308 "		

Topography and geology. Roughly speaking, the island is an undulatory plateau, 100 to 200 m. high, with higher hills, here and there rising to 300 and over 400 m. Generally the middle part is the highest, the elevation gradually decreasing towards the coast. The general trend of the mountains is north-north-east, parallel to the strike of the formation. The rocks consist of shale, sandstone and conglomerate, the shale predominating in the upper, shale and sandstone with coal-seams in the middle, and sandstone and conglomerate in the lower part. It is intruded by porphyrite and basalt dykes and sheets, or covered by basalt, and in general strikes north-north-east. Four fossiliferous horizons, in which abundant fossil fauna are imbedded, are found in the lower part of the formation, and by the study of these fossils it has been proved to represent the Senonian. As to the geological age of the uppermost horizon, in which a fossil flora is found in the coal-bearing beds, we cannot decide whether it belongs to the Senonian or not, as the fossils all belong to dicotyledonous plants which seem to represent the Tertiary. Accordingly, we here put the horizon in the upper part of the Mesozoic or the Senonian, as some of the fossils are found in the Upper Cretaceous in Europe and America and no unconformity can be found between the different horizons.

Fig. 8



The coal-bearing formation is composed chiefly of sandstone in the lower, of shale in the upper, and of alternating strata of shale and sandstone in the middle part. It occupies the western part of the island and has been folded into anticlines and synclines, accompanied by numerous faults. Later erosion and tectonic disturbances separated the formation into three sections, the northern, the middle and the southern.

Three coal-seams are known, they are, beginning with the uppermost, 0.8, 1 to 2, and 3 to 4 feet thick in the northern section, and 3 to 6 feet, 1 to 3, and 0.5 to 1.5 feet thick in the southern. It is a noticeable fact that the thickness of the three coal-seams in the northern and the southern sections is in the reverse order, i.e. the thick seam in the northern becomes the thin one in the southern section. In the middle section only the middle seam is known, the upper and lower seams being absent or very imperfectly developed. These variations are probably due to local differences in the original deposition of the seam.

Quality.—The coal is pitch black with a high lustre and belongs to the semi-anthracite variety, and easily breaks into powder. It is sometimes caking. It passes to an impure natural coke, as a result of the contact action of eruptive rocks, this effect being common is the northern section and also found in the middle, but not in the southern. The result of a proximate analysis of the coal is an follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sp. gr.	Cal.	B.T.U.	Class.
2.17%	10.66%	80.63%	6.54%	1.413	6,881	12,386	A_2

The northern section.—The coal-bearing formation stretches from Sakasegawa westwards to Kōtsufukae where it bends to the south-south-west until the village of Tororo is reached. In the north the dip is north, from 20°-30°, but toward the south it gradually becomes steeper, being nearly W.N.W. 40° in Shiki and Uchida, and 50° or 60° in Tororo. Numerous faults are met with and porphyrite intrudes the formation as sheets and dykes so that the structure is rather complicated. Of the three coal-seams, the uppermost is thin, being generally less than 1 foot or 0.8 foot. The middle seam is 1.5 to 2.8 feet thick and is commonly known as the 2-foot seam; while the lower is 3 to 6 feet, generally 4 feet thick, and is known as the 4-foot seam. Numerous collieries are working in the field but none on a large scale, and their total production in 1910 and 1911 was only 2,508 tons and 8,384 tons, respectively.

In the north the seams are cut by many faults, but may be followed for 3 km. by tracing the outcrops and adits. Southwards the seams are also cut by numerous faults as well as by volcanic rocks; but by outcrops and adits, worked or abandoned, they can be followed for about 6 km. In the middle portion the 4-foot seam often becomes 5 feet in thickness, while in the south, or from Takenosako southwards, the upper two seams appear to have been eroded away. As a result of contact metamorphism by the numerous volcanic intrusions, much of the coal in this section has become a natural coke, the quantity so changed being estimated to be nearly half of the whole amount.

The middle section.—In this section the formation forms a syncline, running in general north-north-east, the Itchōda-gawa and its tributary flowing in the synclinal basin, with the coal outcropping on both sides of the river. The production in 1910 and 1911 was 5,999 tons and 6,468 tons respectively.

In the south, especially in the environs of Kojima and Iwayama, the formation suffers from disturbances, so that the same seam outcrops several times as a result of faults, and the dip and strike often vary within a short distance. In the Asahi colliery a 2-foot seam is being mined, its thickness being 1 to 2 feet, rarely over 2 feet, and dip E. 25°. Northwards the coal may be traced to Higashibira, but its thickness gradually diminishes, being from 0.7 to over 1 foot there. Southwards also the coal is thin, being in general only 1 foot thick. Owing to severe disturbances, mining is difficult, but the coal was worked formerly on a small scale. The Kojima colliery is now working a seam nearly 2 feet thick, which in places becomes 3 feet, but parts into thin seams to the north-west. The coal seam near the coast of Yenju and Tachibana is very thin and not important. On the eastern wing of the syncline the coal seam is rather thin, being generally only one foot thick. It was formerly worked in several places

The southern section.—In this section the formation forms a syncline in the north, but in the south the western wing is concealed under the sea. Faults and intrusions of volcanic rocks are very frequent. The coal seams attain full development in the environs of Uragoe, where the upper 3-foot seam swells to 5 feet, and a 2-foot seam to 3 feet. The angle of inclination of the limbs of the syncline is 35° to 45°. The 3-foot seam in Hirayama has been almost worked out, but the Shinyama colliery is being actively worked at present, having yielded 33,547 tons in 1910 and 29,421 tons in 1911 or nearly two-thirds of the total production of the field. The western wing continues southward to the west of Oniki Bay, which marks a line of fault. As a result of the faults, the seams bend nearly east-west, dipping S.S.E. 60° in Mizunoura, and S. 35° in Nakanohana. Three coal-seams in all are known. They were once actively worked, but are now abandoned because of mine water. As a result of an anticline and a fault they again appear in Urasoko. They form a syncline in the west, the western wing outcropping along the western coast of the peninsula. The angle of inclination in the eastern wing is 60° and in the western 45° to 50°. In the eastern wing the upper two seams have been worked; while in the western the upper one becomes very inferior in quality, and only the middle and lower seams are worked.

The coal-seams in the eastern wing are cut off by a fault to the south of Shinyama and also by the basalt of Mt. Gongen-yama, on the southern flank of which the coal is being mined. Of three seams outcropping there, the middle one is the best, its thickness being 1.3 to 2.5 feet. These seams run south-west, and dip N.W. 45°, being cut off by basalt on the dip side. Southwards the upper two seams become thin and are of inferior quality, only the lower, 0.8 foot seam, having been worked. To the west of Komebuchi the middle and lower seams, and in Eboshi island the upper seam, are said to have been formerly mined.

Quantity.—The coal-seams occupy a tolerably extensive area, but the length actually traced is not great enough to yield a large amount of coal. As the thickness of the coal-seams is often variable and the formation severely disturbed and affected by many intrusions of volcanic rocks, we take 500 feet below the surface as the depth for the estimation of the actual reserves, and 1,000 feet, or sometimes 2,000 feet, for the estimation of the probable reserves. In the middle and southern sections, the formation forms a syncline, by which the vertical extension is often limited. The amount of coal that the field contains has been calculated to be about 3,500,000 tons for actual and 5,000,000 tons for probable reserves.

OTHER SCATTERED, MINOR COAL-FIELDS

Coal in the environs of Ōno.—In the eastern part of the province of Echizen, the Mesozoic is found in many places, underlain by the Palæozoic and intruded and covered by granite, porphyrite, andesite, etc. It consists of shale, sandstone and conglomerate, and contains numerous Jurassic fossils. The coal is soon to be mined along the upper course of the Katsurashima-gawa, about 24 km. east of Ōno, though transportation is difficult. There the formation is much disturbed, but the strike is generally north-west and the dip steeply south-west. Coal outcrops here and there, but its continuity has not yet been established. Five coal-seams have a variable thickness from 0.5 to 7 feet, and three can be followed for about 2 km. It is calculated that the amount of coal in the district is about 5,000,000 tons.

In the environs of Yamura, lying to the north-west of Ōno, one coal-seam, 1 to 1.5 ft. thick strikes N. 60° E., dipping N.N.W. 10°-15°. It was formerly worked on a small scale. The area is narrow, and covered with andesite, so that the amount of coal it contains is very small. The coal is bituminous, belonging to Class C.

Coal near Umezako.—Umezako, in the province of Tamba, is situated on the railway from Ōsaka to Maizuru, lying about 10 km. south of the latter place. The coal is found in a district within 3 or 4 km. from Umezako, and was first mined in 1897. Afterwards mining was abandoned, but preparations are now being made to reopen the seams. The coal is semi-anthracite, belonging to Class A_2. The Mesozoic, consisting of shale and sandstone, was deposited in a small basin in the Palæozoic and forms low hills 100 to 300 m. in height. Folds and faults are very common but, generally, the strike is east in the west and N. 30° E. in the east, and the dip south with a steep angle—50° to 70°. Three coal-seams are interbedded in the shale. The middle one is the thickest, being 4 feet, or 1.5 ft. of workable coal, while the upper and the lower seams are only 1 to 2 feet thick. The amount of coal calculated for this district is only 1,000,000 tons.

Coal to the west of Maizuru.—The Yura-gawa, which drains the province of Tamba, runs northwards to the west of Maizuru, in the province of Tango, and empties into the Sea of Japan. The coal is found on the western bank of the Yura-gawa, conveniently situated about 10 km. west of Maizuru. It was first mined in 1887 and actively worked during 1895 and 1899, though the daily yield was only 15 to 18 tons. Afterwards the mine was abandoned, but it is intended to reopen it. The coal-bearing formation consists of Mesozoic shale, sandstone and conglomerate, and forms an undulatory plateau less than 200 m. in height, sloping abruptly to the valley. It is bounded on the west by the Palæozoic, on which it rests, and is affected by folding and faults. The coal is interbedded in the shale, the outcrops beings found in an area extending about 2½ km. in a north-south and 1 km. in an east-west direction. In the northern part the strike is generally east and the dip N. 70°., but in the middle and southern parts the strike is north and the dip east and west, with an angle of from 60° to 70°. Three coal-seams may be workable, the thickness being 4 to 6 feet, in places increasing to over 10 feet. The area underlain by the seams is not large, so that the reserve amount of coal is small, about 5,000,000 tons. The coal is semi-bituminous, belonging to Class B1.

Coal near Nariwa.—The Triassic, in the environs of Nariwa, in the province of Bitchū, consists of shale and sandstone, in which coal is interbedded. The four coal-seams known at present are each only about 1 foot thick. The lowest seam, which was formerly worked, is 2.5 feet, with partings. The strike is generally north-west and the dip south-west at a low angle, commonly 10°. The coal is anthracite of inferior quality, belonging to Class A1.

The Tsubuta coal-field.—This field is situated near the coast in the south-eastern part of Habu, a town on the southern coast of the province of Nagato. The coal has been mined on a small scale for forty years, as transportation is very easy. It has been used chiefly as a fuel for limekilns in Shikoku and Kyūshū. The production was 223 tons in 1910 and 433 tons in 1911. The field occupies a hilly district along the coast. The strata consist of shale, sandstone and conglomerate, and are considered to belong to the Rhætic. The strike is east-north-east, and the beds lie in steep anticlines and synclines with angles of 60° to 80°. Of several seams, three, 6, 7 and 4 feet thick, respectively, are worked on a small scale. By the intrusion of liparite the coal is often changed to a natural coke. As the area is limited and the inclination is very steep, the coal reserves are small, being only 2,000,000 tons. The coal is anthracite, belonging to Class A_1. The result of a proximate analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal.	B.T.U.
5.78%	3.40%	75.24%	15.58%	0.17%	6,544	11,780

Coal near Tokushima.—The Cretaceous to the south of Tokushima, in the province of Awa, extends from east to west, with the Palæozoic lying immediately to the north. It consists of shale, sandstone and conglomerate. The strike is almost parallel to the boundary between it and the Palæozoic or nearly east, the dip being north. The coal was formerly mined at four places near the coast, and along the Katsura-gawa. Two or three coal-seams have a thickness varying from less than 1 foot to 3 feet. The coal is badly crushed and is of inferior quality. It is bituminous, belonging to Class C.

B—Coal in the Tertiary

1—KARAFUTO (SAGALIN)

The main mountain range of Karafuto runs from north to south. The constituent rocks are Mesozoic, probably Cretaceous, on both flanks of which the Tertiary rests directly. The Tertiary consists of shale, sandstone and conglomerate, the latter often forming thick beds lying directly upon the Cretaceous. Very near the conglomerate, important seams of coal, of various thicknesses are found, so that for the most part the valuable coal-fields in the island form belts along the Cretaceous rocks of the main mountain range, though there are smaller areas scattered throughout the island. The coal in the upper part of the Tertiary is found only in a narrow area near the western coast of the Notoro peninsula, and its quality is inferior to that of the lower coal.

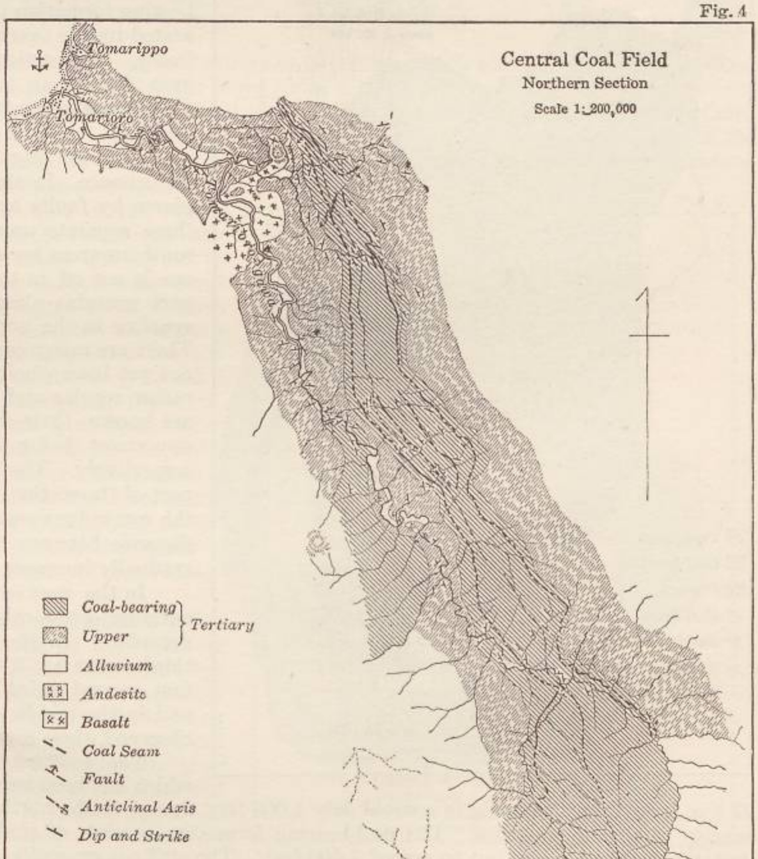
In estimating the reserves, the lowest, thick coal, lying 500 feet below the surface, has been counted as actual coal reserve, though its existence has not yet been proved by boring or otherwise. For probable reserves the coal has been calculated to a depth of from 2,000 to 4,000 feet, according to the thickness of the seams and the geological structure of the fields. Most of the coal-fields in Karafuto, however, have not yet been thoroughly surveyed, so that the amount here given has been calculated only for a few important areas. Thus the calculated amount of the central coal-field is 17,500,000 tons for actual, and 885,000,000 tons for probable reserves, and that of the Notoro coal-field 460,000,000 tons for probable reserves.

The Central or Naibuchi Coal-Field

The central coal-field occupies the middle portion of the island, extending from the coast of Tomarioro, along the western coast, to the southern foot of Mt. Rūtaka, east-north-east of Mōka, and embracing a long, narrow area, drained by the Tomarioro-gawa in the northern, the Naibuchi-gawa in the middle, and the Ane-gawa in the southern part, and having a total length of over 70 km. It forms undulatory hills along the rivers, being bounded to the east by the Cretaceous mountains, generally 300 to 500 m. in height. The Tertiary, which rests directly on the Cretaceous, consists chiefly of a thick series of shales and sandstones. It occurs in gentle folds, or forms small basins. It may be divided into a coal-bearing formation and an upper series.

The coal-bearing formation constitutes the lowest part of the Tertiary and forms a narrow belt resting directly on the Cretaceous. It consists of shale, sandstone and conglomerate with a total thickness of 900 to 2,000 feet. The strike is generally north or N. 30° W., the beds forming an anticline and a syncline in the north and middle parts, and, farther south, a monocline to the west. The angle of inclination is generally less than 20°, but often reaches 30°. The formation attains full development in the central part, thinning out to the north and south. The exact number of the coal-seams is not yet known, nor their thickness, but at least four seams 3 to 15 feet in thickness may be considered to exist. The beds are very fossiliferous, but no detailed examination of the fossils has been made to determine the geological age of the formation; by correlation with other coal-fields, however, the conclusion is arrived at that it is probable the coal-bearing formation represents the Miocene. Transportation facilities are not at present good, but in the northern part the coal lies within 4 km. of the coast and may easily be reached along the Tomarioro-gawa. Trial workings have been carried on by the Government for the last two years. The middle and southern parts, though much more difficult to get at, are only about 15 km. distant from the Naibuchi plain, and can be reached through rather wide valleys. The field may conveniently be divided into a northern, a middle and a southern section.

Fig. 4



The coal is bituminous and generally caking. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.
5.67%	40.15%	46.86%

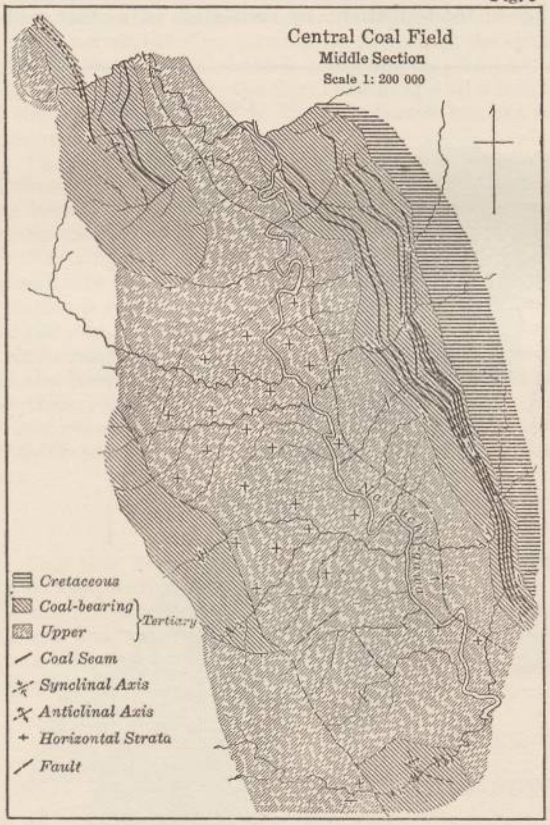
Ash	Sulph.	Class
7.32%	0.40%	C

The northern or Tomarioro section.—In this section (Fig. 4) the area surveyed is about 22 km. long and from $\frac{1}{2}$ to 5 km. wide, tapering gradually toward the north. The coal-bearing formation seems to have suffered severe disturbance, especially in the north. Of the numerous faults, an important one runs from the extreme northern end of the field right across the middle section into the southern part. The hade of the fault in its eastern portion is east or north-east with moderate angles—40° to 45°, while in the western portion it is steeper, being W. or S. W. 60° to 70°. Almost continuous with this great fault, an anticline runs southwards with angles often less than 30°. From this fact as well as from the correlation of the coal-seams to the east and west of the fault, it is apparent that there must be an anticline in the northern and middle parts, where the fault passes. Of three or four groups of coal-seams known in the section at present, the uppermost is the most important, and its continuity has been determined with some degree of accuracy.

In the northern part good outcrops of the upper group are found to the east of the fault only. Three coal-seams have been examined, the thickness being 3 or 4 feet with vertical intervals of from 2 to 7 feet. By outcrops the seams are found to be about 8 km. in length, and for 3 km. have been rather closely followed. One coal-seam, 3 feet thick, is found to the west of the fault, and, though good outcrops are not found for any distance, yet, from geological considerations, it is inferred that the seam extends at least 4 km. In the middle part the seams are often covered by soil, though three or four seams are said to have been followed for 3 km. to the east, and for 4 km. to the west of the fault. The southern part has not yet been thoroughly examined, but a few outcrops are here and there observed on both wings of the anticline, their thickness being generally 2 feet.

In the lower group there is no coal-seam that can be followed for any distance, and the correlation of the seams is difficult. In the northern part a coal-seam, 1 to 2 feet thick, lies to the east of the fault, about 150 feet below the upper group, and has been followed for 2 km. Another, about 200 feet below the first, is 3 feet thick and is cut by many faults. No coal has yet been discovered west of the fault. Several other coal-seams are found along the river, but their continuity has not yet been proved. In the middle part, two important coal-seams are said to have been followed for 2 or 3 km. east of the fault, the upper being 4.5 feet and the lower 3.5 feet thick. Along the rivers and tributaries numerous outcrops of coal have been discovered.

Fig. 5



The middle or Naibuchi section.—This section (Fig. 5) which has been surveyed, is about 18 km. long in a north-south direction and 10 km. wide. The coal-bearing formation is found in four areas, which are separated by the overlap of the upper series and cut off by faults. The section is a hilly tract from 100 to 500 or even 600 m. in height, bounded on the east by the Cretaceous mountains. To the east, regular stratigraphical relation can be observed, the formation generally dipping W.S.W 15° to 35° without much disturbance. In the west, the strata are cut off in many places by faults and the coal-bearing formation forms three separate areas, of which the northern and the southern areas are anticlinal in structure and the middle one is cut off to the east by a large fault. The central part contains almost horizontal strata, which form a syncline in the north and the south, as seen in Fig. 5. There are many coal-seams, though their correlation has not yet been wholly established. To the east they are rather regular and may be easily followed; seven seams are known, their average thickness, beginning with the uppermost, being 3.3, 7.5, 2.2, 2.5, 5.4, 5.8 and 2.4 feet, respectively. They attain full development in the central part of the section, while in the north, six seams and in the south, four seams have been examined. The vertical distance between the seams is least in the south, and gradually increases to the north.

In the west only three or five seams are known, the outcrops of the others being probably hidden by surface deposits. In the northern area the first, second and third seams are 3 to 10 feet thick; in the southern the first, second, third, fifth and sixth are 2 to 5 feet thick, and in the middle only one seam, 2 feet thick, has been observed, their correlation having not yet been studied.

The southern or Anegawa section.—This section, which has been surveyed, embraces a narrow area, about 27 km. long, its width being in general only 4,000 feet, though in the north it is separated into two parts by the overlap of the upper series. The coal-bearing formation consists of shale, sandstone and conglomerate, and its total thickness seems not to exceed 1,500 feet. The strike is generally north. In the north the formation is gently undulating, forming an anticline and a syncline, while in the south it dips westward with angles of generally 20° to 30°, sometimes as steep as 70°, and seems to overlie the Cretaceous conformably.

The exact number of coal-seams occurring in the northern part is not known, but they are numerous; at least five seams over 3 feet thick are known and over thirty if thin seams over 0.5 ft. are taken into account. The thickness is very variable, generally from 2 to 10 feet; a conservative estimate giving an aggregate thickness of 15, or, probably, from 15 to 25 feet. The middle part of the section is the most important and is about 12 km. long. The strike of the formation changes gradually to west, in the south, being N. 20° E. to N. 60° E. The angle of dip is moderate—45° in general. Of the many coal-seams occurring, seven to ten are important, the thickness varying from 3 to 17 feet. The aggregate thickness may be considered to be at least 30 feet, and probably reaches 40 feet and over. The southern part now known to us is about 12 km. long, the extreme southern end not yet having been determined. The strike of the formation is north-south, dip W. 30°. From three to five of the numerous seams are important, the thickness varying from 5 to 20 feet with a minimum aggregate thickness of 20 feet.

The Notoro Coal-Field

The Notoro coal-field (Fig. 6) occupies the middle portion of the Notoro peninsula, covering an area of about 40 km. in a north-south, and about 18 km. in an east-west direction. It is a hilly, undulatory plateau, generally less than 100 m. in elevation, the highest peak being only 600 m. high. The means of access are not good at present. The Tertiary in the peninsula rests directly on the Cretaceous, and is divided into four series: the lower coal-bearing, the lower, the upper coal-bearing, and the upper. The lower coal-bearing series is found near the Cretaceous and rests directly on it, the base being conglomerate. It consists of shale, sandstone and marl. By an abundant fossil flora found in the marl beds it has been proved to represent the Miocene. The upper coal-bearing series forms a long belt near the western coast, and consists of shale and sandstone. A systematic survey of the coal-field has not yet been carried out, but a part of it has been roughly examined.

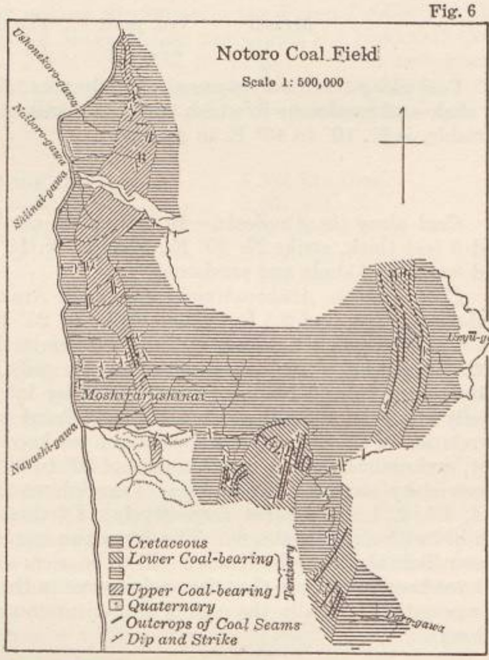
The coal is bituminous and is generally non-caking. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
12.36%	36.28%	43.06%	8.30%	0.45%	1.311	C

The lower coal-bearing series.—This series is exposed along the two sides of a synclinal basin, in the central part of which it is concealed under a cover formed by the lower series.

The eastern section forms a long belt, nearly 40 km. long, along or near the Cretaceous, though its northern and southern limits have not yet been determined, the surveyed area being only 12 km. long. The strike of the series is from north to N. 30° E., forming an anticline with a nearly central axis along which the sandstone outcrops. The angle of inclination is moderate—generally 45° in the north, and steeper, up to 60°, in the south. Numerous outcrops of coal are found on the rivers and their tributaries, and at least three or four seams 2 to 15 feet in thickness can be counted, though their exact extent is not yet known. Along the Uryū-gawa, seams of coal have been traced at intervals for about 12 km., the thicknesses in the western wing of the anticline being, from the top downwards, 2, 3, and 6.5 feet, in the north; 5, 4, 7, and 3 feet, in the middle; and 3.5, 15, 4, and 2.5 feet, in the south. In the eastern wing only two coal-seams have been found. Farther south, along the Dorogawa and upper Nayashi-gawa, little coal is known. On the upper Nayashi-gawa, one coal-seam 4 feet thick occurs, and on the Doro-gawa, three seams are found, dipping W. or W.N.W. 30° to 50°. They represent undoubtedly the same seams that occur in the north, though the correlation has not yet been established.

Fig. 6



The western section may be reached by the broad valley of the Nayashi-gawa, the distance being 24 km. from its mouth, on the western coast. Only the northern part has been examined beyond which to the south there probably lies a large area. The series is severely disturbed, being much folded and faulted, so that it is difficult to work out the stratigraphical relation of the seams. Generally they run from north to south in the east, forming anticlines and synclines and dipping with low angles—in general 25°, while in the west the strike is very variable, being often abruptly disturbed by faults, and the dip is steep—generally 60°. Numerous coal-seams are found; five seams, from 3 to 7 feet thick, being known in the east, while in the west, owing to the frequent faultings, there appears to be a still larger number, of which five seams are said to be from 4 to 17 feet thick.

The upper coal-bearing series.—This series forms a narrow belt, composed of shale and sandstone lying directly on the lower series. Three coal-seams 10 to 20 feet thick and one 4 to 5 feet thick are known to occur in it. The strike is nearly north, the beds dipping west rather steeply and forming an anticline in the middle portion. In the north the belt is very narrow, and one coal-seam over 10 feet thick is found, dipping steeply to the west. Southward the belt widens gradually, and four coal-seams 20, 12, 10, and 4 feet thick, respectively, beginning with the upper, strike N. 20° W., and dip W. 30°. On the Naiboro-gawa, good coal occurs in four seams, 12, 3, 15, and 6 feet thick, respectively, beginning with the upper; the beds strike N. 20° W., forming an anticline with a steep angle of 70°. To the south of this exposure no outcrop is found for about 5 km., at which place coal-seams 2 to 7 feet thick re-appear and continue southwards with the dip E. 60°. Good coal is again met with in the south, where the series covers a narrow area. There are four seams, their thicknesses being 7, 15, 15 and 10 feet, respectively, beginning with the uppermost, and the strike being N. 15° W., dip W. 65°.

The Poronai Coal-Field

The Poronai coal-field covers a belt about 80 km. long, fringing the eastern flank of the main mountain range which runs from north to south. It is a hilly tract from 100 to 200 m. in height, underlain by shale, sandstone and conglomerate, resting directly on the Cretaceous. Numerous coal-seams are known to occur, but they have not yet been examined except in a few places. In the north, near the Russian boundary, five seams, from 5 to 10 feet thick, have been examined. One, on the Hoiye-gawa, in the middle portion, is said to be 10 feet thick. In the south, along the Shitsuka-gawa, one seam, 10 feet thick, strikes N. 30° W., dipping W.S.W. 50°. The value of the coal-field is quite unknown, though it is believed to contain a large amount of coal. Generally the coal is bituminous and slightly caking. The result of a proximate analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
10.92%	38.03%	45.74%	5.31%	0.43%	C

Coal on the Eastern Coast

The Noborippo Coal-Field.—This field lies in the middle portion of the eastern coast area, and is bounded by volcanic rocks on the west. It is a narrow, hilly tract, underlain by shale and sandstone. One coal-seam, 15 to 20 feet thick, runs north-north-east, dipping W.N.W. 40° to 50°, and may be followed for 3 km. The result of a proximate analysis of the coal is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
11.13%	22.87%	58.91%	7.09%	0.53%	B_2

Coal along the Menapet-gawa.—A hilly area, along the Menapet-gawa in the Chitoko peninsula, is underlain by shale and sandstone in which two coal-seams occur, their thickness being from 5 to 10 feet. The strike, often variable, is N. 10° to 40° E. in general.

Coal on the Western Coast

Coal along the Amobeshi.—In the valley of the Amobeshi, near the Russian boundary, two coal-seams, 2 and 5 feet thick, strike N. 20° E., dipping W. 15° to 30°. The coal-bearing formation rests on the Cretaceous and consists of shale and sandstone.

Coal along the Arakoushinai.—Along the Arakoushinai, about 12 km. south of the Russian boundary, three coal-seams, 2, 4, and 2.5 feet thick, strike N. 25° W., and dip steeply west.

The Serutonai Coal-Field.—This field lies in the northern part of the western coast area. Many good outcrops of coal have been examined along the cliffs, where they can be followed for about 5 km. The field is an undulatory plateau, bounded on the east by lofty, volcanic mountains. The coal-bearing formation consists chiefly of sandstone with shale. It has suffered severe disturbance, being much folded and faulted, so that the correlation of the various outcrops is not yet known. The strike is nearly north-south, and the dip west in the east, and east in the west, with angles of 30° to 60° forming a syncline. In some places the upper part has been removed by erosion. Six coal-seams are known to occur, their thicknesses, beginning with the uppermost, being 6, 5, 3.5, 2, 4, and 12 feet, respectively. Of these the third and fourth seams are altered to a natural coke by contact with andesite sheets. The upper two seams were once worked by Russians at various points near the coast where their abandoned adits are still to be seen. Owing to the numerous faults, the continuity of the seams has not yet been proved, so that the coal reserve in the field cannot be estimated; it seems, however, to be moderate in amount. Generally the coal is semi-bituminous and caking. The result of a proximate analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
2.94%	27.47%	66.93%	2.65%	0.89%	B_2

Coal along the middle Nayashi.—The coal-bearing formation, resting on the Cretaceous along the middle course of the Nayashi-gawa, forms a narrow synclinal belt with longer axis running in a north-south direction. Two coal-seams, 2 and 4 feet thick, are said to occur.

Coal along the middle Estoru.—A narrow area along the middle course of the Estoru-gawa is underlain by shale and sandstone striking north and dipping W. 50°. One coal-seam 13 feet thick is found there.

2.—HOKKAIDŌ

Ishikari Coal-Fields

Situation and topography.—In the Ishikari coal-fields (Plate 2) are included those lying east of the Ishikari-gawa, and extending through the middle of the province of Ishikari from north to south. The Pōpet coal-field, in the province of Iburi, considered as the continuation of the Ishikari coal-fields, is, for convenience, included in them. The fields occupy a large area, about 70 km. long and from 15 to 25 km. wide. They are bounded on the east by the Yūparo mountain range, which culminates in Ashpetnupuri, with a height of nearly 1920 m., to the west they fall away to the large drainage plain of the Ishikari-gawa. To the north the fields are cut off by the volcano of Irumpetpu, nearly 900 m. high, but the southern boundary has not yet been accurately determined. The Bibai mountain range, with Bibai-dake, about 1000 m. high, in the middle, branches from the Ashpetnupuri, and runs southerly through the northern portion of the fields, dividing the district into two parts, an eastern and a western. Westward from the rocky and precipitous Yūparo mountain range, the configuration of the land is quite different, abruptly lowering to the Mesozoic mountains, which gradually slope to the coal-fields. The coal-fields form a narrow, undulatory, plateau-like tract with the highest peak 800 m. high, the tributaries of the Ishikari-gawa breaking the uniformity of the surface, so as to form small ridges, running mostly from east to west. The volcano of Irumuketpu occupies a large area in the north, covering the Tertiary, and limiting the coal-fields in that direction. The Sorapchi-gawa in the north part of the fields and the Yūparo-gawa in the southern part are two large tributaries of the Ishikari-gawa; the Ikushumpet-gawa and the Poromoi-gawa in the central part are the next largest, crossing the fields nearly from east to west. The Mukawa, in the province of Iburi, flows from north-north-east to south-south-west, bounding the fields on the south.

History and production.—The coal in Hokkaidō is almost all produced from the Ishikari coal-fields. The coal is said to have been discovered before the Restoration of Meiji, and six years later the survey of the coal-fields was undertaken by a number of geologists under the direction of Prof. Lyman, who was then in the service of the local Government of Hokkaidō. In 1874 preparation for mining was begun at the Poronai colliery in the Ikushumpet coal-field, and in 1890 the Hokkaidō Coal Mining and Railway Company (now the Hokkaidō Coal Mining and Steamship Company) was organized and the coal-fields connected by railway. After two years, as a result of better transportation facilities, the production of coal greatly increased. In the last fifteen years the coal mining industry has made rapid progress, especially in the last five years. The production of coal in the fields was as follows:

1879	289 tons	1907	1,384,349 tons
1884	32,139 "	1908	1,607,304 "
1889	115,076 "	1909	1,691,930 "
1894	393,148 "	1910	1,591,695 "
1899	642,423 "	1911	1,701,748 "
1904	1,078,168 "		

Geology.—The basement complex is made up of Palæozoic strata consisting of metamorphosed schists, such as chlorite-graphite-schist, graphite-schist and chlorite-schist, together with limestone, schalstein, hornstone, clayslate, etc., striking generally north-south and dipping E. 60° to 80°. These rocks constitute the high and precipitous Yūparo mountain range. Unconformably on the complex lies the Mesozoic, the topography of which is quite different from that of the Palæozoic.

The Mesozoic consists chiefly of shale in the upper part, alternating strata of shale and sandstone in the middle part, and sandstone in the lower part. Conglomerate is found in many cases between the middle and upper parts, with a thickness as great as 500 feet in places, for example, in the upper Penke-otaushinai. The strike is in general nearly north-south, but the strata are often folded. The angle of inclination varies generally from 20° to 50°. To the north of the Bibai range, the formation forms an anticline and disappears under the Tertiary near the Sorapchi-gawa. By the abundant fossils found in it, the formation has been proved to represent the Cretaceous.

The Tertiary consists of tuff, shale, sandstone and conglomerate, with marl and coal-seams, and rests on the Cretaceous. The dip and strike of the two formations are quite the same, but, although we can find no sign of unconformability nor any discontinuity between them, a heavy conglomerate, found between these formations everywhere, suggests a great physiographic change at that period.

The Tertiary may be divided into two series, an upper and a lower; the upper consisting of tuff, tufaceous shale and conglomerate, and the lower of shale, sandstone and conglomerate, with marl and coal-seams, but no unconformability is discernible between them. The lower series occupies the eastern part, resting directly on the Cretaceous, while the upper covers the outer zone or western part. The coal-seams occur in the lower series, the number known being over 150. They are in the form of lenses, their thickness varying from a few inches to 60 feet. The general strike is north-south, but in the north an elongated half-dome is formed, following the contour of the underlying Mesozoic, with dips to the north, east, and west. Locally the formation has been severely disturbed and forms anticlines and synclines, accompanied often by faults. An abundant fossil fauna has been found, especially in the lower part, but there are no diagnostic fossils to determine the geological age of the formation, though they are quite different from those in the Cretaceous, so that they may be considered to represent the Miocene. The upper series is tufaceous, which suggests the volcanic activity of that age. Along the wide plain of the Ishikari-gawa, narrow terraces fringe the mountains. Eruptive rocks are rarely found in the fields. Serpentine and diabase are found intruding the Palæozoic and Cretaceous, while andesite, liparite and basalt intrude the Cretaceous and Tertiary. The liparite intrudes the Tertiary in the form of dykes, being found in Akahira, on the southern bank of the Sorapchi-gawa. The andesite, besides forming the Irumuketpu volcano, is found in a few places as dykes in the Cretaceous and Tertiary. Basalt, found at the foot of the volcano, forms two solitary peaks, Kamui-dake and Shō-kamui-dake, on the west of Otaushinai.

As above stated, the Tertiary has been severely disturbed, suffering lateral pressure from the west which has caused complicated folding and overthrusts. Numerous faults also traverse the fields, their principal directions being north-south, east-west, and north-west—south-east. Along the western foot of the Bibai range step-faults are common. Generally the formation is fairly regular and can be followed easily on the east of the Bibai range, with the strike north or north-west, dip east; while in the west it is much more disturbed and the strike is very variable, so that it is difficult to follow it, though the general strike there also is nearly north-south.

Coal-seams.—Lenticular coal-seams are interbedded in the Cretaceous, their thickness being only from 0.2 to 1 foot. The more important seams are found in the lower series of the Tertiary and are being actively mined. Those found in the upper series are very inferior in quality and are very thin, being only 0.5 to 1 foot thick. They, like those in the Cretaceous, are not considered to be of economic value.

The coal-seams are numerous, numbering 150 if thin ones are included. They attain their best development on the north-west of the Bibai range, where the formation is complicated in structure. Southwards they have not all been traced, so that the number of seams known in that direction is much smaller, but, in the central part, or north of the Ikushumpet-gawa, it again increases. The development of the seams appears, therefore, to be quite local, or limited often to a short distance, so that, with our present knowledge, it is impossible to correlate the seams of different coal-fields. The seams vary very much in thickness, being from 1 foot to 60 feet. Even the thick seams in places thin out for short distances, forming lenticular seams, or parting into thin, non-workable seams.

Quality.—The physical and chemical characters of the coal vary greatly in different places and seams, and in the same seam the coal is caking in one locality and non-caking in another. The coal generally is black and caking, and has a resinous lustre; it burns freely with a long smoky flame, and may be considered a good bituminous variety. The results of proximate analyses of it are as follows:

	Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
	%	%	%	%	%				
Ashpet	3.35	36.86	50.03	9.76	0.45	1.318	6,606	11,890	C
Otaushinai	2.11	39.06	52.65	6.18	0.53	1.304	6,974	12,552	C
Naie-bibai	2.37	41.41	50.62	5.60	0.34	1.302	6,805	12,249	C
Ikushumpet	4.41	42.53	46.89	6.17	0.33	1.321	6,234	11,221	C
Poronai	4.87	40.41	48.43	6.29	0.43	1.314	6,815	12,267	C
Yūparo	2.74	41.05	50.65	5.56	0.40	1.277	7,375	13,274	C
Pōpet	5.31	42.32	40.97	11.40	0.33	1.312	....	....	C

Quantity.—The Ishikari coal-fields, which are among the most important in Japan, have very large reserves of coal. The geological structure is so complicated that it is difficult to obtain very accurate data for the calculation of the reserves. In the following table the figures have been calculated from a very conservative estimate of the thickness and extent of the seams, the resulting amounts may therefore be understood to be minimum estimates and will be increased when a closer examination and detailed survey has been carried out. In cases where the ground has not been proved by borings or in any other way, we take the coal contained in a block extending 500 feet below the level of the surface to represent actual reserves.

Calculated on this basis we got, for the reserves, the following:

	Actual (tons)	Probable (tons)
Ashpet	86,000,000	968,000,000
Otaushinai	63,000,000	106,000,000
Naie-bibai	23,800,000	146,500,000
Ikushumpet	19,800,000	50,000,000
Poronai	30,000,000	151,000,000
Yūparo	85,000,000	345,000,000
Pōpet	....	25,000,000
Total	307,600,000	1,791,500,000

(1) THE ASHPET COAL-FIELD

The Ashpet coal-field embraces an area about 22 km. long and 16 km. wide, lying along the Sorapchi-gawa and its tributary the Ashpet-gawa, to the north-east of the Bibai range. The area includes the narrow drainage plain of the Sorapchi-gawa, where the coal-seams have been cut off, many of the seams found on one side of the river not being traceable on the other. The seams, which are numerous, may be classified into three groups, a lower, middle and upper. No colliery is now working in the field.

The lower group forms an elongated half-dome in the north-western corner of the area and may be followed southwards, along the eastern flank of the Cretaceous, to the Ashpet-gawa. The strike is almost parallel to the boundary between the Cretaceous and the Tertiary, and the dip is nearly east with an angle of 40° to 50°, except in the north, where the formation forms a half dome, the angle of inclination there also, generally, being 40° to 50°. Many faults occur at the crest of the dome, and towards the south the formation is much disturbed and the coal becomes rather inferior in quality. Near the Sorapchi-gawa seams are very numerous, seventeen having been found on the south, and eight on the north side of the river; but many of them thin out or disappear to the south, only six important seams being known on the southern part of the area. The coal-seams north of the Sorapchi-gawa have not been followed beyond the river, the extension there being 4,500 to 13,000 feet. The average thickness of the seams varies from 3.5 to 13 feet each, the aggregate thickness being 170 feet in the northern, and 29 feet in the southern part of the field.

The middle group runs nearly north-south to the Sorapchi-gawa, the continuation of the seams beyond the river being yet undetermined. They are also cut off in several places by faults. To the south of the river the dip is east, the angle of inclination being 10° to 20° in the northern part and steeper in the southern. There are eleven coal-seams, of which seven have been traced for some distance and four are known only by their outcrops. The thickness of the seams is from 3 to 12 feet each and the aggregate thickness 50 feet. On the northern side of the river the seams strike N. 5° to 30° W., dip E. 50° to 75°. To the north they are not known and seem to thin out or to be covered by soil. Five seams have been followed for from 3,500 to 6,000 feet, the thickness varying from 3 to 14 feet, the aggregate thickness being 30 feet.

The upper group runs almost parallel to the western boundary of the Cretaceous, or is semi-circular in the north and north-south in the south. On the north side of the river the strike is east-west in the north and the dip N. 20° to 25°. It gradually bends southward, and in the middle the strata have been severely disturbed, folded and faulted, and it is difficult to follow the seams in a general direction. In the south the trend of the beds becomes east-west again. The angle of inclination varies greatly, but is usually 30°. There are many coal-seams and seven are important, but to the north they appear to become thin. The average thickness of each seam is from 5 to 8 feet, and the aggregate thickness 44 feet.

South of the river the strike is nearly parallel to the Ashpet-gawa, being north-east in the north and north-south in the middle and south. The dip is east, the angle of inclination being 30 °to 50°. The strata are affected by many faults and two cut the coal-seams, displacing them to the west. The important seams are six in number, and their thickness varies from 5 to 10 feet, the aggregate thickness being 36 feet.

Besides the seams above mentioned there are many outcrops of coal 2.5 feet and over in thickness, but as their continuity has not yet been established the amount of coal they represent has not been included in the estimate.

(2) THE OTAUSHINAI COAL-FIELD

The Otaushinai coal-field occupies the northern part of the area lying along the western flank of the Bibai range, and five collieries, Sorapchi, Usui, Utagami, Nakamura and Monjyu, are working; the largest of these, Sorapchi, produced 312,330 tons in 1909, 204,455 tons in 1910 and 151,1?3 tons, or two-thirds of the total output for the year, in 1911. The field is drained by two tributaries of the Ishikari-gawa, the Penke and Panke Otaushinai, which run almost parallel to one another from east to west, with low mountains, nowhere higher than 400 m., between them.

The coal-bearing formation consists mainly of sandstone and shale of the lower Tertiary, with conglomerate and nodules of marl. The formation has been very severely disturbed and many folds and faults give rise to a most complicated structure, so that it is not easy to work out its stratigraphical relations. Generally the axes of the folds seem to run nearly north-south and the faults traverse the district mostly in the same direction. The coal attains its full development in this field and as many as two hundred seams in all are known. Of these more than thirty seams are 2 feet thick and over and may be followed for a distance. The thickness of the coal-seams is very variable, a thin seam often becoming abruptly thick for a short distance. The seams that have a workable thickness contain partings, except in a few cases. The greatest thickness observed is 40 feet. The angle of inclination also is variable, being sometimes very steep and sometimes gentle, but generally it is 40° to 50°.

The lower and middle groups are intermingled and, in the south, are found only 600 to 700 feet apart, so that it is difficult to distinguish between them. However, it is known that in the collieries of Sorapchi and Usui, the coal-seams worked are of the lower group, and in the collieries of Nakamura and Monjyu those of the upper group. The coal-seams considered as the lower group are repeated in many places by folding and faults, but thirty-one seams 3 feet and over in thickness are known, their aggregate thickness being nearly 170 feet. The coal-seams considered as the middle group outcrop along the Sorapchi-gawa and run southward, though in places they are cut off by faults and disturbed by foldings. In the north eleven seams are known, and to the south a still greater number, though the distinction between the lower and middle groups has not been clearly established. The thickness is very variable, the average thickness of each seam being from 2 to 17 feet and the aggregate thickness 47 feet in the north and over 100 feet in the south.

(3) THE NAIE-BIBAI COAL-FIELD

The Naie-bibai coal-field embraces a long area, drained by the Nai-gawa, the Naie-gawa and the Bibai-gawa, extending 17 km. in a north-south and 8 km. in an east-west direction and forming a slightly undulatory table-land. The Naie colliery is the only one worked at present; its production was 17,255 tons in 1910 and 14,050 tons in 1911. The geology is quite similar to that of the Otaushinai field but the structure is much simpler, though several large faults make it difficult to correlate the coal-seams. A few small folds are also observed. The strike is generally north or north-north-west, and the dip generally about 60°, but near the Cretaceous the strike changes to north-east, and the dip to north-west at angles of 20° to 30°.

Numerous coal-seams are found in the eastern and western part of the field. Some of the seams in the Otaushinai field seem to thin out to the south, and a smaller number of them may be followed in this field, though the continuity of all of them has not yet been exactly proved and the two groups approach each other so that they cannot be distinguished. Seventeen coal-seams of good quality are known in the eastern part and four in the western. The average thickness of each seam in the eastern part is from 2.5 to 18 feet and the aggregate thickness 47 feet, but it reaches over a hundred feet where thickest and in places diminishes to 25 feet. The Naie colliery is situated near the Ishikari plain or 2 km. from Naie, the nearest railway station. The coal-seams at the colliery are considered to represent the upper horizon and form an elongated half dome in the north. The strike is generally north-south and the dip 60°. There are abundant outcrops of coal-seams, of which three are important. The aggregate thickness is 14 feet. In the north-western corner of the area, near the plain, many seams outcrop, of which one, 10 to 16 feet thick, is important.

Along the middle course of the Bibai-gawa, numerous outcrops of coal have been examined but only two seams have been followed for any distance. The eastern seam is undulatory, dipping at 10° W. in the north, and 20° E.S.E., in the south, while the western seam dips W. 20.° The average thickness is 6 and 5 feet respectively.

(4) THE IKUSHUMPET COAL-FIELD

The Ikushumpet coal-field lies on the north side of the Ikushumpet-gawa, extending about 8 km. in a north-south, and 15 km. in an east-west direction. Three collieries, Ikushumpet, Pompet and Mikasa are working, the production of the first two having been over 50,000 tons each in 1911, as follows:

	1909	1910	1911
Pompet....................	69,014 tons	87,310 tons	106,549 tons
Ikushumpet.................	77,062 "	83,667 "	72,974 "

A range of hills, between the Ikushumpet-gawa and the Bibai-gawa, runs through the middle of the area from east to west, rising highest in the central part. Alternating strata of thick sandstone and shale rest directly on the Cretaceous. The Cretaceous, which outcrops in the north-eastern part of the area, is bounded by faults. The Tertiary to the south of it is much disturbed and forms an elongated half-dome opening to the south. The coal-seams are cut off at the Pompet-gawa, where several faults are met with. The strike is N. 10° to 30° E., its eastern wing dipping steeply and the western at a rather low angle. The coal-seams that surround the Minenobu range form two long basins in a nearly east-north-east direction. The strike is east to N. 70° E., dipping with an angle of 30° in general.

In this field the coal-seams are both thicker and more numerous than in the Naie-bibai field, though the number is far less than in the Otaushinai field. Eight seams run south, almost parallel to the boundary with the Cretaceous, dipping west with a rather steep angle—60° to 75°. The average thickness of each seam varies from 3 to 8 feet, being mostly 4 to 5 feet, and the aggregate thickness is 35 feet. South of the Ikushumpet the seams run from north-north-east to south-south-west, the dip being steep to the east, or from 60° to vertical.

The coal-seams in the two basins flanking the Minenobu range are very numerous although only two or three in each basin are important. The outer basin, in the lower horizon, is greatly elongated in an east-west direction and is much disturbed in the southern wing. The angle of inclination is low—15° to 20°—in the northern wing and rather steeper, even 25°, in the southern wing. In the northern wing several faults occur in the eastern part of the area. The aggregate thickness of the seams varies from 10 to 13 feet. In the southern wing the coal-seams have an aggregate thickness of 12 feet and were formerly worked at the Minenobu colliery.

Still farther south, two important seams, each 6 feet thick, run nearly east-west, dipping S. 35°. In the north they seem to form an anticline, though they are cut off by faults at both ends. The Mikasa colliery is working in this district at present.

In a small basin, near the top, two out of nine seams have a thickness of nearly 3 feet. The angle of inclination is nearly 25°.

(5) THE PORONAI COAL-FIELD

The Poronai coal-field embraces the southern part of the region drained by the Ikushumpet-gawa, covering an area about 16 km. in a north-south, and 13 km. in an east-west direction. Three collieries, Poronai, Poromoi and Manji are working, although the two last named have yielded less than 50,000 tons a year. Poronai produced 196,176 tons in 1909, 170,415 tons in 1910, and 151,584 tons in 1911. To the east a Cretaceous ridge projects southwards like a promontory, and on it the coal-bearing Tertiary lies, dipping east with an angle of 60°. In the southern part another large area is occupied by the Cretaceous, surrounded by Tertiary strata, dipping away from it at angles of 20° to 30°. Near the Cretaceous, numerous coal-seams are found which are considered to be continuations of those at the Ikushumpet colliery. Eight seams have been followed, but southwards they are much disturbed and diminish in number by uniting or thinning out.

Farther south, where the seams bend eastwards, following the boundary of the Cretaceous, they again increase in number and the structure becomes more complicated, an anticline occurring, the western wing of which still retains its original direction across the Poromoi-gawa, where foldings and faults are met with. The eastern wing, after bending eastwards, again turns north, fringing the Cretaceous until it is cut off by a fault. Only two important coal-seams have been traced with average thicknesses of from 2 to 8 feet and an aggregate thickness of 24 feet in the north, and 12 feet in the south.

The Poronai colliery was the second opened in Hokkaidō, the Kayanuma being the first. There are fourteen coal-seams, of which five, over 2.5 feet thick each, are mined. They form an elongated dome, about 4 km. in its longer diameter, which trends N. 50° E. The angle of inclination is low in the north-western wing, being 15° to 40°, and steeper—or 50° to 80°—in the south-eastern. The south-western part is cut off by a fault, beyond which the coal-seams have not been exploited. The seams appear to represent the lower of those above described. The aggregate thickness is 20 feet.

To the south of the Poromoi-gawa also the coal-seams follow the boundary of the Cretaceous. Along the Poromoi-gawa four important seams run southward dipping E. 20°, and are at one place cut off by a fault. In the south they run east-south-east, dipping north-north-west, with an angle 20° to 30°; to the north of the Manji colliery they bend southward following the boundary of the Cretaceous. Of the numerous seams, six are workable, with an aggregate thickness of 17 feet, in the west, but, to the east, they decrease in number and at the Manji colliery only two seams, 3 and 5 feet thick, are being worked.

The Poromoi colliery is situated on the north bank of a tributary of the Poromoi-gawa. There are numerous outcrops of coal, and four seams can be followed. They form a small, elongated dome with a north-south axis 2,000 feet long. The angle of inclination is steep. The aggregate thickness of the four seams is 13 feet.

On the north-east, or east of the Cretaceous promontory, two groups of coal-seams run almost parallel to one another, dipping south in the northern, and east in the western wing. Of many seams occurring, these two are important. The upper group is said to lie about 1,500 to 2,000 feet above the western group already mentioned. The angle of inclination is generally 50°. The aggregate thickness of the seams of each group is 11 feet.

(6) THE YŪPARO COAL-FIELD

The Yūparo coal-field adjoins the Poronai field on the south and extends over an area 26 km. long and 10 km. wide. It has railway connection and is cut in two parts by the Yūparo-gawa. The field is the most actively worked among those in Hokkaidō, the following collieries having yielded over 50,000 tons in 1911:

	1909	1911	1911
First Yūparo	509,605 tons	471,371 tons	566,168 tons
Second Yūparo	139,710 "	128,678 "	148,203 "
First Shin-Yūparo	130,373 "	119,071 "	128,226 "
Second Shin-Yūparo	25,974 "	34,816 "	61,804 "

To the north of the Yūparo-gawa the seams form two groups, an eastern and a western, but in the south they seem to approach each other, or else thin out.

The area north of the Yūparo-gawa.—In the eastern part of the area, coal occurs along both slopes of a range of hills about 700 m. high running from north to south. The formation consists of shale and sandstone with conglomerate. Generally the strike is north-south, dipping E. 30° to 60°. In the north, however, the formation is disturbed by several faults, beyond which the important coal-seams cannot be followed, while in the south the seams have been moved eastwards, as a result of one large fault and several smaller ones, and strike N. 20° W., dipping E.N.E. 40°.

The known coal-seams may be classified into three groups. The lower two groups lie near the Cretaceous, to the east of the range of hills; conglomerate, 20 to 40 feet thick, is found between the two. The thickness of the coal varies, but by using the conglomerate as a horizon marker we can correlate the seams. Three seams in the lower, and two in the middle group, are known, the thickest being 13 feet. The third group lying to the west of the range is important, and is worked by the Ō-yūparo colliery. It, again, may be divided into two series with a vertical interval between them of over 100 feet.

The series on the east, which is situated about 300 to 400 feet higher than the other, consists chiefly of two seams, with a thickness 4.5 feet and 9 feet, respectively.

In the western series the Cretaceous limits the northern border, besides appearing in a small area along Ponporokapet-gawa. Important collieries, such as the First Yūparo and First and Second Shin-yūparo, are working in the area and are all connected with the railway. In the north, near the Cretaceous, the strike is nearly east-west, and farther south bends to the north-west, dipping N.E. 30°. Owing to faults the formation again turns to the north-east, dipping S.E. 25°. Faults are especially numerous in the middle part, near the First Shin-yūparo colliery, where the strata are severely disturbed and from which point a large fault runs farther southwards. Southwards the strata again turn to the north-west, dipping N.E. 30°. Near the main stream of the Shii-porokapet-gawa an anticline seems to run to the south to near the Yūparo-gawa, where the series is cut off by a large fault, the coal-seams being moved eastward.

The main coal-seam in the First Yūparo colliery is 24 feet thick, and about 180 feet above, and 280 feet below it, lie coal-seams, each being nearly 4 feet thick. They have been followed both to the north and south, though they suffer disturbance. One seam in the west, running from north to south and bending eastward in the south, probably corresponds to the main coal-seam mentioned above, but the upper and lower ones are lacking.

In the First Shin-Yūparo colliery, near which the formation is severely disturbed, three seams, 6, 8 and 10 feet thick, are being worked. They form an anticline, though a fault passes through almost the middle of the area. They seem to correspond to the main coal-seam which is divided by thick partings in the south and is very thin in the north. The upper and lower seams are, respectively, 6 and 2.5 feet thick in the south.

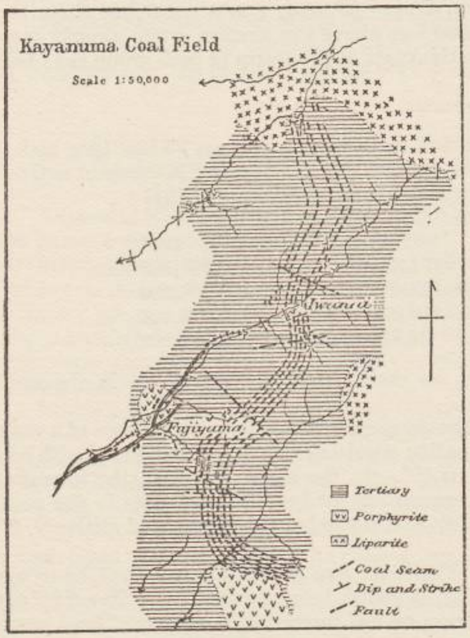
The area south of the Yūparo-gawa. This area is drained by two small tributaries of the river, the Maya and the Kuruki, and is worked at the mines of Mayachi, Kaede and Noborikawa, known by the name of the Second Yūparo colliery, being connected with the Yūparo by a tramway.

The coal-seams worked are three in Kaede and six in Mayachi, the thicknesses being 3 to 25 feet, in places as much as 60 feet. The formation consists of shale, sandstone and conglomerate, and strikes north, but westward bends to north-west.

The coal-seams in the area to the north of the Yūparo-gawa approach each other, though they are still arranged in eastern and western groups. In the east, six seams are said to be important, their thickness varying from 3 to 15 feet with a minimum aggregate thickness of 19 feet.

In the west, four seams outcrop in the middle of the area along the Panke-maya-gawa, and seem to extend to Kaede and still farther south, forming a syncline. The angle of inclination is rather gentle in the eastern wing, while that in the western is steep, varying from 40° to almost vertical. The upper seam is the thickest; at the Panke-maya-gawa it is 32 feet thick, with a parting of coaly shale 15 feet thick. In the deep workings of the Mayachi colliery the parting is absent, the workable coal attaining a thickness of 40 feet. The other three seams are, in descending order, 8, 9 and 2 feet thick. The aggregate thickness is said to be 30 feet.

Fig. 7



(7) THE PŌPET COAL-FIELD

The Pōpet coal-field occupies an area drained by the tributaries of the Pōpet-gawa, the main branch of the Mu-kawa, in the northern part of the province of Iburi. In the north this field adjoins the Yūparo coal-field. A heavy soil cover has prevented its thorough examination. Five coal-seams are now known to occur in the lower part of the Tertiary, but only two are worth mining. Of these the eastern one is 3 to 10 feet thick, averaging at least 6 feet, and dips W. 60° to 80°; it has been traced for about 3 km. The western one averages at least 6 feet in thickness and runs from about north to south, dipping W. 70° to 80°; it has been followed for about 4 km. There are other seams with as much as 2 feet of coal, but they have not been explored. Two coal-seams along the Mu-kawa have a thickness of 8 feet and strike N. 30° E., dipping W. 80°. Along the Ninyū-gawa, a tributary of the Mu-kawa, about 20 km. north-west of the seams referred to above, two other seams, 2.5 to 3 feet thick, are known to occur.

THE KAYANUMA COAL-FIELD

The Kayanuma coal-field (Fig. 7) lies in Kayanuma, in the province of Shiri-beshi, about 3 km. from the coast, with which it is connected by a tram-line. The coal is said to have been discovered in 1856, and was worked on a small scale before the Restoration of Meiji, when mining was stopped by the war. After the Restoration the mine was reopened by the Imperial Government and worked until 1883 when it was transferred to a private company. The production of coal was 15,779 tons and 21,391 tons in 1910 and 1911, respectively. The field occupies a hilly tract of country about 200 to 300 m. high, sloping to a terrace near the coast, nearly 20 m. high. The Tama-gawa drains the field from north-east to south-west, dividing it into nearly equal parts.

The coal-bearing formation consists of tuff, shale, sandstone and tufaceous conglomerate, and is intruded by igneous rocks, such as porphyrite and liparite. Though the formation has suffered disturbances that have caused numerous faults, yet the general strike is nearly north-south and the dip W. 35° to 40°, changing in the southern part to N. 70° W., dip S.W. 40°.

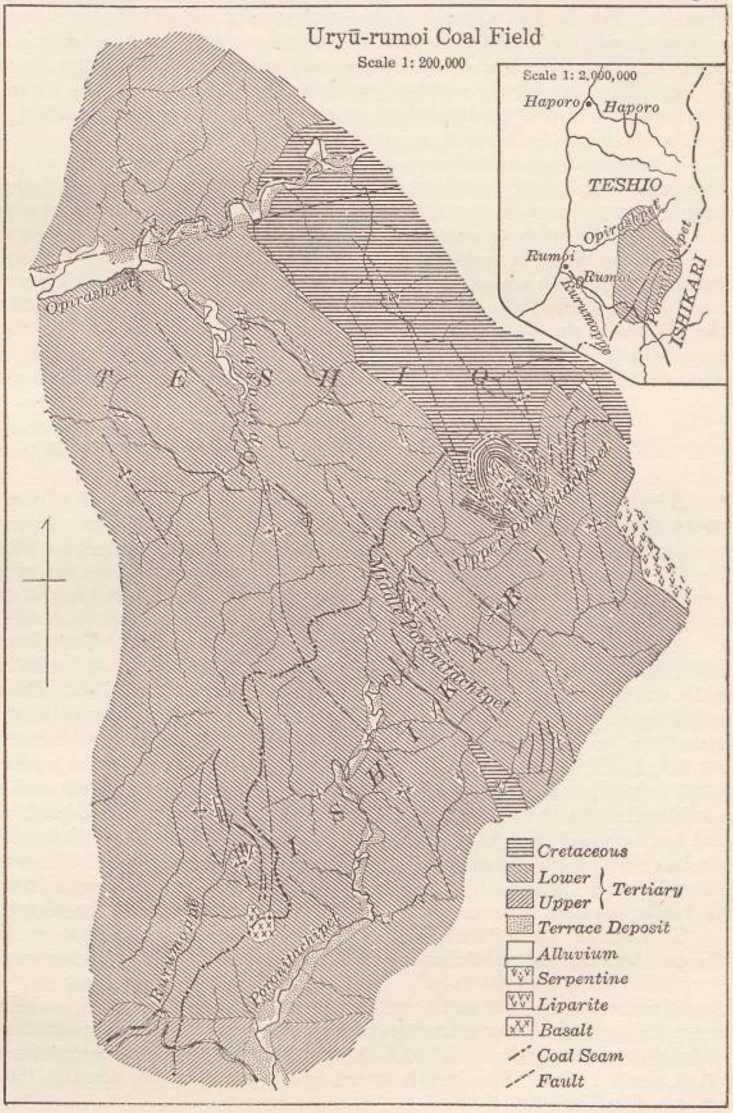
Six coal-seams, which may be followed for over 3 km., are being mined by two collieries, the Iwanai and the Fujiyama. The coal-seams are thickest in the middle portion, gradually becoming thinner towards both sides. The average thickness of each coal-seam, beginning with the uppermost, is 4, 7, 6, 6, 4, and 5 feet; or 2.5, 4, 3, 5, 3, and 3 feet of available good coal. The third and fifth seams are not worked because of their thinness and inferior quality.

The coal above the level of the entries has mostly been worked out, the amount still remaining being estimated at only 176,226 tons. As no drilling has yet been carried on we do not know the extent of the coal down the dip. However, we are very sure that the seams may be worked 1,000 feet below the surface level and the coal in that block is therefore calculated as actual reserves. The coal in the next 1,000 feet below has been calculated as probable reserves. Thus the amounts are 6,500,000 tons for actual and 25,000,000 tons for probable reserves.

The coal is black and lustrous and breaks with a conchoidal fracture. As a result of disturbances, some of it is badly crushed, as in a part of the Iwanai colliery. The result of a proximate analysis of the coal is as follows:

Moist.	Vol. mat.	Fixed C.
1.97%	34.88%	53.05%
Ash	Sulph.	Sp. gr.
10.10%	1.84%	1.302
Cal.	B.T.U.	Class
6,796	12,053	C

Fig. 8



The Uryū-rumoi Coal-Field

The Uryū-rumoi coal-field (Fig. 8) covers an area east of the port of Rumoi, lying near the boundary line between the provinces of Ishikari and Teshio. The district is undulatory and hilly, one main range of hills running north-north-east with an average height of 400 to 500 m. Three rivers drain the field, the Opirashpet in the north, the Rurumoppe in the south and the Poronitachipet in the east.

The Cretaceous formation constitutes the north-eastern part of the field and is composed chiefly of shale with sandstone and conglomerate. The Tertiary, in which the coal-seams are interbedded, is divided into a lower and an upper series. The lower series occupies a large area, and attains a thickness of over 8,000 feet. It seems to overlie the Cretaceous without interruption, while the upper series lies unconformably upon that system. The lower series may be again subdivided into lower and upper parts. The lower part consists of alternating strata of shale and sandstone with conglomerate and important coal-seams, the total thickness, where best developed, reaching nearly 5,000 feet. The contained fossils are not sufficient to determine its geological age, though they tend to prove that it represents the Miocene. The upper part consists chiefly of shale with sandstone. The coal-seams, as at present known in it, are all thin, and not important.

The upper series occupies areas north and south of the lower and may also be subdivided into lower and upper parts. The lower part is exposed in the north and consists of shale and sandstone with numerous conglomerate layers, while the upper part covers the southern portion of the area and consists of the same kinds of rocks, which are, however, generally tufaceous. The coal-seams in the upper part are worked near Rumoi, though they are less important than those of the lower series. Only a few of the fossils in the series have been determined; they are considered to represent, probably, the Pliocene.

Terrace deposits, chiefly of gravel with layers of sand and clay, cover a narrow area along the rivers and rivulets. Serpentine is found in the eastern part, where it forms a conspicuous mountain. Liparite and basalt, which intrude both the Cretaceous and Tertiary, occupy a small area. The structure is complicated. Generally speaking, the strike is east-west in the northern part, north of the Opirashpet, while to the south four anticlines and synclines run nearly north-north-west, the inclination of the wings being 40° to 70° in general. Faults are common and, except an important one in the north running east-west, the chief ones traverse the district in a nearly north-south direction, as shown in fig. 8.

Coal-seams are very numerous, the number of those which have been traced in at least two places, with a thickness over 3 feet, reaching thirty-seven. Some of these are without doubt repetitions of the same seam, brought to the surface by folds or faults. As a detailed geological survey of the area has not yet been carried out, it is not possible to correlate each of these coal-seams, and for convenience I describe them one by one. In upper Poronitachipet eighteen coal-seams are known, the largest being over 30 feet thick, while in the middle Poronitachipet ten seams are known, one having a maximum thickness of 25 feet. Of five seams in upper Rurumoppe, one was followed for about 5 km., the thickness varying from 6 to 20 feet. In Opirashpet there are four seams, the thickness sometimes reaching 20 feet. Many other seams outcrop, but their continuity has not yet been ascertained. The seams near the port of Rumoi, in the upper series, are the only ones that have been proved. The coal is bituminous and generally caking. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
5.62%	40.05%	46.74%	7.59%	0.74%	1.316	6,494	11,689	C

The upper Poronitachipet section occupies the eastern part of the field, lying along the boundary line between the two provinces. The section is uninhabited and is not easily accessible at present, though the railway passes through Rumoi which lies about 20 km. south of the field. The coal-bearing Tertiary rests directly on the Cretaceous in the north and forms a plateau with an elevation of 400 to 500 m. A north-south anticline traverses the centre of the area and two synclines run almost parallel to it to the east and west. Three faults are conspicuous, the one in the west corresponding to the synclinal axis.

The central part, between the two synclinal folds, is the most important and contains ten coal-seams, the correlation of the upper three not being known. The angle of inclination near the synclinal fold is 40° to 50°, while near the anticline on the east it is steeper, being 60° to 70°. The average thickness of the seams is, in descending order, 2, 3, 6.5, 4.5, 5, 6, 7.5, 14.5, 3, and 8 feet, respectively. The sixth and ninth seams have been traced far eastwards, across the anticlinal fold; the distance each seam has been followed is 0.3, 0.7, 0.3, 1.5, 2.6, 4.7, 2.5, 2.6, 3.8, and 2.5 km. The depth of the sixth seam at a point under the axis of the syncline is about 1,000 feet below sea-level. To the east of the central part three coal-seams were examined, the lowest being considered to be the continuation of the fifth seam of the central part. The upper seam dips E. 70° in general, and has been followed for 2 km., with an average thickness of 22 feet, or 19 feet of workable coal. The lower one has been traced for only 0.5 km. It dips E. 45° to 75°. To the west of the central part, beyond the fault, six coal-seams are found dipping generally S.S.W. 70° to 80° or sometimes vertical. The average thickness of the six, beginning with the upper, is 3, 10, 7, 8, 3.5, and 4 feet and the length traced 0.2, 1.5, 1.6, 1.2, 1.2 and 0.9 km.

The middle Poronitachipet section borders the above section on the south-west and is also uninhabited. The coal-bearing formation forms an anticline and a syncline running north-north-west. The angle of inclination is variable, being from 40° to 80°. A great many coal-seams outcrop, but in thickness and quality the coal is much less important than that of the section described above. Of ten coal-seams six lie to the north and four to the south, their relations to one another being unknown. The average thickness of the seams in the north, beginning with the most westerly, is 8.5, 3.5, 3.5, 3.5, 10 and 6.5 feet, and of those in the south, in descending order, 4.5, 3.5, 8.5 and 7 feet. The length traced in the north is 3.4, 0.8, 0.8, 0.6, 1.5 and 0.5 km. and that in the south 1.8, 1.3, 1 and 0.4 km.

The Rurumoppe section lies south-west of the last described section and is about 8 km. from Tōgeshita railway station. It is, thus, the most conveniently situated part of the coal-field. The structure is simple though the formation suffers slight local disturbances with one anticlinal fold running in a curve from north to south like a bow. A fault cuts the formation, dislocating it to the north. Of the five coal-seams known, the lowest, which is the most important, has been traced for about 5 km., and dips east or north-east, the angle of inclination being generally 50° to the south of the fault, but steeper to the north of it. The thickness varies from 6 to 20 feet, being 12 feet on an average. The four other seams are of less extent, and can be followed for only 0.2 to 0.4 km., the average thickness being 3.5 feet.

The Opirashpet section embraces the northern part of the field and is a hilly district rising 300 to 400 m.

in elevation. A broad synclinal fold traverses the section from north to south, while a great fault runs from east to west in the north. Four coal-seams are found, all to the south of the fault, where the formation strikes north-north-west. The correlation of the seams has not yet been worked out, though they appear to be repetitions of the same seam. The important seam on the eastern limb of the syncline is 3.7 km. in length and 6 feet in thickness, while that on the western limb often parts into two or three seams, having an aggregate thickness of 15 feet on an average. The two other seams are 1 and 0.6 km. in length and 3 and 6.5 feet in thickness.

Many other outcrops of good coal which have been examined but not followed are not considered here, though they seem to promise a tolerably large amount of coal.

The Rumoi section lies in the south-western part of the area near the port of Rumoi. It is the only area of productive coal contained in the formation that is considered as the upper series. The Ōwada colliery is situated about 6 km. south-east of Rumoi, lying very near the railway station of the same name. The coal is worked on a small scale. The formation consists of shale and sandstone with conglomerate. One coal-seam is now being worked, striking N. 60° W. and dipping N.E. 30°. The thickness is 5 feet on an average and the seam can be traced for about 1 km. Three faults have been met with, the eastern one being important.

As no boring has been done in the field and no coal-seam yet been mined, except in the Rumoi section, it is impossible to tell the depth of the coal-seams. However, the seams are thick and numerous and I take a depth of 500 feet below the surface, together with the length actually traced, as a reasonable measure of the actual reserves. Thus the amount calculated is 13,200,000 tons for actual and 250,000,000 tons for probable reserves.

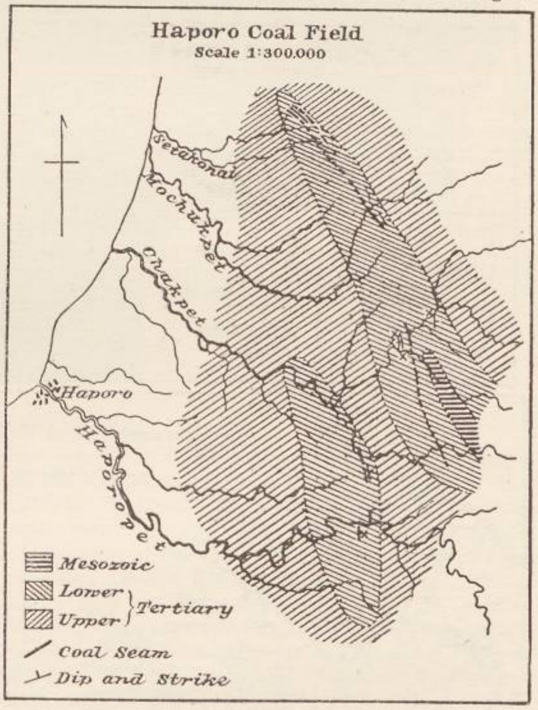
The Haporo Coal-Field

The Haporo coal-field (Fig. 9) is situated in the central part of the province of Teshio, extending in a north-north-west direction to the east of Haporo and Chukupet near the west coast. The coal-bearing formation consists of shale and sandstone, with associated white tuff in places, and is regarded as the lower series of the Tertiary. Though the strata suffer local disturbances, the general strike is north-north-west, forming two anticlines with an angle of 30° to 60° on both wings.

In the eastern anticline area, the coal-seams along the eastern wing of the fold, in the northern part, dip E.N.E. 35°, while no coal outcrops in the western wing to the north. Of numerous seams, three are important, their general thickness being 3 feet, in places increasing to 7 feet; they may be traced about 6 km. They were formerly worked in the extreme north. The coal-seams of the western wing are found only in the southern part, where only thin seams occur in the eastern wing. Of several coal-seams, two can be traced for about 4 km., the thickness being 3 to 5 feet.

In the western anticline area, only two seams are considered important. Towards the north, two seams, dipping E.N.E. 35°, are 1.5 and 8 feet thick. The Washimine colliery, situated about 16 km. east of Haporo, has two important coal-seams. The one to the north of the Haporo-gawa dips N.E. 45°, and has been traced for over 1 km. The thickness is 13.5 feet or 6.5 feet of good coal. The other, to the south of the river, can be followed for about 1 km., dipping W. 30° to 50°. The thickness is 12.5 feet, or 5.5 feet of good coal. It is cut off in two places by faults. The two seams are probably identical, outcropping in both wings of the anticline. As transportation is not good, the production is insignificant, being only 75 tons in 1911. The coal is probably a variety of lignite, and is non-caking. The result of a proximate analysis is as follows:

Fig. 9



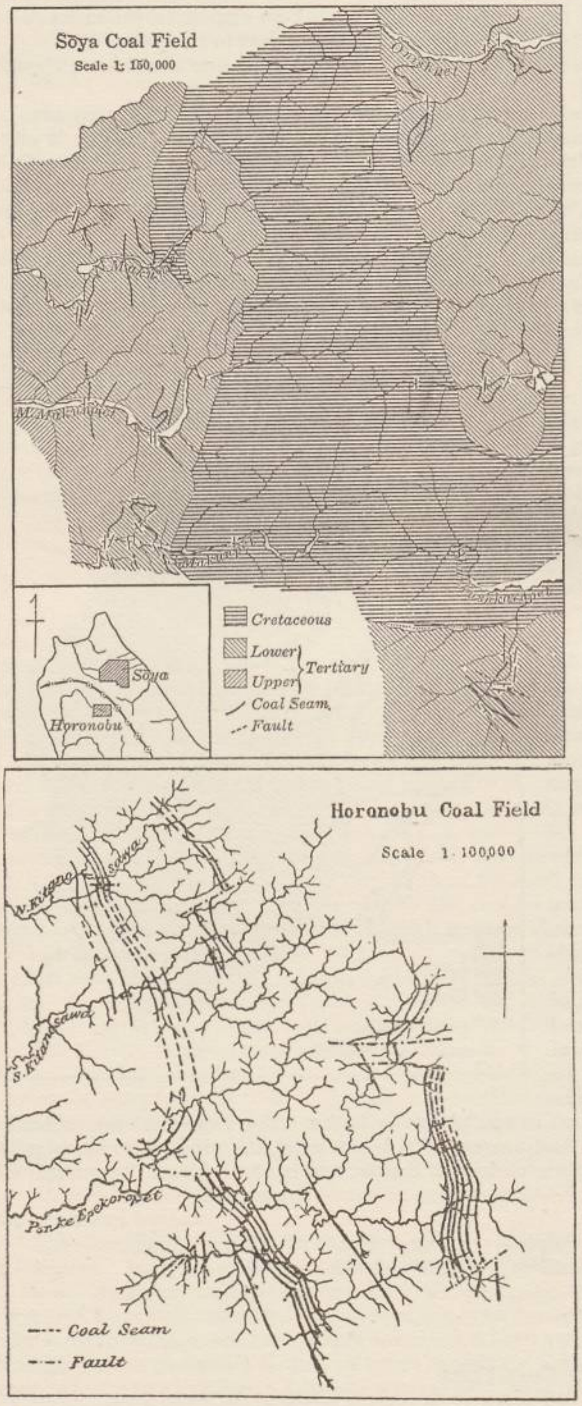
Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
14.29%	42.95%	40.13%	2.63%	0.27%	1.255	5,445	9,801	D_1

The amount of coal estimated is 35,000,000 tons.

The Horonobu Coal-Field

The Horonobu coal-field (Fig. 10) extends along the upper Panke-epekoropet in the northern part of the province of Teshio, and represents the continuation southerly of the Sōya coal-field. The surface of the area is low and undulatory, the elevation rarely exceeding 200 m. Five years ago coal was mined on a small scale by the Horonobu colliery, but owing to the difficulty of transportation mining was soon abandoned.

Fig. 10



The coal is a variety of lignite, and is non-caking. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash
11.51%	39.79%	40.39%	8.31%

Sulph.	Sp. gr.	Cal.	B.T.U.	Class
0.47%	1.361	5,372	9,669	D_1

The district forms part of a widespread area of Tertiary strata consisting of shale, sandstone and conglomerate. The coal-bearing formation consists chiefly of sandstone and conglomerate, with shale, and represents the lower part of the Tertiary. The strike is north to north-west and the dip is both east and west, a syncline and an anticline occurring there. The angle of inclination is generally moderate, or 40° to 50°, but in places it is as steep as 70° to 80°. Numerous faults cut the coal-seams, dislocating them to the east or to the west. Three conspicuous faults are met with in the east, while, to the west, four are probably important.

More than ten seams are known, generally interbedded in shale, rarely, in sandstone. Six important coal-seams are found in the east, and are cut off by faults to the north and south. Beyond the faults only two or three of the seams have been traced. The thickness, beginning with the uppermost, is 3, 7, 8, 6, 5, and 7 feet, and the length is 1.5 km. for each of the upper two, 1 km. for the third and ½ km. for each of the lowest three. Three seams, in the north, have a thickness of 6.5 for the upper and 6 feet for each of the lower two, and a length of 500 to 1,500 feet; while two seams to the south of the fault are 2 and 4.5 feet thick, their length being 500 to 600 feet.

The western coal-seams seem to be a repetition of those on the east, though they are fewer in number and are cut by a fault nearly in the middle of the area. The coal-seams to the north of the fault dip nearly east with an angle of 40° to 50°, except one seam in the west, which dips W. 70°, forming a syncline. They are again cut off by faults on the north. They may be divided into two groups, an eastern group, carrying two important seams and a western carrying three. The thickness of the two seams of the eastern group is 4 feet each, with a length of over 1 km., while, in the western group, in descending order, the thickness is 4.5, 6, and 2 feet, and the length of 2.4, 2.4 and 1.1 km., respectively. To the south of the fault the dip is E.N.E. 40° to 50° on the eastern side of the anticline, where four seams have a thickness, beginning with the uppermost, of 3.5, 4.5, 5, and 2 feet, the length varying from 4,000 to 5,500 feet. Two seams on the western side of the anticline are 5 and 9.5 feet, but their ascertained length is only 600 to 1,000 feet.

From the data above given we get 170,000,000 tons for probable reserves

Coal is found in the Tertiary which extends southwards to the provinces of Teshio and Ishikari, especially along the tributaries of the Teshio-gawa, in the province of Teshio, also along the upper course of the Uryū-gawa in the province of Ishikari. The known coal-seams are generally thin and the coal is of inferior quality. In some places more than ten seams have been found, all, however, rather thin. The greater part of the district is unexplored.

The Sōya Coal-Field

The Sōya coal-field (Fig. 10) is situated in the central part of the northern promontory, partly in the province of Teshio and partly in Kitami. It extends over the northern end of the central mountain range of Hokkaidō which slopes gradually to the cape of Sōya, and falls away more abruptly to the Sōya strait, forming an undulatory plateau generally 200 to 300 m. in height. The district is uninhabited and not easily accessible, the settlements being found only along the coast. The Cretaceous formation, consisting of shale and sandstone, runs from north to south in the central part of the field.

The Tertiary overlies the central Cretaceous area on both sides, unconformably. It may be divided into two series, an upper, found in the western part of the field and consisting of loose sandstone and shale without coal; and a lower, consisting of tuff, shale, sandstone and conglomerate, containing coal, two seams being known in the east and more than two in the west. Generally the strike is north-south and several anticlines and synclines occur. From its geological relations, the series is considered to correspond to the upper coal-bearing series in other parts of Hokkaidō and in Karafuto.

To the east of the Cretaceous formation, one or two anticlines are known in the Tertiary, but to the south that formation ends in a bay-like extension overlapping the Cretaceous, about 3 km. north of the Shunkushukaripet valley, reappearing again in that valley and extending farther south. The total extension now known is about 25 km. in length, though the northern and southern parts have not yet been explored. In the portion to the north of the Cretaceous, two or three seams have been traced, the strike being nearly north-south, and the angle of inclination varying from 20° to 60°. The thickness is very variable, being generally 4 feet in the upper and 7 feet in the lower seam, though it sometimes increases to 10 feet. To the south of the Cretaceous the series is so severely disturbed that it is difficult to follow the seams, but at least two seams appear to be included, their thickness varying from 3 to 9 feet.

In the west the coal-seams appear to continue farther south, the known dimensions of the area being 22 km. long and 3 km. wide. The formation is much disturbed, forming anticlines and synclines, and the general strike is north-south. Three or four seams are known to occur, their thickness varying from 2 to 5 feet.

The coal reserves of the surveyed area are estimated at about 130,000,000 tons. The coal is a lignitic variety of superior quality, the result of its proximate analysis being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Class
13.57%	40.08%	38.14%	8.21%	0.54%	1.362	D_1

The Province of Kushiro

The three important coal-fields in the province of Kushiro are Kushiro, Shitakara and Shakpet, the latter extending farther westward, to the province of Hitaka. The coal-fields occupy an area of hilly land less than 200 m. in average elevation, gradually rising towards the north from the coast and forming the so-called Kushiro plateau. The coal-bearing formation consists of Tertiary shale, sandstone and conglomerate. As to the geological age of the formation, we cannot determine it with any certainty, as the fossil flora found in Harutori and Shakpet tends to prove that it represents the Miocene while the fossil fauna in Kushiro and Kombumori indicates the Pliocene. The dip is gentle near the coast, but gradually becomes steep farther inland. The coal in Shiranuka is said to have been mined before the Restoration of Meiji. In 1885 the Kushiro coal-field was opened but, owing to the thinness and inferior quality of the coal, mining is being done only on a small scale. The production in 1910 and 1911 was 65,144 and 65,336 tons, respectively. The coal is generally black and non-caking, the fracture being cuboidal or hackly. The result of a proximate analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
8.44%	39.92%	42.91%	8.73%	0.45%	C

The Kushiro Coal-Field.—This coal-field, lying on the east of Kushiro, is divided into three sections.

The Kombumori section is situated about 12 km. north-east of Kombumori, which lies about 11 km. east of Kushiro. The strata of the coal-bearing formation lie in low undulations, the dip angle being only 4°. The thickness of the coal is nearly 3 feet. The area, now known, is said to be only 0.6 sq. km. in extent, by which we get as the amount of contained coal, 700,000 tons. However, by further exploration the area will doubtless be much enlarged and a moderate amount of coal can be mined in future.

The Beppō-Ōsaka section occupies an area lying about 10 km. east-north-east of Kushiro, in it the two neighbouring collieries of Beppō and Ōsaka on the Beppō river, a tributary of the Kushiro-gawa, are being worked on a small scale. The coal-bearing formation consists of sandstone and conglomerate, with thin shale beds. The strike is north-north-west in general, dipping W. 4°–5°. There are numerous faults, one large one traversing the section from north to south. Of the two coal-seams known at present, the upper one is only one foot thick, or less, and is only found at the Beppō colliery in the north-western part. The lower seam, which is being worked, is 2 feet thick in general, but in places increases to 3 feet or diminishes to 1.5 feet. In the Beppō colliery all the coal above the level of the entry has already been worked out, while at the Ōsaka colliery only 0.9 sq. km. of the coal remains for future mining. As the coal tends to become thin underground and is cut by numerous faults, we take a depth 1,000 feet below the surface as the limit for probable reserves. The amount of coal thus estimated is 3,000,000 tons for actual and 5,000,000 tons for probable reserves.

The Harutori section, in which the Harutori colliery is working, is situated about 3 km. east of Kushiro. To the north the section is limited by Harutori lake, from the shore of which a tramline connects the colliery with Kushiro. The section lies in hilly land, sloping gradually to the sea with an elevation of nearly 30 to 50 m., the highest hill not exceeding 90 m. The coal-bearing formation consists of shale and sandstone, and in general dips W.S.W. 4°-5°, though numerous faults cut and disturb the strata. Of the three coal-seams known at present, the upper is thin and not workable; the middle is 4 feet thick with 2 feet of available coal, and the lower is 5 feet thick with 3 feet of workable coal, the vertical interval between the last two being 22 feet. The coal may be followed for over 3 km. and for the probable coal reserves our calculations have been based on a depth of 1,000 feet below the surface, including the submarine area. Estimated thus, the amount of coal is 5,500,000 tons for actual and 10,000,000 tons for probable reserves.

The Shitakara Coal-Field. This coal-field is situated about 3 km. north-west of Shitakara and lies about 20 km. north of Otanoshike railway station, adjoining Kushiro. The coal-bearing formation consists of shale and sandstone, the latter prevailing, and strikes north-east, dipping N.W. 3°-4°. Of two coal-seams, the upper is 2.5 feet thick, but of inferior quality; the lower, lying about 60 feet below the upper, is 3 feet thick, with a thin parting, and is said to widen to 5 or 6 feet. It is now worked by the Kushiro colliery, and has yielded 3,538 tons in 1910 and 3,580 tons in 1911. The area is not yet well explored and the area known at present is only 2 sq. km., which will surely be increased by exploitation and detailed survey. The probable amount of coal estimated is 4,000,000 tons.

The Shakpet Coal-Field. This coal-field is situated about 14 km. north of the town of Shakpet, on the sea-coast. Two coal-seams with a thickness of about 3 feet each, strike N. 20°-30° E., dipping S.E. 30° in general. The area now known to contain coal is estimated to be only 2.5 sq. km. and the probable coal reserves about 5,000,000 tons. The coal-field extends farther westward, to the province of Tokachi, and is believed to cover a large area, containing a large amount of coal.

As no detailed geological survey has yet been carried out, it is impossible to estimate the extent of the coal-fields or to correlate them with one another. Numerous outcrops of coal are found here and there between the coal-fields and elsewhere in the extensive Tertiary area which occurs in the province, especially in the southern half.

The Province of Tokachi

The Uraporo Coal-Field.—The Uraporo-gawa, a tributary of the Tokachi-gawa, drains the middle portion of the Tokachi district in the province of Tokachi. The coal outcrops in the southern half of the district, on the tributaries of the Uraporo-gawa which run from the east. The coal-field has not yet been surveyed, except in the case of the Rushin and Tokom-oro sections, about 14 km. north of Uraporo station.

The Rushin section lies adjacent to Tokom-oro on the west, on a hilly plateau about 200 to 300 m. high, underlain by shale, sandstone and conglomerate, the shale prevailing, especially in the lower part. The strike is N. 65° W. and the dip N.E. 10°-30° in the south, and S.W. 20° in the north, forming a syncline. In the Tokom-oro section the strike is generally N. 45° E. and the dip is south-east, the angle of inclination becoming steeper in the north, i.e., 30°-35° in the south-west, 45° in the middle and 70° in the north-east. Between Rushin and Tokom-oro a fault seems to run north-east.

Seven or eight coal-seams are known to occur, their respective thicknesses, beginning with the uppermost, being 1.4, 1.2, 0.5, 10, 1.2, 1, 2, over 3, and 5 feet. Of these the fourth, eighth and ninth seams are important and have been roughly surveyed. The fourth seam, which, in the Tokom-oro section, is over 10 feet thick, with thin partings, may be followed for nearly 12,000 feet along the strike. As it is cut off by a large fault from the Rushin section on the west, its continuation in that section is not clearly established. However, a seam in the northern part of the Rushin section seems to be the same bed, but no large amount of coal can be expected from it as it lies near the synclinal basin. The eighth seam is only known in the Rushin section, where its thickness seems to exceed 3 feet. The strike is N. 45°-55° W., dipping N.E. 30°, its length being about 6,000 feet. The ninth seam is the southernmost and it also is known only in Rushin. It is generally 5 feet thick with thin partings. It strikes N. 60°-75° W., dipping N.E. 30°, and, it is said, can be followed for about 6,000 feet along the strike. For probable reserves there has been calculated the known area to a depth of 2,000 feet below the surface level, or about 15,000,000 tons. The coal is bituminous and is said to be similar to the better quality in the Jōban coal-field.

Coal outcrops in a wide area which occupies the southern half of the Tokachi district, and though the Uraporo coal-field has not yet been surveyed it is generally believed to contain a large quantity of coal for future mining.

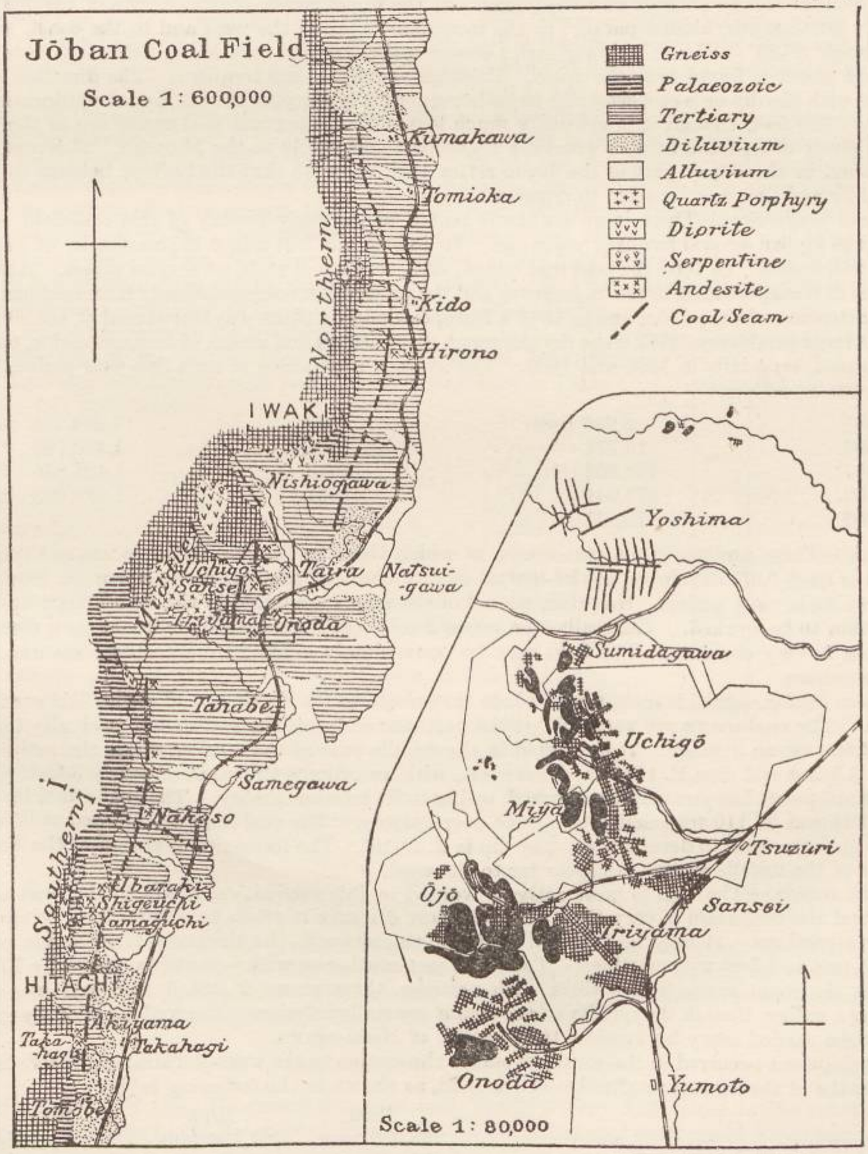
The Province of Hitaka

In the province of Hitaka coal is found in the Tertiary strata, which cover a wide area in the south-west. The Makunpet coal-field lies in the middle of the province, about 10 km. from the coast. It was opened in 1870, but one year later mining was abandoned, owing to the lack of means of transportation. The strike of the beds is N. 45° W. and they dip at an angle of 45°. Two coal-seams are known to occur, the upper being 3 feet thick and the lower 4 feet. The probable reserves have been estimated at 15,000,000 tons. The coal is a superior quality of lignite. The result of a proximate analysis being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Class
13.74%	39.20%	39.06%	8.00%	1.28%	D_1

Almost continuous with the Makunpet coal-field, coal-seams of various thicknesses have been examined,

Fig. 11



but the geological survey of the district has not yet been carried out, so that we have no data on which to base a description of them. The localities of Nioi, Horukawae, Kemanai, Niikap, Taushinai, etc., are known to contain coal.

3—HONSHŪ

The Jōban Coal-Field

Topography and geology.—The Jōban coal-field (Fig 11) lies along the Pacific coast, fringing the eastern flank of the Abukuma plateau and occupying a narrow district about 80 km. long. The railway from Tōkyō to Sendai runs along the coast, and the large collieries have been connected by branch lines, so that transportation facilities are good. It is a hilly or undulatory tract, sloping gradually to the coast and broken by rivers and rivulets flowing easterly to the sea.

The basement complex is composed chiefly of gneiss and other metamorphic rocks, with diorite and granite, on which the Tertiary lies unconformably. The Tertiary is best studied in the middle part and is conveniently subdivided into three series, a lower, middle, and upper. The lower series consists of shale, sandstone and conglomerate, being often tufaceous in the upper part, and is about 1,500 feet thick when best developed. The middle series consists chiefly of shale and sandstone, and the upper series chiefly of tuffs of various kinds. The strike is nearly north-south, almost parallel to the mountain range in the west and to the coast, and the dip is east with an angle 5°-20°. Thus the lower series occupies the western part of the field, and rests on the older rocks, while the upper is found near the coast. Foldings and faults are frequent. The direction of the faults often coincides with the dip or is east-west, the angle being generally steep, or 60°-80°, and the dislocation sometimes reaches nearly 1,500 feet, though it is generally much less. The important coal-seams are in the lower series, which, by the study of its fossil flora, is generally regarded as belonging to the Miocene. However, some of the fossil shells found in the upper part of the lower series tend to prove that the horizon belongs to the Pliocene, which the middle and upper series seem to represent.

History and production.—There is no authentic record of the early history of this coal-field, but it is said that the coal was known several hundred years ago. In 1853 it was first mined in the district of Taga and a few years later in Shiramizu. In 1868 the coal was mined, on a very small scale, at several places. About ten years later the means of transportation began to improve and the production correspondingly increased until the district attracted the attention of the public, and in 1884 a European mining plant was introduced at the Onoda colliery, now one of the large producers. With the development of industries and means of transportation, the production suddenly increased, especially in 1896 and 1900. The average production of each five year period, and recently of each year was as follows:

1887	5,255 tons	1908	1,264,135 tons
1892	19,774 "	1909	1,425,702 "
1897	163,955 "	1910	1,424,836 "
1902	673,941 "	1911	1,633,083 "
1907	1,178,951 "		

Coal-seams.—There are numerous coal-seams, of which those in the middle series are not important. As the formation is most fully developed in the central part of the field, the coal-seams there are thick and good in quality and mining is most active. However, not all of the seams are found in the middle part and some found there are too thin to be worked. Generally two seams 3 to 4 feet thick may be followed for a distance, though local thickening is very common. The field may be conveniently subdivided into three sections, a northern, middle, and southern.

The northern section.—In this section we include the area from the northern end of the field southward to the plain of Taira. The coal-seams are very thin at the northern end, but the main seam gradually thickens to the south, being 2 feet on an average. It is worked in the middle part of the section, where the main seam attains a thickness of 3.5 feet and dips E. 15°-18°. One seam, with an average thickness of nearly 3 feet, about 150-200 feet above the main one, has not yet been worked, owing to its inferior quality. The coal raised by the collieries in 1910 and 1911 was 33,110 tons and 67,008 tons, respectively. The coal may be followed still farther southwards, but its quality seems to deteriorate. The dip is E. 5°-10°. The formation is cut off at the Taira plain and the coal-seams of the middle section reappear far to the west.

The middle section.—The coal is most actively worked in this section, especially to the west of Taira. At the northern end the coal-seam is very thin, but in a short distance it swells to several feet, being nearly 6 feet thick, including partings. It may be followed south-south-eastward, the thickness of workable coal being 2.5 feet in general, or 4 to 7 feet with partings. The dip is east-south-east with low angles, generally 10°. In Nishi-ogawa, besides the main seam, 8 feet thick with partings, three seams 2 and 3 feet and one 0.9 ft. thick are found along a valley, though the quality of the coal is generally inferior. The coal is cut off by granite, or the Tertiary has been carried away by erosion, to the south of Nishi-ogawa.

Great development occurred in the southern part of the section to the west of Taira, where five large collieries yield three-fourths of the annual production of the field, as shown in the following table:

	1909	1910	1911
Iriyama	238,930 tons	251,736 tons	270,759 tons
Uchigō	231,519 "	258,921 "	317,927 "
Onoda	159,887 "	169,678 "	189,804 "
Yoshima	156,659 "	158,150 "	180,914 "
Sansei	4,306 "	54,153 "	125,269 "
Other collieries	326,047 "	191,506 "	141,197 "

The geological structure is very complicated, anticlines, synclines and faults being common, but the strike is generally north-north-east and the dip east-south-east at a low angle, often less than 10°. The coal lies very nearly on the basement complex or directly on it. Six coal-seams (Fig. 12) are known to occur, their thicknesses, beginning with the uppermost, being 2, 3, 5, 2.5, 1, or 2.5 feet in general, the third seam being the principal one. Local thickening occurs in many places, the coal widening to 9 feet and over. In the north, where the Yoshima colliery is working, the main seam shows 5 feet of workable coal of rather inferior quality, the seam being 7 feet thick with four thin partings, and the upper or second seam shows 8 feet of workable coal of good quality, the seam being 9.5 feet thick with four thin partings.

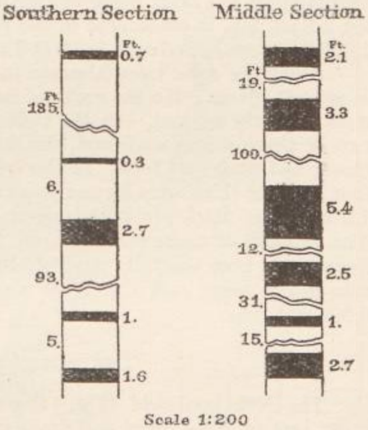
To the south are the collieries of Iriyama, Uchigō, Sansei, Onoda, etc., which lie in close proximity to one another and are the most actively worked. A great fault traverses the middle of the district, dividing it into two areas which may be described separately.

In the area to the north are the collieries of Uchigō, Sansei, etc., where three coal-seams are found. The main or third seam is 7.5 feet thick, the upper or second seam 6 feet, and the lower or fourth 2 feet, thin partings being present in all of them. Generally the dip is E. 12°. Near Tsuzure railway station, where the Sansei colliery is working, the main seam widens to over 8 feet thick, and in the south, where the Miya colliery is working, two lower seams, each 1 foot thick, besides the main one, are found. The aggregate thickness of workable seams is 13 feet.

In the area to the south-west of the fault, the well-known collieries of Iriyama and Onoda, are situated. Three important seams occur there, 4, 6-8, and 2-3 feet thick, the best being the middle, or so-called main or third, seam. Many thin partings are found in the coal-seams. In general the strike is north-south, dipping E. 12°. Southwards the seams become thin and are cut off at the drainage plain of Tanabe by a great fault.

The southern section.—In this section there are five or six coal-seams, their correlation with those of the middle section having not yet been ascertained. In the northern part of the section the coal is mined on a small scale along the Same-gawa and its tributaries. The production was 91,229 tons in 1910 and 78,473 tons in 1911. The main seam is important here and its thickness is, in general, 3 to 4 feet, though the quality is rather inferior. However, the first seam increases locally to a thickness of 3.5 feet, being worked in the Nakoso colliery in the southern part.

Fig. 12



In the middle part of the section three collieries, Shigeuchi, Ibaragi-muentan and Yamaguchi-muentan, each yielded over 50,000 tons in 1911, as shown in the following table:

	1909	1910	1911
Shigeuchi..	77,844 tons	80,542 tons	74,532 tons
Ibaragi-muentan.	65,964 "	66,219 "	68,322 "
Yamaguchi-muentan.	......	42,211 "	52,201 "

Of five seams (Fig. 12) two are generally workable, the lower being of good quality and 2.5 to 5 feet thick, while the upper is rather inferior and 1 to 2.5 feet in thickness. Though the formation is disturbed, the general strike is north-south, dipping E. 15°.

In the southern part of the section the collieries of Takahagi and Akiyama, etc., are being worked, and yielded 47,958 tons in 1910 and 61,566 tons in 1911. One main seam is workable, its thickness varying from 2.5 to 5 feet, and, in the Akiyama colliery, attaining a thickness of over 10 feet, with partings, or 7 feet of workable coal. To the south it is cut off by granite and metamorphic rocks or is covered by diluvium, and no coal can be traced there.

Quality.—The coal is generally black and non-caking, the fracture being hackly. The result of a proximate analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
12.24%	40.61%	36.11%	11.04%	1.02%	1.381	5,423	9,759	D_1

Quantity.—Except in a few limited areas, the coal-seams have not been surveyed. Near Yumoto, borings have been sunk far below 2,000 feet, but they have not in all cases been successful, and the coal has been proved to occur underground only in a few places. The estimate given below is based mainly on the geological structure. It is 43,500,000 tons for actual and 306,000,000 tons for probable reserves.

The Aburato Coal-Field

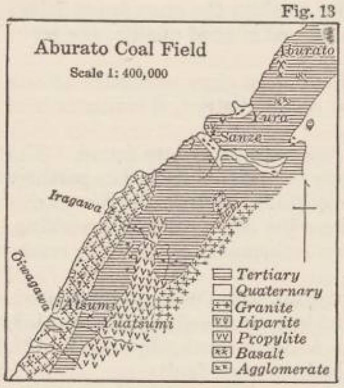
The Aburato coal-field (Fig. 13) covers a narrow belt, nearly 20 km. long, close to the coast of the Sea of Japan, south-west of Sakata in the province of Uzen. In the north the coal outcrops in Aburato and runs south-westwards along the coast to Atsumi, cropping out here and there near the coast. The coal is of an inferior bituminous variety, the result of an average proximate analysis being as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
3.92%	33.27%	46.69%	16.12%	0.95%	1.368	7,150	12,870	C

The field was opened in 1879 by the Imperial Government and, after ten years' working, was transferred to a private company. The output of the Aburato colliery, the only one worked at present, was 6,174 tons in 1910 and 6,363 in 1911.

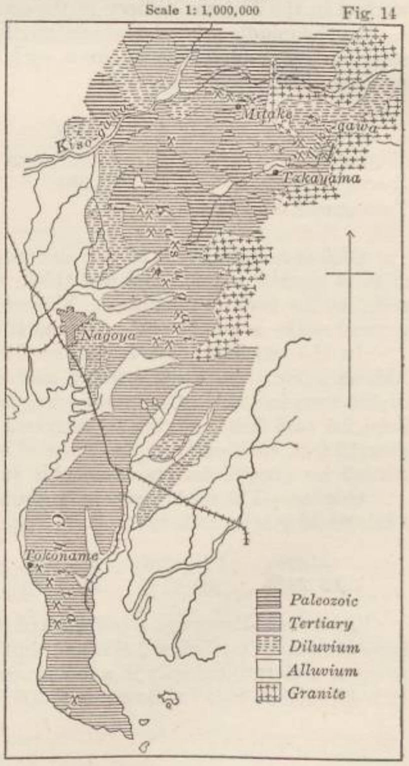
The Tertiary strata, which cover a wide area near the coast, consist chiefly of tuff and tufaceous conglomerate in the upper, shale in the middle, and tufaceous shale and sandstone in the lower series, three coal-seams being interbedded in the middle and lower series. Basalt dykes intrude the formation, but they have no direct influence on the coal. The northern part of the field, in the environs of Aburato, constitutes an important area which is worked by the Aburato colliery. The colliery is situated to the south-east of the town of Aburato. Of three coal-seams, the uppermost is most important and is the only one worked. Its thickness is from 4 to 8 feet with partings, but that of clean coal is only 4 or 5 feet. The middle seam lies 14 to 18 feet below the upper and is 3 feet thick with a parting, or has 1.5 ft. of clean coal. The lowest seam, lying 8 or 9 feet below the middle one, is 3 feet thick with a parting, or has 1.2 ft. of clean coal of inferior quality. Two unimportant seams are known below the lowest seam. The strike is N. 40° E. in the north, but, toward the south, it gradually approaches a north-south direction, with an average dip of 30°. An anticline in the east forms the hills that rise in that portion of the field. As the upper part of the Tertiary on the eastern wing of the anticline has been eroded away, the quantity of coal on that side is very small. Most of the seams on the western wing are worked, but many faults are met with. Generally the seams tend to become thin in the east and future mining will be carried on in the southern and western parts, below sea-level. To the north of the river emptying into the sea at Aburato, no outcrop is seen, though the coal is probably present deep down, the measures having been dropped by a fault. As no close examination has been made of the district, only a small area containing 2.8 sq. km. is considered in the estimate given below. This gives 1,000,000 tons actual and 5,000,000 tons probable reserves.

Fig. 13



Along the coast from Aburato to Atsumi the coal has been worked at several places. To the north of Sanze two seams 1.7 to 2 feet thick, were formerly worked. In the collieries in the environs of Ira-gawa, two or three seams are found, the thickness in general being 2 feet, in places widening to 4 feet. In the collieries near Atsumi, coal-seams 1 foot to 3 feet thick were formerly worked. Near Ōiwa-gawa two seams 1.5 to 2 feet thick are found along the coast, dipping W.N.W. 25°. The relation of these seams to one another and to those in Aburato has not yet been carefully studied; but the quantity of coal they contain is not large, and the total amount probably does not exceed 5,000,000 tons.

Fig. 14



The Nōbi Coal-Field

The Nōbi coal-field (Fig. 14) occupies an extensive hilly district lying east of Nōbi plain and drained by the Kiso-gawa, and includes the Chita peninsula. It is bounded on the north and east by Palæozoic and granite mountains and projects southwards to form the Chita peninsula. The surface is low and undulatory, being only 100 m. in height and cut up by many rivers and rivulets. The beds containing the coal consist chiefly of sand, pebble and clay with tuffs and volcanic ash. The coal-bearing formation rests on the Palæozoic or granite unconformably and lies in a horizontal or slightly undulatory attitude, the angle of inclination being quite low, in rare cases as great as 15°. In the north the coal-bearing formation may be conveniently divided into three sections, separated by areas of the Palæozoic and granite on which it rests.

The coal was known in remote times and it is said to have been mined nearly three hundred years ago. Since the Restoration of Meiji the production has gradually increased, the coal being used mostly as fuel for silk, cotton and other small factories, and locally as a substitute for wood and charcoal. The production of recent years together with that of each five years is as follows:

1879.....	303 tons	1894.....	2,375 tons	1907.....	58,547 tons	1910.....	83,198 tons
1884.....	256 "	1899.....	7,373 "	1908.....	68,333 "	1911.....	78,382 "
1889.....	88 "	1904.....	38,667 "	1909.....	81,433 "		

The coal is a lignite of very inferior quality. An average proximate analysis of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Property	Class
14.77%	39.77%	27.82%	17.64%	0.28%	Non-caking	D_2

The Toki section.—This section lies to the east of Takayama and occupies the north-eastern corner of the field. The Toki-gawa runs through the central part of the district from east to west. The coal-bearing formation lies in a granite basin, unconformably, and dips toward the centre of the basin, the angle of inclination being 5° to 10°, but, locally, becoming 25° in a few places. One workable coal-seam is found, its average thickness being 2.5 to 3 feet. The amount of coal has been estimated at about 2,000,000 tons for actual and 5,000,000 tons for probable reserves.

The Mitake section.—This section occupies the northern part of the field. The coal is mostly worked on the north side of the highway between Mitake and Fushimi along the Kani-gawa, a tributary of the Kiso-gawa. The coal-bearing formation is bounded on the north by the Palæozoic, on which it rests unconformably. The dip is generally south at an angle of 5°. One coal-seam is important. The thickness in the east is 4.5 to 8 feet, while to the west it is 3.5 to 5.5 feet, or 4 feet on an average. To the south of the river the seam becomes still thinner and is worked at one colliery only, where the thickness of the coal is 2.5 feet. The amount has been estimated at about 1,500,000 tons for actual and 2,000,000 tons for probable reserves.

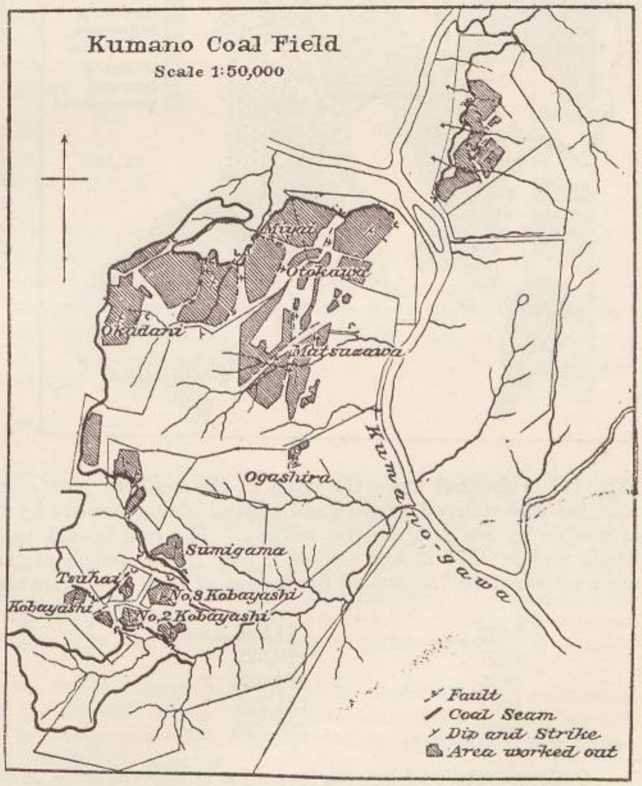
Fig. 15

Scale 1:200

The Kasugai section.—This section is the most important in the field, occupying the middle portion on the east of the Owari plain, where it covers an area about 20 km. long in a north-south direction. In the north the coal-bearing formation lies on the Palæozoic and in the east on the granite. It is slightly undulatory or almost horizontal. Three coal-seams are known to occur. The lowest is the only one workable and seems to correspond to the upper seam in the Chita peninsula. Its thickness is 5.5 feet, but the good portion varies from 1.5 to 5 feet. Two other seams have been proved to exist about 50 feet below it, their thickness being estimated to be 3 feet each (Fig. 15). Southwards the seams become thin and inferior in quality. The amount of coal has been estimated at about 9,500,000 tons for actual and 21,000,000 tons for probable reserves.

The Chita peninsula.—Coal is found in the southern half of the Chita peninsula. The coal-bearing formation runs nearly parallel to the west coast, generally dipping to the east at an angle of 4° to 5°, rarely 15°. Four coal-seams are known to occur; they are generally thin, in many places less than one foot thick. The lower three lie very close together often all within 20 feet, the lowest being the one generally worked. Its thickness is 1 to 2 feet, but in places it increases to 3 feet. The coal reserves are small, being estimated at only 2,000,000 tons.

Fig. 16



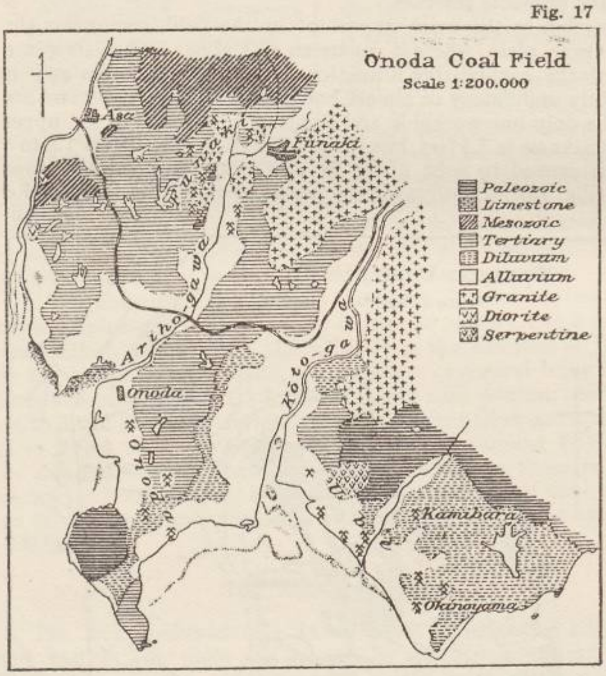
The Kumano Coal-Field

The Kumano coal-field (Fig. 16) is situated in the south-eastern part of the province of Kii, near the Kumano-gawa. The important area of the field is rather limited, being 5 km. in a north-south and 4 km. in an east-west direction. It is high and precipitous, being 600 to 700 m. high, and descends abruptly to the valley with no wide plain on either side, so that the adits were opened on the side of a mountain sometimes at a height of about 400 m. Transportation is by the Kumano-gawa to Shingū, a small port on the Pacific coast, about 25 km. south-east of the field, from which the coal is shipped. It is said that the existence of the coal was known before the Restoration of Meiji but mining operations began in 1869. Owing to the lack of demand, mining was abandoned in 1879. In 1885 the workings were reopened and became most active in 1898, yielding 72,000 tons in that year and 54,000 tons in each of the years 1897 and 1899. Since 1900 the production has decreased, averaging 36,000 tons a year. The total production since mining began has been estimated at about 900,000 tons, the average production of each five years and, recently, of each year, having been as follows:

1879	2,027 tons	1907	40,992 tons
1884	66 "	1908	41,143 "
1889	15,973 "	1909	30,979 "
1894	42,650 "	1910	35,198 "
1899	39,723 "	1911	45,315 "
1904	32,184 "		

The coal-bearing formation consists of shale, sandstone and conglomerate which carry fossils, by the study of which the field is now commonly accepted as representing the Miocene, though it had long been considered to represent the Cretaceous, as does the Amakusa coal. The strike is variable but is generally N. 30°-60° E., dip S.E. 10°-18°. There are numerous faults, mostly dip and strike faults. Three coal-seams are interbedded in shale and outcrop in the northern and western parts of the field. Of these the middle one is important, while the upper and lower seams are thin and inferior in quality. The thickness of the middle seam is variable but is 4 feet, including one or more partings, or 3 to 3.5 feet of workable coal, in the Otokawa and Miyai collieries. To the north and south of these collieries the partings gradually thicken and the thickness of the coal diminishes, so that in the Sumigama colliery there are two layers of coal 0.8 ft. each in thickness with a 7-foot parting. The average thickness is 2.5 feet. As the coal seems to become thin both in the north and south, the area now known to contain coal is not wide, and as a large part of the easily workable coal appears to have been taken out, the amount remaining cannot be large, being estimated at 5,000,000 tons. The coal is an anthracite, belonging to Class A_1. The result of a proximate analysis of it is as follows:

Fig. 17



Moist.	Vol. mat.	Fixed C.	Ash	Sulph.
5.75%	4.72%	81.99%	7.56%	1.94%

The Onoda Coal-Field

Situation and history.—The Onoda coal-field (Fig. 17) is situated along the coast in the southern part of the province of Nagato. It consists of low hills, together with diluvial terraces and alluvial plains, drained by the Kōtō-gawa and the Ariho-gawa, and is easily accessible by sea and also by railway. The coal is said to have been discovered before the Restoration of Meiji, and in 1875 it was worked mostly by the people of the district. Since 1890, mining has gradually become more active, the annual production of each five years and recently of each year, having been as follows:

1889	71,946 tons	1908	311,404 tons
1894	189,329 "	1909	239,818 "
1899	184,683 "	1910	290,057 "
1904	131,798 "	1911	398,757 "
1907	293,335 "		

Geology.—The coal-bearing formation consists of shale, sandstone and conglomerate, is considered as Tertiary and lies on the Palæozoic, Mesozoic and granite, unconformably. To the south it dips to the sea, under which the coal is also worked. Generally the formation forms low undulatory strata, the angle of inclination being less than 10°, say 5° to 6°, except in those parts where it rests directly on the basement complex. The field is conveniently divided into three sections.

The Funaki section.—In this section we include the environs of Funaki and also the district west of the Ariho-gawa. In the north the coal-bearing formation rests on the Mesozoic, where the inclination is rather high, say 10°. Granite, limestone and the Mesozoic are found in the middle part of the section. Whenever the formation rests on the basement complex, the inclination becomes somewhat higher, being about 10°, but gradually decreases to 5° or 6°, forming low undulations. There are five coal-seams, of which the lower four may be workable. The thickness is variable, from 1.2 to 3.5 feet. Most of the collieries are working only one seam at present, the thickness in the western part being 1.5 to 2 feet, and that in the eastern portion 2 to 3 feet.

The Onoda section.—In this section is included an area between the coast of Onoda and the Kōtō-gawa. The coal-bearing Tertiary runs from north to south and is covered by diluvium and alluvium on both sides. There are five coal-seams (Fig. 18*a*), the upper seam corresponding to the second of the Funaki section; but in the plain the upper part has been eroded away. The thickness is very variable, say from 1.5 to 5.5 feet. The third seam, 5.5 feet thick, consists of coaly shale, which becomes good coal in the Ube section. The fourth seam is the best and is the only one now worked. The thickness is 2 to 3.5 feet, or 2.5 feet on an average. The first seam, 1.8 ft. thick, and the second, 2.2 feet thick, were formerly worked.

The Ube section.—This section lies in the south-eastern part of the field, and includes an area along the sea-coast to the east of the Kōtō-gawa. The larger part of the section consists of diluvial plateau, with underlying coal-bearing Tertiary and alluvial plain extending along the south-western bank of the Kōtō-gawa. This section is the most important, and the two collieries of Kamibara and Okinoyama have yielded over 500,000 tons in the years 1909, 1910 and 1911, as follows:

	1909	1910	1911
Kamibara......	49,286 tons	82,712 tons	125,892 tons
Okinoyama.....	46,274 "	96,123 "	112,405 "

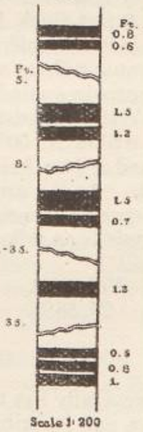
Of six coal-seams (Fig. 18*b*), the upper five correspond to those in the Onoda section. The important seams are the third and the fourth, the former being 5 feet thick and the latter 4 feet, sometimes thickening to 7 or 8 feet. The other coal-seams are thin and inferior in quality, and are only worked when they develop locally.

Quality.—The coal is lignite, belonging to Class D_1. The result of a proximate analysis of it is as follows:

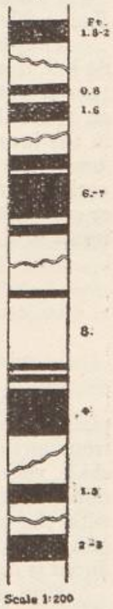
Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.
7.97%	43.08%	35.55%	13.40%	1.46%	1.399

Fig. 18

a



b



Quantity.—In the Ube section the coal above the level ground has been mostly worked out so that the future mining will be confined to the submarine area which is now being worked. In the other sections, most of the good and easily workable coal has been taken away and mining in the future will be unprofitable. The amount estimated is 10,000,000 tons for the actual and 85,500,000 tons for the probable reserves.

Coal in North-eastern Honshū

(1) the province of mutsu

Coal in the east of Tanabe.—The hilly terrace that forms the north-eastern peninsula of the province of Mutsu consists chiefly of shale with sandstone and conglomerate of the Tertiary and is considered to represent the Miocene. The coal is found near the Pacific coast east of Tanabe, not far from Sarugamori, and was first mined about forty-five years ago. Afterwards it was worked at times on a small scale, and in 1896 it was abandoned, the total yield since its opening having been only 400 tons. The dip and strike are variable, but in general the strike is either north-west or nearly east and the dip N.E. or S.W. 10°-20°, forming a syncline. One coal-seam is 3 to 4 feet thick, but the partings are very numerous, so that the workable coal is only 1.5 ft. thick. The known area is small and the coal reserves are probably small. The coal is a non-caking, bituminous variety of inferior quality, probably belonging to Class C.

Coal in the environs of Iwasaki.—The Tertiary that extends along the Sea of Japan consists of shale, sandstone and tuff, with interbedded coal-seams. The strike is variable. There are two coal-seams known, but both are thin, generally 1.5 to 2 feet in thickness. The coal is of inferior quality, but a part is metamorphosed to anthracite by contact with volcanic rocks. The amount now known is small.

Coal in the south of Hirosaki.—The coal found about 4 km. south of Hirosaki is interbedded with Tertiary shale and sandstone. There are five seams, all thin, dipping N. 30°. Mining was at one time planned, but the idea has now been abandoned.

(2) THE PROVINCE OF RIKUCHŪ

Coal near the Osarusawa copper mine.—Coal is said to have been mined near the Osarusawa copper mine, lying east of Nanukaichi in the province of Ugo. The coal-seams are interbedded in the same formation as that of Nanukaichi and their thickness often reaches 5 feet. The coal is a non-caking, bituminous variety of inferior quality, probably belonging to Class C. The area is limited and, as the coal reserves are probably insignificant, further details are omitted here.

Coal in the environs of Kuji.—The Tertiary, that forms the hilly terrace in the environs of Kuji along the Pacific coast, consists of shale, sandstone and conglomerate, with interbedded coal-seams. The strike is variable, being N. 15°-80° W. in general, and dipping E.N.E. or N. 15°-20°. As no fossils have yet been found, its geological age is not known, but it is commonly accepted as representing the Miocene. The coal is said to extend about 15 km. in a north-south, and 8 km. in an east-west direction, Kuji lying almost in the middle. There are numerous coal-seams, of which one or two may be workable, though the quality is inferior. The thickness varies from a few inches to 6 feet, but is generally 3 to 4 feet of workable coal. The coal is said to have been mined about sixty years ago and again fifteen years later. In 1894 mining was again begun and soon abandoned. Recently it was resumed, but yielded, in 1911, only 109 tons. The known areas underlain by coal are limited and the coal reserves are probably small, being estimated at about 3,500,000 tons. Coal is of a lignitic variety, belonging to Class D_2.

Coal in the south-east of Ichinohe.—Coal is found to the south-east of Ichinohe along the railway, east of Kuji. The seam is nearly 2 feet thick, but is an inferior variety of lignite, belonging to Class D^2.

Coal in Kado.—Kado is inconveniently situated in the central part of the province of Rikuchū, lying about 64 km. from the Numamiyanai railway station. The Kado colliery was opened a few years ago and yeilded 264 tons in 1911. The coal occurs in an undulatory, low and narrow basin of Tertiary age which has been deposited on the Palæozoic. The Tertiary consists of sandstone and conglomerate with shale, the tuff being intercalated in the lower horizon, and strikes N. 50°-60° W., dipping N.E. 30°. Of several coal-seams in the Tertiary the lowest one is important, and is now being worked. This seam can be traced for about 2 km. The thickness varies from 2.5 to 5.5 feet. As the area is quite limited, the estimated coal reserves are consequently small, or only 4,000,000 tons. Generally the coal is a lignite, of an inferior quality belonging to Class D_1. The average result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.
6.91%	27.58%	23.33%	42.18%	0.40%	1.794

(3) THE PROVINCE OF RIKUZEN

The low hilly ranges, generally less than 100 m. in elevation, flatten to the eastward and end in the drainage plain of the Kitakami-gawa and its tributaries and also near the coast. The coal is found in the middle part, from north to south, and also west of the Kitakami-gawa. The coal-bearing formation consists of sandstone and shale, very loose and tufaceous, and volcanic ash. Abundant fossils have been found, but not sufficient to determine the geological age, though it is generally considered as Pliocene. The formation forms undulatory folds, with the general strike north-north-east, dipping east-south-east at a low angle. The numerous coal-seams known at present are all thin, the thickest being 2 feet, and two seams are generally mined. All of the coal produced is lignite of very inferior quality, belonging to Class D_2.

Coal in the environs of Monji.—Monji is inconveniently situated in the northern part of the province, lying about 24 km. west of Wakayanagi station between Sendai and Ichinoseki. Coal was discovered about forty years ago, and seven years later it was first mined and consumed as fuel for local use, the production in 1910 and 1911 being 39 tons and 42 tons, respectively.

There are six coal-seams, which, under the most favourable conditions, develop thicknesses varying from less than 1 foot to 5 feet, with thin partings. Generally, two seams, over one foot thick, are found. To the west the coal is covered by andesite, so that it is only exposed along the valley. The known area underlain by coal is not large and the amount of the reserves is probably small, being estimated at about 3,500,000 tons.

The same formation in Tama-sawa, 8 km. south of Iwagasaki, contains one workable seam, the production in 1910 and 1911 being 328 tons and 334 tons, respectively.

Coal in the environs of Sanbongi.—Sanbongi is about 22 km. north of Sendai, conveniently situated to the south of the fertile plain of Furukawa. The coal is found in a hilly district south of Sanbongi. It was first mined twenty-four years ago. Five collieries are working there, their production in 1910 and 1911 having been 1,653 tons and 1,564 tons, respectively.

The Matsuyama colliery, about 8 km. east of Sanbongi, yielded only 85 tons in 1911. The Matsusaka colliery, about 8 km. south of Sanbongi, or near Yoshioka, yielded only 53 tons in 1911.

In Sanbongi the loose shale and sandstone, interbedded with the coal, strike generally east-north-east, dipping north-north-west with a low angle (5°-20°), though it is often undulatory. One main coal-seam, 5 to 6 feet thick, with partings, is found, the other seams being thin or inferior in quality. The good portion is 4 feet thick on an average. In Matsuyama and Matsusaka, the thickness diminishes, being 2 to 2.5 feet. The area known is small and the amount calculated is only 2,500,000 tons.

Coal in the environs of Sendai.—In the hills to the south and west of Sendai the coal is interbedded with loose sandstone and shale. About thirty years ago it was mined. Fourteen collieries are working there, their total production having been 5,183 tons in 1910 and 5,743 tons in 1911. Two coal-seams are important. The thickness is 2 to 4 feet in general, but the good portion is only 1 to 2 feet thick. The strata are undulatory, dipping at low angles. The amount calculated is small, being 4,000,000 tons.

Coal scattered to the west of the lower Kitakami-gawa.—The low, scattering hills west of the lower Kitakami-gawa, near the coast, consist of the younger Tertiary containing coal-seams. The strata are undulatory, the angle of dip being generally 5°. One coal-seam is worked here and there, the thickness varying from 1.5 to 5 feet. The production in 1910 and 1911 was 588 tons and 731 tons.

Coal in other scattered areas.—The younger Tertiary, which covers a wide area, contains coal-seams as above stated. West of Tsukitate two important seams are known, the upper one, which is 1 to 2.5 feet thick, now being worked.

In Kawasaki, south-west of Sendai, thin seams, sometimes with a thickness of 2 feet, are found. Numerous thin seams are found elsewhere, but they are not all given here.

(4) THE PROVINCE OF UGO

Coal near Iwadate.—Iwadate lies on the coast of the Sea of Japan, about 20 km. north of Noshiro. The coal is found in a valley of the Koiri-gawa east of Iwadate, interbedded in Tertiary shale, which dips W. 40° and is covered by volcanic rocks. Two seams are found, the thickness being 3 to 4 feet. The coal ranges from semi-bituminous to semi-anthracite, the former belonging to Class B_2 and the latter to A_2.

Coal in the environs of Takanosu.—In a district about 8 km. from Takanosu, between Noshiro and Odate, coal is found in loose sandstone and shale which form undulatory strata, striking generally north-south. Two coal-seams 1.5 to 3 feet thick are known to occur. The formation seems to represent the upper horizon of the Tertiary, or the Pliocene. The coal reserves are probably small. The coal is a lignitic variety, belonging to Class D_2.

The Nanukaichi coal-field.—Nanukaichi is situated about 8 km. south of Takanosu. The field lies south-east of the village, along rivulets running to Takanosu through Nanukaichi. Mining began on a small scale in 1895, the production being insignificant. It is a hilly district, the rocks consisting chiefly of shale with sandstone. The strike is very variable and the dip varies from 30° to 70°. The geological age of the coal-bearing formation has not yet been well studied, but it is said to represent the Miocene. Three workable coal-seams are known to occur, their thickness varying in a wide range from one foot to 20 feet, or on an average 5 to 7 feet. The coal is anthracite belonging to Class A_1. The amount is difficult to calculate, but it has been estimated at about 9,500,000 tons.

Coal in the valley of the Ō-ani-gawa.—The Ō-ani-gawa, a large tributary of the Noshiro-gawa, runs south, draining the central part of the province of Ugo. Coal is found along the valley from Hitachinai to the Ani copper mine, a distance of about 12 km. Transportation facilities are not good at present. The coal is said to have been discovered in 1868, and has been mined chiefly for the Ani copper mine. At present the collieries are all abandoned, but it is intended to reopen them and connect the district with the main railway by a tramway. The hilly district along the valley is underlain chiefly by shale with sandstone, conglomerate and tuff. The strike is very variable but is generally north-south, dipping east with moderate angles, 20°-40°. Five coal-seams are known to occur, but they are not all found throughout the district. Two seams are often workable, their thickness being generally 2.5 to 7 feet, sometimes increasing to over 10 feet. The coal ranges from semi-bituminous to semi-anthracite, the former belonging to Class B_2 and the latter to Class A_1. As the correlation of the coal-seams in the district has not been worked out, and as they are disturbed by faults and foldings and partly removed by later erosion and in places covered or cut off by liparite and andesite, the amount of the reserves is difficult to calculate, but it has been estimated at 6,000,000 tons.

Coal in the environs of Honjō.—In the Tertiary that covers a wide area in the environs of Honjō, some coal is found. In an area about 20 km. south-east of Honjō, one coal-seam 1 to 3 feet thick occurs, but it has not yet been mined. South of Honjō, or along the coast of the Sea of Japan, one seam one foot thick is found. Other localities are not given here.

(5) THE PROVINCE OF UZEN

Coal along the middle Mogami-gawa.—The Tertiary along the middle Mogami-gawa may be divided into two series, a lower, consisting chiefly of hard tuff, and an upper, consisting chiefly of loose sandstone with shale, but the relationship of the lower and the upper series has not yet been established. The tuff in the upper series is sometimes found alternating with shale and sandstone, which are often tufaceous. The lower series forms the backbone of the main mountain range, and the upper probably lies on it, being considered to represent the Pliocene. The upper series is lightly folded, with dips generally of less than 10°, but sometimes reaching 30°. Small faults are met with. The series is most fully developed in the middle part of the fields, from Shimidzu to Tominami, where numerous coal-seams are found, their correlation having not yet been established. Generally one or two seams from 1.5 to 4 feet in thickness can be worked. As the coal-seams known at present occur in the upper horizon of the formation, they have in places, particularly in the valleys, been in part or wholly removed by erosion. Though the area is moderately large, the quantity of coal will hardly reach a large amount, being estimated at

20,000,000 tons. The coal is of a lignitic variety, belonging to Class D_2, and was somewhat actively worked in 1896 but, owing to its inferior quality and the lack of transportation facilities, mining soon declined. The production was 4,205 tons in 1910 and 5,133 tons in 1911.

Coal is also found on a tributary of the Mogami-gawa, about 25 km. south-east of Sakata, and was formerly worked. Two coal-seams are known and one, 3.5 feet thick, is workable. The coal is of a lignitic variety, belonging to Class D_2.

(6) THE PROVINCE OF IWASHIRO

Coal in the environs of Kōri.—Kōri is situated about 10 km. north of Fukushima. The coal is found near the Handa silver mine, north of Kōri. The hilly land is underlain chiefly by loose sandstone of the younger Tertiary. The strike is nearly east, dipping S. 10°. Three coal-seams are known to occur, the lowest one being important. It is 3 feet thick, but partings are so numerous, that the workable coal is only 1.5 ft. thick. It was first mined forty years ago, but, after being worked a few years, was abandoned. The coal is probably a semi-bituminous variety of very inferior quality, belonging to Class B_2. As the known area underlain by coal is limited, the coal reserves are probably very small.

(7) THE PROVINCE OF IWAKI

Coal in the west of Nakamura.—The coal-seams that are found west of Nakamura along the Pacific coast are all thin, only one of them attaining an average thickness of 2 feet. They seem to represent the northern continuation of the Jōban coal-field or the upper horizon of the same. As the quality of the coal is very inferior, it has not yet been worked.

In Kekaya near the northern boundary one coal-seam, 2 feet thick, is found.

The Shirakawa coal-field.—In this coal-field we include a low hilly district from Shirakawa eastward to the foot of the Abukuma plateau. Mining began in 1875, and has continued on a small scale to the present time, the production being 1,614 tons in 1910 and 1,511 tons in 1911.

The coal-bearing Tertiary was deposited on the gneiss and the Palæozoic as well as on granite, and is covered by diluvium and alluvium. Andesite is also met with in the field. The Tertiary consists of loose tufaceous shale, sandstone and conglomerate, in which several coal-seams are interbedded. The strike is generally west-northwest, dipping N.N.E. 25°, though the strata are, in many places, slightly undulatory. In the middle part of the field, between Shirakawa and Tanakura, two coal-seams are important, the upper being nearly 1.5 and the lower 2 feet thick, though the upper one is poor in quality and, in places, has been removed by subsequent erosion. The thickness of the lower seam varies from 1 to 3 feet and the quality is also inferior. The coal is a lignitic variety, belonging to Class D_1. The area underlain by coal is 7.5 sq. km. The coal reserves are estimated at 6,000,000 tons.

The Tertiary which covers the western foot of the Abukuma plateau, extends farther westward, forming a wide, low, hilly tract, and is considered as a continuation of the coal-field. In the Tertiary one or two coal-seams of inferior quality occur. Though the distribution is wide, it is only occasionally worked on a very small scale in a few places, owing to the inferior quality and the thinness of the coal.

Coal in Central Honshū

Coal near Akatani.—Coal is found on the south-west of Akatani, south of Shibata, in the province of Echigo. It was discovered in 1860 and has been worked on a small scale since 1864, the production in 1911 being 662 tons. The Tertiary, which rests on the granite, consists of sandstone and tuff and strikes N. 70° W., dipping N.N.E. 60°. One coal-seam, interbedded in the sandstone, is 3 to 4 feet thick, and can be traced for one-half kilometre. As the area known is limited, the coal reserves are insignificant. The coal is a non-caking bituminous variety of inferior quality and probably belongs to Class C. The average result of proximate analyses of it is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.
5.24%	41.88%	45.30%	7.58%	2.18%	1.296

Coal on the north-west of, or along the Shinano-gawa, in the provinces of Echigo and Shinano.—The Tertiary, in the provinces of Echigo and Shinano, contains petroleum and is commonly accepted as representing the Miocene. Coal is found in the upper part of the strata that contain petroleum, and has been mined for local consumption for about twenty years. It was formerly in demand chiefly as fuel for drilling machines, which now use heavy oil, so that mining has greatly declined. The coal-bearing formation consists of shale, sandstone and conglomerate with tuff. The strike is very variable, but is generally north-east. There are numerous coal-seams, of which one or two are workable, though their thickness rarely exceeds 2 feet, being commonly less than one foot. The coal is a lignitic variety belonging to Class D_2.

The coal in Matsuda on the west of Tōkamachi, along the Shinano-gawa, is mined on a very small scale, the production being insignificant. There are two coal-seams, which are nearly horizontal. The thickness is very variable, but is generally one foot.

From Tanahiro, east of Takata, the coal has been followed southwards to the province of Shinano where it continues in the same direction west of the Shinano-gawa, to Nagano, and also along the Sai-kawa. It is worked, here and there, on a very small scale for local use. The strike is variable, but is generally north-north-east. The dip is east and west, forming synclines and anticlines. The dip is also very variable but is generally from 20° to 80°. There are numerous coal-seams, many of them less than one foot, though one or two are one foot or more in thickness, in places increasing to 3 feet. Though the area is large the reserves of coal are small.

Coal in the environs of Nishijō.—Nishijō is situated to the north of Matsumoto, in the province of Shinano, with which it is connected by railway from Nagano. The hilly district round the town slopes west to the valley of the Sai-kawa and covers a moderately wide area about 8 km. long, in a north-south direction. The rocks consist chiefly of loose shale, with sandstone, conglomerate and tuff. Judging from the fossil fauna, the formation is considered to represent the Pliocene. Coal-seams, more than ten in number, are known to occur. They are all thin, mostly less than one foot, only one or two reaching 1.5 ft. The general strike is north-south, the strata being slightly undulatory or dipping at a low angle, in general 5°-10°. Though the thickness sometimes reaches 3 feet, it soon becomes thin. The coal is a bituminous variety and belongs to Class C. It was first discovered in 1886, and from 1902 mining became gradually active until 1907, when it began to decline. As the seams are all thin and the quality is inferior, mining the coal, under the deeper cover, is not possible in the near future, and the good part, above the level ground, is almost worked out, so that the remaining coal reserves are small, being estimated at 4,500,000 tons. Numerous small collieries, more than ten in number, are working on a small scale, the annual production in 1910 and 1911 having been 18,410 tons and 18,678 tons, respectively.

Coal between Nishijō and Takasaki.—The Tertiary along the Chikuma-gawa and its tributaries, in the central district, between Nishijō and Takasaki, also contains coal-seams. The thickness is mostly less than one foot, one or two seams attaining a thickness of 1 or 1.5 ft. They are not important.

Coal in the environs of Takasaki.—A low hilly district underlain by Tertiary rocks, on the south-west of Takasaki, in the province of Kōtsuke, about 60 m. in elevation, fringes the northern end of the Kwantō mountains, running south-east. In the north it is covered by volcanic rocks from Haruna-san, while the Karasu-gawa limits its north-eastern part. Coal was discovered in 1870, and has been worked on a small scale for local use. Since the development of the silk industry in the vicinity, the production has much increased, though it is yet small. Mine water often makes mining so difficult that adits are soon abandoned and others opened. Mining on a large scale is not probable, because of the thinness of the seams and the inferior quality of the coal. The small collieries working there are very numerous, their production being 4,192 tons in 1910, and 4,550 tons in 1911. The coal-bearing Tertiary consists of shale, sandstone, conglomerate and tuff, the conglomerate prevailing in the upper, and the shale in the lower horizon. The strike is north-west, in the south and middle districts, but bends west-north-west in the north. The dip is north-east, generally with an angle of from 20° to 35°, but is gentler in the south. Two workable coal-seams are interbedded in the shale and may be traced for about 24 km. along the strike, or from north of Isobe south-eastwards to Yoshii, south of Takasaki, and across the hill east of Takasaki, crossing the main railway line near Annaka. The seams are thin, the lower being 1.5 feet, sometimes thickening to 2.5 feet. The upper one, about 240 feet above the lower, is only 0.5 ft., thickening sometimes to one foot. It is sometimes worked. The coal is a lignite belonging to Class D_2. Though, generally, it breaks up easily into thin plates or disintegrates, that occurring near the volcanic rocks is black and lustrous, and of rather good quality. As the coal is thin, or of variable thickness, it is difficult to calculate the coal reserves far below the surface, so that I have taken into account coal to a depth of 800 feet below the surface only. This amounts to 4,500,000 tons.

The Tertiary to the south-east of Takasaki was deposited on the eastern flank of the Kwantō mountains, which are Palæozoic, or in the basins of the Palæozoic. Coal, generally less than one foot in thickness, sometimes thickening to 2 feet, is found here and there, as in Ōmiya, Minano, Ogawa, Itsukaichi, etc., and was formerly mined on a very small scale. It is not important.

Coal along the Katsura-gawa and its tributaries.—The narrow band of Tertiary that extends along the Katsura-gawa basin in the province of Kai, overlying the Palæozoic, consists of tuff, shale, sandstone and conglomerate intruded by andesite. The coal-seams occur, generally, in the shale and were worked on a small scale until last year. As the formation is much disturbed, mining is often difficult. The strike is very variable, being N. 60°-75° E. in the east, but bends northwards in the west. The dip is also variable, being north-west or south-east, the angle of inclination being 50°. A few coal-seams are known to occur. They are all thin, but sometimes thicken to 2 feet and occasionally to 5 feet. The coal is lignite, of an inferior quality belonging to Class D_1, but where it has suffered contact metamorphism by the andesite, changes to good bituminous coal. Though the area of the Tertiary is wide, the coal reserves are probably small.

Coal near the shore of Toyama Bay.—The Tertiary in the province of Etchū covers a wide area, extending from the western shore of Toyama bay southwards, and consists of tuff, shale, sandstone and conglomerate, with interbedded coal-seams here and there. The coal-seams are all thin, often less than one foot, and the coal is of inferior quality. The coal is of lignitic variety, belonging to Class D_2.

In the environs of Isobe, near the shore of Toyama bay, one coal-seam, 2 to 4 feet thick, is interbedded with sandstone and dips N.W. or S.E. 40°. It is worked on a small scale. The other localities are omitted here.

In Ōtaira, near the coast, east of Toyama bay, near the boundary of the province of Echigo, two coal-seams, 2 to 6 feet thick, are interbedded with the Tertiary but have not yet been studied. The coal is worked on a small scale.

Coal in the province of Kaga.—In Senzaki, along the coast, in the province of Kaga, thin coal is also found in the shale and sandstone of the Tertiary. Thin coal is also found in the Tertiary along the Sea of Japan.

Coal in the west of Fukui.—Ayukawa lies on the coast of the Sea of Japan, west of Fukui, in the province of Echizen. The Tertiary, that extends from the coast near Ayukawa, westward, consists of shale, sandstone and conglomerate, often tufaceous, and is covered by volcanic rocks in the north. One coal-seam, with thin partings, is 1 to 2 feet thick and was worked formerly on a small scale.

Coal on both sides of the Suzuka mountain range in the provinces of Ise, Ōmi, and Iga.—The Suzuka mountain range on the west of the Ise-no-umi, runs nearly north and south, and consists chiefly of the Palæozoic in the north, and of granite or gneiss in the south, being covered by the Tertiary on both flanks. The Tertiary areas are low and hilly, the rocks, consisting chiefly of shale, sandstone and conglomerate with interbedded coal-seams, are covered by the diluvium or sink directly beneath the alluvium. The Tertiary strata, deposited on the eastern flank of the mountain range, occupy a wide area and strike north or north-north-west, generally dipping to the east at low angles, while on the western flank the strike is north and the dip west, commonly at low angles, though anticlines and synclines are sometimes met with. The dip is steeper, from 30° to 40°, near the basement complex. As to the geological age, nothing is certain, but the upper part, consisting chiefly of sand, gravel and clay, seems to represent the Pliocene. The lower horizon, on the contrary, is considered to be much older, and some of it, probably, represents the Miocene. The coal reserves have been estimated at about 4,500,000 tons.

The coal near Ageki, in the province of Ise, was first mined in 1882, but, owing to its inferior quality and thinness, mining was abandoned two years ago. Ageki is situated about 25 km. north-west of Kuwana on the Inabegawa. One coal-seam, 1.3 feet thick, is interbedded in the Tertiary shale and sandstone, dipping E. 35°. The area now known is limited and the amount of coal is small. The coal is a lignite belonging to Class D_2.

In the environs of Kono, about 15 km. north-west of Kuwana, coal in the same formation and of the same quality, was formerly worked on a small scale.

The coal in the environs of Seki, in the province of Ise, was first mined about fifty years ago. Since then mining has been carried on at times, but lately it has been entirely abandoned. Seki lies on the highway from Nagoya to Kyōto, along which the railway passes. The coal is all found within 4 km. of the railway. In the east, near the Tōkai colliery, about 4 km. south of Seki station, the strike is nearly north, dip E. 25°, but westward it gradually bends to the east, dipping generally S. 35°. Small faults are often met with. Two coal-seams are interbedded with shale and sandstone, the upper one, which alone is workable, is 3 feet thick. It is a lignite, of superior quality, belonging to Class D_1. The production was 1,207 tons in 1910 and 137 tons in 1911. To the west, separated from the last named locality by granite, is the Asahi colliery, situated about 4 km. north-west of Kabuto station and 5 km. west of Seki. Seven coal-seams are found, dipping S. 35°, but only the upper four have been mined. The thickness varies from 1 to 3.5 feet. As the area now known is only 4 sq. km. in extent, the coal reserves are small.

Coal is also found scattered throughout the province of Ise, but it is all thin and inferior in quality, and is not important.

The coal in the environs of Hino, in the province of Ōmi, is found to the south and east of the town, on the western side of the Suzuka mountain range, and is said to have been mined two hundred years ago. In 1887, mining was recommenced. The production was 2,942 tons in 1910 and 34 tons in 1911. The coal-bearing Tertiary strata are undulatory, but near the Palæozoic the dip becomes steeper, often from 30° to 50°. Numerous coal-seams are known to occur, though their development is quite local. One or two seams are workable, the thickness being from 2 to 4 feet. The coal reserves are small. The coal is lignite, belonging to Class D_2.

The coal in the environs of Uyeno, in the province of Iga, has been mined on a very small scale continuously from 1897. The production was 1,324 tons in 1910 and 1,544 tons in 1911. The Tertiary beds have been deposited in a basin on the gneiss and granite, and form a low hilly district, Uyeno being situated almost in the middle of the basin, which is undulatory, the dip being often less than 10°. Two or three coal-seams, interbedded in shale, have a thickness varying from 1.5 ft. to 3 feet. As the area underlain by coal is limited, the amount of coal is probably small.

Coal in Kinai

Coal-seams are found in the upper and lower series of the Tertiary that underlie wide hilly districts in Kinai, in which Kyōto, Ōsaka and Nara are situated. The coal is thin, and the quality is inferior, so that it is only worked here and there on a small scale. The coal found to the west of Kōbe is nearly 3 feet thick and lies in the lower series. That found in Nameri, about 18 km. east of Kishiwada, along the coast, is 2.5 feet thick, being interbedded with sand and gravel layers, while that to the south of Ogihara is nearly 3 feet thick and occurs with shale and sandstone, dipping north-east steeply. All are lignitic varieties belonging to Class D_1 or D_2.

In the environs of Nagano, in the province of Yamato, at the southern end of the Suzuka mountain range, Tertiary coal-bearing rocks occur, overlying the gneiss and covered by andesite. Two coal-seams, nearly one foot thick, are found. Owing to the lack of transportation facilities, mining will be difficult. The area is very limited in extent and the amount of coal is consequently insignificant. The coal is of a bituminous variety of medium quality, probably belonging to Class C.

Coal in Chūgoku and on the Islands in the Inland Sea

Coal near Yumura.—Yumura, a hot spring near the coast of the Sea of Japan, is situated in the north-western part of the province of Tajima, and on the highway from that province to Tottori. The Tertiary underlies a small hilly area near the town and consists of shale and sandstone, intruded by liparite. The strike is generally N. 30° W., dipping E.N.E. 15°. One coal-seam is found which varies in thickness from a few inches to 5 feet. By contact with the liparite the coal is often changed to anthracite.

Coal in the environs of Matsuye.—The Tertiary that develops along the Shinji-ko extends to the coast of Naka-umi, forming low hills. It consists of shale and sandstone in the lower, and chiefly of tuff in the upper part. The coal is found in the hills near Matsuye, to the west and north-west, and also in Yata, south of Umakata-seto, which connects two lakes. Near Matsuye the strike is north-west or north-north-west in the south, while in the north it is north-east or north-north-east, dipping north-west in the east and north-east in the west at a low angle, usually 15°. The important coal-seams are two in number, the upper being 0.7 to 1 foot and the lower 1.5 to 3 feet. In Yata the strike is east, dipping north at an angle of about 13°. One coal-seam is 2 to 3 feet thick, on an average, though it is variable. The area is only 1½ km. in a north-south and 2½ km. in an east-west direction. The coal near Matsuye was first mined in 1887, the industry being most active in 1904 and 1905. After 1905 mining grew slack, the production being 2,007 tons in 1910 and 1,735 tons in 1911. The coal of Yata is said to have been mined about forty-seven years ago, and reopened ten years later. After that mining was intermittent, being rather active in 1905 and 1906, though it is now entirely abandoned. The coal is a lignite, belonging to Class D_1. The coal reserves are small, being 3,000,000 tons.

Coal near Takakubo.—The Tertiary rests on granite and porphyry in the southern part of Izumo plain, and consists of shale, sandstone and conglomerate. One coal-seam is found in the shale, striking N. 60° W. with the dip N.N.E. 10°. The thickness is generally 1.5 ft. It is worked on a small scale. The coal is a lignitic variety, belonging to Class D_1.

Coal in the north of Hamada.—Kokubu, on the coast of the Sea of Japan, is situated about 7 km. north-east of Hamada, in the province of Iwami. One coal-seam, nearly 1.5 ft. thick, is interbedded with Tertiary shale and sandstone with conglomerate, and dips W. 10°. It was formerly worked. The coal is lignite of inferior quality belonging to Class D_1.

Coal in the south of Katsuyama.—In the Tertiary, which occupies a small area overlying the Palæozoic to the south of Katsuyama, in the province of Mimasaka, three coal-seams are interbedded with sandy shale. They are 2 or 3 feet thick, but thin to 0.5 ft., containing much clayey matter. The strata are quite undulatory. The coal is mined on a small scale. It is lignite of a very inferior quality, belonging to Class D_2.

Coal in the environs of Okayama.—The Tertiary, deposited in small basins of granite in the environs of Okayama, in the province of Bizen, consists of loose shale, sandstone and conglomerate, with coal-seams. In Tomiyoshi, about 10 km. north-west of Okayama, one coal-seam has a thickness of 7 feet with partings, or 4 feet of workable coal. The strata are nearly horizontal. In 1887 the coal was discovered in boring a well, and it is said to have been mined rather actively in 1905. Afterwards it was abandoned and there is now talk of reopening it. In Minoshima, about 10 km. west-south-west of Okayama, one coal-seam nearly 1.5 ft. thick is found in a hill. The coal is lignite belonging to Class D_2.

Coal in the environs of Miyoshi.—The Tertiary, in the environs of Miyoshi, in the province of Bingo, rests on granite porphyry and porphyrite, and consists of shale and sandstone with conglomerate. The strike is variable, the dip being low, or in general 15°. Numerous thin coal-seams are interbedded in the Tertiary, the thickness varying from 0.5 to 2 feet. In Megurikami, about 8 km. south of the town, the coal was formerly worked. The coal found in the central part of the province of Bingo is interbedded in Tertiary shale. The thickness is 3.5 feet with partings, or 1.5 ft. of workable coal. The coal is lignite of a very inferior quality, belonging to Class D_2. The area is quite limited and difficult of access.

Coal in the north of Hongō.—A small basin of Tertiary strata occurs about 10 km. north of Hongō on the railway between Okayama and Hiroshima. The beds are nearly horizontal and consist of loose shale, sandstone and conglomerate. One coal-seam is 2 feet thick on an average, with a thin parting. The coal was mined on a small scale until last year, when mining was abandoned; but it is to be resumed. The coal is lignite, belonging to Class D_2.

Coal in Awaji-shima.—A Tertiary area, overlying the granite in the north and the Mesozoic in the south, occupies a narrow hilly district, almost midway between Sumoto and Minato. It consists of shale and sandstone, striking nearly east-west and dipping N. 5°. The one known coal-seam is 4 feet thick, with partings, and has 3 feet of workable coal. The coal reserves are small. In 1872 the coal was first mined as fuel for salt pans. Since that time mining has been carried on at times on a very small scale, the coal being chiefly used as domestic fuel and in small factories in Sumoto, until last year, when it was abandoned. Coal is also found at Osaki and Maruyama near the western coast, where it has a thickness varying from a few inches to 5 feet. The coal found midway between Sumoto and Minato is lignite; while that in Osaki is a semi-bituminous variety of Class B_2.

Coal in Shōdo-shima.—The Tertiary found in the eastern part of Shōdo-shima, in the Inland Sea, rests on the granite and has in the central part of the area been covered or intruded by volcanic rocks. It consists of shale and sandstone in which coal-seams are interbedded. The strata are slightly undulatory, and form a syncline, the central part of which is overlain by andesite. In the north it dips S. 10° and in the south, N.W. 5°. There are three thin seams, from 0.5 to 1 foot in thickness or in places less. The coal was first mined in 1879 and used as fuel for salt pans. Owing, however, to its thinness and inferior quality, mining has often been abandoned. The production was 344 tons in 1910 and 434 tons in 1911. The coal is a lignitic variety, belonging to Class D_2.

4—KYŪSHŪ WITH RYŪKYŪ

The Chikuhō Coal-Field

Situation and topography.—The Chikuhō coal-field (Plate 3) occupies large areas, extending over the provinces of Chikuzen and Buzen. The most important district lies in the basin of the Onga-gawa and its affluents, and covers an area about 55 km. in length and 14 to 26 km. in width. Three other districts are situated near the coast and separated from the first by low mountains. They are much smaller in area and less important. The coal-field is situated in a hilly undulatory tract, cut by rivers and rivulets flowing from relatively high mountains which are underlain by the older complex on which the coal-bearing beds were deposited. It is very conveniently situated near the coast and is connected by railway with the nearby ports of Wakamatsu and Moji. For convenience the field may be divided into the four districts of Kokura, Onga-gawa, Munakata and Fukuoka.

History and production.—There is no authentic record of the early history of this coal-field, but it is certain that coal was mined over two hundred years ago. Mining was, however, conducted by an old and primitive method until 1881, when some large mining plants were successfully introduced. Since then, the improved methods and the installation of new plants, combined with better transportation facilities, have caused a rapid development of the industry and the production has consequently greatly increased, so that, in 1891, it amounted to nearly one million tons. After the wars with China and Russia, the development of the mines was still more remarkable, the output being correspondingly increased. Since 1909, owing to the universal depression of the mining industry, there has been no marked increase.

This coal-field is the first and most important of those known in Japan, over one-half of the total production having been supplied by it. The production was as follows:

1884	277,931 tons	1907	7,284,867 tons
1889	675,181 "	1908	7,800,497 "
1894	1,724,229 "	1909	8,027,274 "
1899	3,522,697 "	1910	8,077,551 "
1904	5,387,473 "	1911	9,203,954 "

Geology.—Metamorphic rocks and the Mesozoic, together with such eruptive rocks as granite, diorite, porphyrite, diabase, peridotite, etc., form lofty mountains in the two provinces of Chikuzen and Buzen. The Tertiary has been deposited in basins in these rocks and consists of shale, sandstone and conglomerate, with important coal-seams. By lateral pressure from the west, it has suffered two or three foldings, accompanied by numerous faults. The throw of the faults sometimes reaches several hundred feet, but is generally much less. Many andesite and basalt intrusions are encountered underground and, in some places, their presence has caused considerable difficulty in mining operations. The stratigraphy of the Tertiary is best studied in the district along the Onga-gawa, where it is divided into the upper and the lower coal-bearing series.

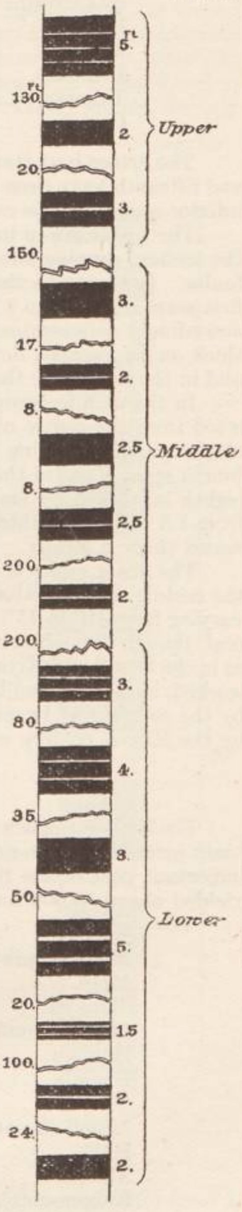
The upper coal-bearing series occupies the greater part of the northern area, east of the Onga-gawa, and is subdivided into two parts, the upper and the lower. The upper part consists chiefly of sandstone and conglomerate with shale. Several coal-seams are said to be interbedded in the series, but they are not worked at present, owing to thinness and inferior quality. The lower part consists of shale and sandstone, rarely with conglomerate, and contains numerous productive coal-seams, seven of which may be workable, though they are often cut off or thin out within a short distance. In some cases several thin partings occur in one seam which in places thicken so as to separate it into two or more seams. Faults are relatively few and small, and no intrusions have disturbed the series.

The lower coal-bearing series covers a wide area, chiefly west of the Onga-gawa, and consists of shale, sandstone and conglomerate. There are numerous coal-seams, some of which have been changed to natural coke by contact with volcanic intrusives. These are classified into four groups, of which the third is the most important. Two large synclinal folds run almost parallel in a nearly north-south direction, their axes lying to the east, near the basement complex, so that the dip is steeper in the east than in the west. Faults are very frequent, as shown in Plate 3. The strike is generally north-north-west, the dip being usually from 10° to 20°, though near the basement rocks it is always much steeper. The geological age of the coal-bearing series has not been ascertained with any degree of accuracy, as the fossils found were not sufficient for this purpose, but from stratigraphical and petrographical relations, it is commonly accepted as Miocene.

The thickness of the coal-bearing series varies in different places, but when estimated from borings, or other reliable data, that of the upper series ranges from 2,500 to 3,000 feet and that of the lower from 4,000 to 4,500 feet.

Coal-seams.—There are numerous coal-seams which are best developed in the district along the Onga-gawa. The seams of the upper series have been found to number fifteen, of which seven, 2 to 5 feet thick, are workable. The first, or upper group, of the lower series, consists of two seams with many shale partings. In places this group has been eroded away, so that it has been examined in the southern part only. Generally the seams are thin and the quality of the coal is inferior, so that they are worked only where they thicken locally. The second group contains, generally, six or seven seams which are best developed in the southern half of the middle part. The thickness is variable, being 8 feet where thickest. The third group is the most important, and contains more than twelve seams, of which the so-called 3-foot and 5-foot seams have been mined extensively and, as they are more uniform in thickness and quality than the others and can be traced throughout the district, will probably be productive for many years. Other seams attain thicknesses in some cases reaching 8 feet, but their development seems to be variable, the presence in places of many shale partings making them of little value, or they thin out and become unworkable. The fourth group carries six seams, which are actively worked in the south-western part. The thickness is variable, being generally from 3 to 5 feet. In three other less important districts, there are two or three workable seams, generally from 3 to 5 feet thick. Their correlation with those mentioned above has not yet been studied.

Fig. 19



Scale 1:200

Silicified wood is found in the coal-seams in abundance, reaching in some cases an amount equal to from twenty to thirty per cent. of the coal. It is irregular in form and its size is very variable, the diameter sometimes being as much as 10 feet, though the sections are generally short.

Quality.—The coal is a good caking, bituminous variety belonging to Class C. The average of a number of proximate analyses is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.
4.21%	42.92%	45.71%	7.33%	0.68%	1.334	7,205	12,965

Quantity.—The coal-seams have been proved by numerous borings, but to calculate the actual reserves of coal, in so extensive an area, many more borings are necessary. Only the coal-seams worked at present or those worked formerly have been taken into calculation for the actual reserves. There are, however, numerous seams, thick enough to be mined, which are not being worked, owing to the inferior quality of the coal, though they compare not unfavourably with seams worked in other coal-fields in Japan. The amounts calculated from the data given are as follows:

	Actual	Probable
Kokura	1,500,000 tons	6,000,000 tons
Onga-gawa—		
Onga	33,000,000 "	200,000,000 "
Kurate-tagawa	141,000,000 "	450,000,000 "
Kurate-Kaho	144,000,000 "	429,000,000 "
Kaho	69,500,000 "	138,500,000 "
Munakata	1,500,000 "	1,500,000 "
Fukuoka	15,000,000 "	30,000,000 "
Total	405,500,000 tons	1,255,000,000 tons

(1) THE KOKURA DISTRICT

The Kokura coal district is a small area with the town of Kokura almost in its centre. It is bounded on the north by the sea. The formation is a basin, dipping toward the centre at Kokura at low angles; to the east, however, near the Mesozoic, the dip becomes somewhat steeper, from 15° to 20°, and small faults occur frequently. Of three coal-seams, the lowest, containing 4 feet of workable coal, is the only one worked. The upper seam is 2 feet thick and the middle one 3 feet, the latter being of inferior quality. The Shin-washimine colliery is the only one working, the coal being 4 feet thick and dipping N.E. 15°. The production was 8,502 tons in 1910 and 16,455 tons in 1911.

(2) THE ONGA-GAWA DISTRICT

The Onga-gawa district is the richest and most important, almost the whole output of the field being produced from it. It is subdivided into four sections, the Onga, Kurate-tagawa, Kurate-kaho and Kaho, the first one, only, representing the upper series.

(a) The Onga Section

The Onga section is underlain by the upper coal-bearing series, which forms a syncline in the eastern part, near the basement complex, running nearly north-north-west. The dip is consequently steeper in the east, being

30° to 40° near the basement complex, where faults are rather frequently met with. Westward, to the drainage plain of the Onga-gawa, the formation becomes less disturbed and dips at angles of from 10° to 20°. Numerous collieries in close proximity are in operation. Those that yielded over 50,000 tons in 1911 are as follows:

Colliery	1909	1910	1911
Takaye	....	....	221,832 tons
Ōtsuji	412,360 tons	354,848 tons	197,855 "
Shinte	69,550 "	87,448 "	135,029 "
Nakatsuru	79,033 "	107,470 "	120,770 "
Kiyase	11,244 "	68,969 "	110,249 "
Miyoshi	99,340 "	81,382 "	91,739 "
Iwasaki	89,102 "	59,477 "	66,296 "
Takamatsu	51,249 "	56,717 "	64,756 "
Ōtani	47,372 "	58,443 "	55,422 "

The fifteen important seams are shown in Fig. 19. Of these the first, third, fourth, eighth, eleventh, twelfth and fifteenth have been worked, while the others have not yet been mined, owing generally to the thinness and inferior quality of the coal. They are arranged, for the sake of convenience, into three groups.

The upper group includes the first, second, and third seams. These seams outcrop in the northern end of the section, running almost parallel to one another, towards the south-south-east, though they are cut by several faults. In the south the coal-seams bend gradually to the north, so as to form a syncline. The thickness of the first seam is from 3 to 4 feet; but, from the middle of the section, southward, the partings increase and the seam accordingly deteriorates. The second seam is 2 feet thick and is sometimes mined; while the third is 2.5 feet thick on an average, developing to 5 feet in the middle of the section. These seams are worked on the north and in the middle by the collieries of Ōtani, Miyoshi, Takamatsu, etc.

In the middle group are included five seams from the fourth to the eighth. They have been traced southward from the centre of the section and are continuations of those formerly worked in the north. They run almost parallel, dipping N.E. 12°-18°, and in the south, bend gradually northward so as to form a syncline. The fourth seam is one of the main seams of the Ōtsuji and Takamatsu collieries, being 3 to 3.5 feet thick, while the eighth is worked by small collieries, the average thickness being 2 feet. The three seams between them are from 1.5 to 2.5 feet thick, but the coal is generally inferior in quality, being worked on a small scale where the seams thicken locally.

The lower group is the most important and contains seven seams which can, however, be traced only from the middle of the section to the south. The strike is north-north-west and the dip is east-north-east, the angle varying from 10° to 15°. The thickness of three important seams, in descending order, is 3, 4 and 2 feet of good coal, though they often contain numerous partings. The lowest one thickens in places to from 3.5 to over 4 feet, as in the Ōtsuji and Kiyase collieries, while the other two often thicken to from 4 to 6 feet where they are actively worked, as in the Ōtsuji, Shinte and Iwasaki collieries. Other coal-seams are locally worked, as the ninth seam, by the collieries of Iwasaki, Kiyase, etc., where the coal is 3 to 4 feet thick, and the one below the twelfth seam by the Kiyase colliery where it is 2.5 feet thick, etc.

(b) *The Kurate-tagawa Section*

The Kurate-tagawa section lies along the Onga-gawa and its tributary the Hikosan-gawa, and forms a narrow basin extending north-north-west, and covering an area about 45 km. long and 4 to 9 km. wide. It is the most important part of the field and numerous large collieries are now actively working there. The collieries that yielded above 50,000 tons in 1911 are as follows:

	1909	1910	1911
Mitsui-tagawa	569,861 tons.	661,334 tons.	784,941 tons.
Meiji	394,249 "	433,401 "	538,292 "
Shinnyū	399,612 "	424,743 "	398,838 "
Mitsui-hondō	263,171 "	316,526 "	378,293 "
Hōkoku	185,032 "	261,855 "	334,854 "
Kanada	298,475 "	298,243 "	319,003 "
Ōto	202,829 "	298,039 "	234,497 "
Mineji (Second)	150,754 "	168,621 "	225,439 "
Hōjō	148,940 "	171,879 "	202,160 "
Akaike	163,414 "	176,856 "	192,486 "
Kaigun-gotoku	195,068 "	183,977 "	139,085 "
Iwase	70,220 "	65,851 "	118,904 "
Mineji (First)	58,913 "	55,537 "	64,883 "
Kanaya	64,173 "	42,339 "	58,399 "

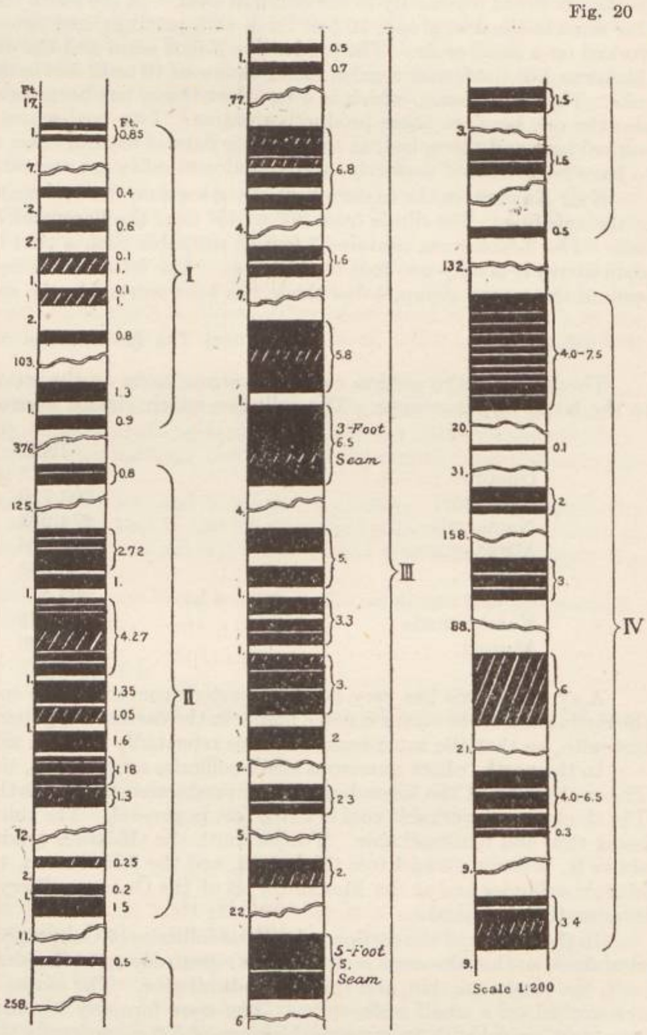
In the north the beds have been eroded away or remain in nearly flat-lying patches distributed over a small area. The strike is generally north-north-east dipping E.N.E. 10°-20°, though the formation is cut by many faults. From south of Nōgata, however, the formation can be studied from its lowest horizon, though the structure is complicated by folding and faults. The coal-seams, after crossing the river, bend west along the Mesozoic and form a syncline and an anticline, though they again turn to the north-west, dipping N.E. 15°-25°. From Kanada the strike regains its original direction of north-north-west, dipping E.N.E. 10°-20°. As a result of faults, the same seam crops out repeatedly. The intrusions of andesite are many, causing the coal to metamorphose to natural coke. With the exception of the coal-seams of the third group, especially the 3-foot and 5-foot seams, the development of many of the seams is local, and in most cases those of the upper horizon have been removed by erosion. A typical section was obtained at the Meiji colliery which is shown in Fig. 20.

In the northern part of the section the first group has been wholly eroded away, while the seams of the second group, remaining here and there, are too thin to be worked. The seams of the third group are best developed in the south, and are actively worked at the Shinnyū colliery, where the 3-foot seam thickens to 5 feet, while the 5-foot seam diminishes to 3 feet in thickness. West of Shinnyū a part of the 3-foot seam has been changed underground to natural coke, by the intrusion of andesite. Generally the other seams are not workable, but one, directly above the 3-foot seam, develops a workable thickness of 4 feet, in places, in the Shinnyū colliery. Northwards the seams become gradually thinner, the 3-foot seam becoming 2.5 feet, the 5-foot seam 1.2 ft. and the one above the 3-foot seam about 3 feet. The fourth group is not important.

In the area where the collieries of Gotoku, Meiji and Akaike are actively working, the coal-seams of the first group are all thin and contain rather thick partings. One seam, 1.5 foot thick, may be workable. Those of the second group are all thin and limited in extent; they are sometimes worked in the east, where one seam widens to 2.5 feet. In the third group, besides the productive 3-foot and 5-foot seams, one above the 3-foot seam and another between the two seams are also important, while one below the 3-foot seam is sometimes worked. In the north the one above the 3-foot seam is especially productive, being 4 feet thick on an average. The 3-foot seam in the middle part of the section is 4 feet thick but thickens to from 6 to 7 feet in many places in the north, and in the Akaike colliery, in the south, to 5 feet. In the Hondō colliery a part of the coal of the southern section is metamorphosed to natural coke. The 5-foot seam in the west develops to nearly 6 feet and diminishes to the east, being 3.5 feet in the Hondō colliery and still less in the Akaike. The seam between the 3-foot and 5-foot seams is from 2 to 4 feet thick. Three seams of the fourth group are also sometimes worked, though the quality is inferior. The thickness, in descending order, is 3.5, 3, and 4 to 4.5 feet, though the seams tend to become thin towards the north.

In the southern area, numerous large collieries are grouped in the northern part, where the coal-seams attain full development. In the north, where the collieries of Kanada, Kanaya, Hōkoku and Mineji are working, coal-seams of the first and second groups were formerly worked, abandoned adits being found here and there. The thickness of the seams varies from 2 to 4 feet and the quality is relatively inferior. The important third group contains six coal-seams. In the colliery of Kanaya, the 3-foot seam thickens to 5 feet, and southward, in the Kanada, to from 6 to 8 feet, while the 5-foot seam is 1.5 foot in the north, increasing to 4 feet in the south. The seam next above the 3-foot seam,—and they are often less than 1 foot apart—varies from 5 to 8 feet in thickness and the other above it is 3 to 4 feet thick, and is worked here and there. The seam between the 3-foot and the 5-foot seam is productive, being 3 to 5 feet thick, and the one below it is also workable. Two seams in the fourth group may be workable,

Fig. 20



the thickness being 2 to 3.5 feet. Andesite is observed only in the south, intruding the 3-foot seam so as to cause metamorphism.

In the middle of the section, where the Tagawa colliery is actively at work, faults cause the important third group to outcrop in two rows, in a nearly north-south direction. In the first group only one seam, 5 to 6 feet thick, is worked, in the Ita pit of Tagawa colliery, its continuity to the north and south having not yet been ascertained, while the coal-seams of the second group are not important, being worked at several places on a small scale only. The 3-foot seam is 6 to 9 feet thick, but the coal is to a great extent metamorphosed to natural coke to the east of the fault, while to the west it changes to natural coke near the outcrops, but underground the proportion of bituminous coal increases. The 5-foot seam is 5 feet, with partings, but the coal changes to natural coke to the south. The seam between the above two is also productive, being 3.5 to 4.5 feet thick. In the Tagawa colliery six seams are workable, their thickness being, in descending order, 3, 8 (3-foot seam), 5, 5 (5-foot seam), 2, and 3 feet. One seam, in the fourth group, 3 to 4 feet thick, is also worked on a small scale.

In the south, where the collieries of Ōtō, Mineji (Second), etc., are at work, the same seams, as a result of faults, are found repeatedly to the east and west. In the south the coal-seams bend northward to form a syncline. One seam in the first group, 10 feet thick with partings, and two seams in the second group, 2 to 5 feet thick, are worked on a small scale. The productive 3-foot seam and the one above it again increase to from 4 to 5 feet in thickness, but the former regains the thickness of 10 to 12 feet in the south, for the most part changing into natural coke. The 5-foot seam, which is 4 to 5 feet thick, has been metamorphosed extensively into natural coke, and also the one between these productive seams. Two coal-seams, 3 and 5 feet thick, in the fourth group are worked here and there, but, as they often consist of natural coke, mining is difficult. The lowest two seams appear to have been worked formerly, and abandoned adits are scattered here and there.

Near Kawara, in the eastern part of the section, the coal-seams dip nearly east, representing the eastern wing of the syncline. The dip is from 30° to 40° near the basement complex, but flattens to 17° or less towards the east. The 3-foot seam contains 5 feet of workable coal, a part becoming natural coke near the outcrops. The seam above it is only one foot in thickness. The 5-foot seam decreases to from 3 to 3.5 feet in thickness. One seam of the second group, 4 feet thick, has been worked in the south by the Imatō colliery.

(c) *The Kurate-kaho Section*

The Kurate-kaho section covers a narrow basin on the west of the Kurate-tagawa section, and ranks next to the latter in importance. The collieries which yielded above 50,000 tons in 1911 are as follows:

	1909	1910	1911
Ōnoura	653,845 tons.	586,288 tons.	763,706 tons.
Shakanō	393,710 "	391,933 "	389,382 "
Namazuda	274,281 "	335,371 "	389,170 "
Mitsui-yamano	255,754 "	297,612 "	345,825 "
Yoshio	226,245 "	238,842 "	258,970 "
Shimoyamada	908,841 "	149,016 "	181,978 "
Kamiyamada	119,121 "	122,875 "	140,181 "
Muroki	52,196 "	61,671 "	62,309 "

A synclinal axis lies very near the eastern contact of the coal-bearing beds with the older complex, so that the inclination of the strata is much higher in the eastern wing than in the western. Faults and folds are frequently met with, so that the same seam outcrops repeatedly on both sides of the syncline.

In the north, where numerous small collieries are working, the upper group seems to have been eroded away. The coal-seams of the second group are productive in the north, three seams towards the base being worked. The thickness of workable coal is 2 to 3 feet in general. The third group is not important in the north, the seams being thin and non-workable. To the south the thickness gradually increases, the 3-foot seam, and two seams above it, becoming 3 to 4 feet thick each, and the 5-foot seam, 4 to 5 feet thick. They are being worked at the Muroki collieries and at the Mannoura pit of the Ōnoura colliery. Those of the fourth group are all too thin and inferior to be worked.

In the middle of the section, where the collieries of Ōnoura, Shakanō, etc., are worked, the faults are especially abundant, so that the same seam appears repeatedly on both sides. Though the first group is found in the eastern part, the seams are thin, and the quality is inferior. The seams of the second group are also less important and are worked on a small scale only. They were formerly worked in the south. The third group contains four important seams with an average thickness of 5 feet, generally thickening to the south. They are the 3-foot and the 5-foot seams, with the one above the 3-foot seam and the seam between them. The 3-foot and 5-foot seams are 3 to 4 feet thick, in the north, while, to the south, the former increases to from 6 to 7 feet and the latter to from 4 to 5 feet. As a result of contact with volcanic rocks, a part of the coal changes to natural coke. The fourth group is not important in the north but, to the south, one seam, 5 feet thick with partings. is sometimes worked.

In an area bounded on the west by the Kama-gawa and the Yamada-gawa, and worked by the collieries of Namazuda and Yoshio, the coal-seams are all cut off by a great fault, the line of faulting following the course of the river. A synclinal axis runs through the eastern part almost from north to south, the dip in the eastern wing being W.N.W. 30° and in the western wing E.S.E. 15°. Generally the structure is simple, though the seams are often cut off by faults which cause a change of strike for short distances, though it is north-north-east in general. The coal-seams of the first group are only workable in the south. Two productive seams are 2 and 5 feet in thickness, but the partings are so numerous that the quality of coal is inferior. To the north the seams decrease in thickness and become unworkable. One seam, 4 to 8 feet thick, in the second group, was formerly worked, but the partings are so numerous that the good coal is rather thin. To the south there are three workable seams, their thickness being, in descending order, 8, 5, and 3 to 5 feet.

The third group is especially important in the north, where the Namazuda colliery is actively at work, while in the south good coal has been intruded by volcanic rocks. In the north the 3-foot seam, together with one above it, is worked, the thickness being nearly 7 feet. The one between the 3-foot and the 5-foot seams is worked, being 5 feet thick. The 5-foot seam is 5 feet or more in thickness and very superior in quality. Southward it becomes inferior in quality with many partings, while the 3-foot seam with the one above it becomes superior in quality, maintaining a thickness of 7 feet. Volcanic rocks are found intruded between the 3-foot and the 5-foot seams, the coal metamorphosing into anthracite or natural coke. In the eastern wing, where the Miyanoura colliery is working, the 3-foot seam attains a thickness of 8 feet, while the 5-foot seam remains 5 feet and the seam between them, 4 feet. The one above the 3-foot seam is 3 feet thick and is sometimes worked.

The fourth group carries numerous coal-seams, of which two are important, with a thickness of from 2 to 3 feet. Other seams can be worked where they develop locally, but the thickness is generally inconsiderable or the quality inferior.

The area bounded by the Kama-gawa and the Yamada-gawa (which follow important lines of faulting), is a narrow tract running from north-west to south-east. In the north the Yamano colliery is working the coal-seams of the third and fourth groups which dip to the east, while, to the south, beyond the Kama-gawa, the four groups, with the exception of the first, can be traced, though they are often cut off by faults, and the strike bends north-west, the dip being S.E. 10°-20°. Intrusions of volcanic rocks are numerous and change the coal to natural coke or anthracite. The second group contains five seams over 2 feet thick, of which two, and sometimes three, are 4 feet thick each and are being worked, while the others are from 2 to 3 feet thick. The third and fourth groups are important and their coal-seams are worked throughout the area. The 3-foot seam is not known in the Yamano colliery, the uppermost seam there being the one below it. It is 4.5 feet thick and is now being worked, while the 5-foot seam is here only 3 feet thick.

To the south, across the Kama-gawa, the 3-foot seam, with the one above it, attains a thickness of 7 feet, with partings, or 3 feet of good coal. The 5-foot seam again increases to over 8 feet, with partings, and has 4.5 feet of good coal, the upper part being changed by volcanic rocks to anthracite, as in the Shimoyamada colliery. The seam between these two becomes over 8 feet thick with partings, but the coal changes to natural coke in the Shimoyamada colliery.

Still farther southwards, the 3-foot seam decreases to 4 feet and is inferior in quality. The one between the 3-foot and the 5-foot seams is 6.5 to 7 feet thick, and is the best in the Kamiyamada colliery. The intrusion of volcanic rocks makes mining difficult and changes the coal into natural coke, so that it is difficult to obtain the amount expected.

The fourth group carries four or five productive seams, two being worked in the north and four in the south. The thickness is generally from 3 to 4 feet of workable coal.

(*d*) *Kaho Section*

The Kaho section lies in the south-western part of the district. There are four collieries which yielded over 50,000 tons each in 1911. They are as follows:

	1909	1910	1911
Futase	386,946 tons.	372,964 tons.	427,858 tons.
Tadakuma	238,594 "	324,505 "	344,493 "
Mameda	135,507 "	122,439 "	136,101 "
Aida	86,153 "	92,464 "	62,443 "

In the north, the area where the collieries of Futase and Aida are working is a narrow basin deposited on the granite and bounded by the Honami-gawa on the south-east. The geological structure is complicated and large faults traverse the area from north to south. The second group carries one or two seams, the thickness being from 6 to 7 feet. The quality of the coal is good in the north, but becomes inferior in the south. In the third group, the 3-foot and 5-foot seams are most productive. In the north, the former is 3.5 to 4 feet thick and the latter 4.5 to 5 feet. Two seams above the 3-foot seam are also important, but the uppermost, 5 feet thick, is inferior in quality, while the other is often mined together with the 3-foot seam. A seam between the 3-foot and the 5-foot seams is 2 feet thick and is sometimes worked. To the south the coal-seams increase in thickness, the 3-foot seam, together with two above it, sometimes having an aggregate thickness of over 9 feet of good coal, and the 5-foot seam together with one below it, of 8 feet. The seam below and the one above the 5-foot seam have a thickness of 4 feet each. The fourth group crops out only in the west and three seams may be workable. The thickness is 2 to 4 feet of workable coal, but the coal is rather inferior in quality.

The area near Doi, bounded on the east by a large fault and on the west by the basement complex and worked by the Tadakuma colliery in the north, is traversed by two large faults running south. The coal-seams outcrop repeatedly on both sides of the faults. The strike is nearly north-south, dip east; but to the south it gradually bends north-west, until the formation rests directly on the granite. Volcanic rocks occur, frequently intruding the formation underground, especially in the south, and cause the coal to change to natural coke.

The second group contains two productive seams, the upper being 2 feet thick and the lower 4 to 5 feet. In the third group there is a 3-foot seam in which the coal is inferior in the north, but becomes better in the south. The original 5-foot seam is thin here and the coal is inferior, but to the south it is 3 feet thick. The two seams between them are the best, the upper being 3 to 4 feet and the lower 5 to 8 feet thick, though in the middle of the area they are thin and of inferior quality. The two seams above the 3-foot seam are 3 to 4 feet thick, but the coal is of inferior quality, though they are worked in the north. The fourth group carries four or five productive seams in the north, of which the uppermost and the lowest are worked, while others between them abound in partings. The thickness of workable coal in these seams is 3 or 4 feet, while the other seams vary from 2 to 5 feet in thickness. To the south they have been intruded by volcanic rocks. To the west, in the northern part, the group can be traced from very near the edge of the Mesozoic at Rakuichi, where one seam is worked. From the west of Doi the group runs south-east, dipping N.E. 25°-30° and two seams are worked, the thickness being 2 to 5 feet. In the extreme south, the seams crop out repeatedly as a result of faults. Two, and in places three, seams are worked on a small scale, their thickness being 3 to 5 feet in general. Numerous intrusions of volcanic rocks make mining difficult and change the coal into natural coke.

The coal-bearing beds where the Mameda colliery is working were deposited on metamorphic rocks west of Doi and form a rectangle, elongated in an east-west direction. The coal-bearing Tertiary is covered broadly by diluvium with outcrops of metamorphic rocks here and there, especially in the valleys. The strike is nearly north-west and the dip north-east in the east, and south-west in the west, forming an anticline. The angle of dip is generally 10°. In the eastern wing of the anticline one seam of the third group, 5 feet thick, was formerly mined. Three seams of the fourth group may be workable, the thickness being 3 to 5 feet. In the western wing coal-seams of inferior quality and with numerous partings correspond to the second group. Two seams of the third group 4 to 5 feet thick may be workable. Two seams of the fourth group are 5 feet thick, while the others are inferior in quality, though local variation may be noticed. In a small area in the north, one coal-seam, 4 feet thick, is worked.

(3) THE MUNAKATA DISTRICT

The coal-bearing area of the Munakata district, in the northern part of the province of Chikuzen, lies near the coast in the form of a basin in the granite and porphyrite mountains. The rocks consist of shale, sandstone and conglomerate, and in general strike north-west. The coal-seams in the environs of Ikeda are important and are being worked. Of five seams, three may be workable, the uppermost being over 6 feet, the middle one 3 feet and the lowest 4 feet in thickness, while the other two are inferior in quality, though they attain a thickness of 3 feet. The strike is N. 45° W. and the dip N.E. 15°-20°, increasing to the north to 45°. The coal-seams found in other parts of the district are thin and not important.

(4) THE FUKUOKA DISTRICT

The Tertiary that surrounds Fukuoka fringes mountains built up of metamorphic rocks and granite, and underlies hilly tracts broken by rivers and rivulets. It is composed of shale and sandstone, with the strike often running parallel to the contact with the basement complex. The collieries which yielded over 50,000 tons in 1911 were:

	1909	1910	1911
Takata	117,015 tons.	149,500 tons.	168,172 tons.
Kaigun-shinbaru	15,796 "	56,786 "	72,922 "

In the northern district, drained by the Tatara-gawa and bounded by the metamorphic rocks, productive coal is only found in the southern part, where the measures form a syncline with dips of from 15° to 25°, the drainage plain corresponding to the synclinal axis which lies nearly parallel to the contact of the Tertiary and metamorphic rocks. Of four seams known in the northern wing, three are worked, their thicknesses being generally 3 to 4 feet, and at the Takata colliery, the largest in the area, 3, 6, and 5 feet, respectively. In the southern wing, two or three other seams have been examined, besides the three seams of the northern wing, the usual thickness being also 3 to 4 feet.

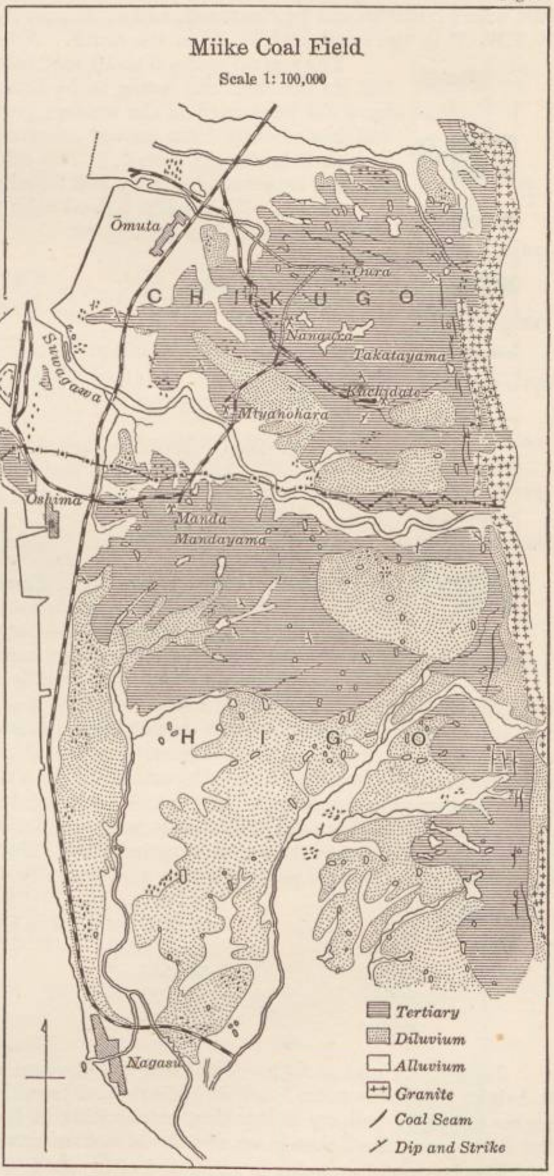
In the middle portion of the district east of Fukuoka, where the Kaigun-shinbaru colliery is working, a terrace deposit covers wide areas, especially in the middle part. The Tertiary strikes north-west, and forms two anticlines and synclines. The coal is worked here and there. In the important middle part, bounded by two rivulets, five seams are known to occur, of which the lower two, 3 to 4 feet thick, are usually worked, while the others, 2 feet thick, are sometimes mined, the uppermost being inferior in quality. To the north, one seam only is worked, being good in quality and 3 to 4 feet in thickness, while others are inferior in quality though they sometimes develop to a workable thickness. South of the middle part, two of the five seams are worked, the thickness varying from 2 to 5 feet.

In the south, south of Fukuoka, the strike is north or north-west, dipping east or north-east at a low angle. Two or three coal-seams were formerly worked, the thickness varying from 1 to 2 feet, more or less.

The Miike Coal-Field

Situation and history.—The Miike coal-field (Fig. 21) is conveniently situated near the shore of the Ariakeno-umi, the main railway of Kyūshū crossing the western part of the field. It covers a wide area, about 16 km. in a north-south and 8 km. in an east-west direction on the boundary of the provinces of Chikugo and Higo, and also extends under the sea. The coal is said to have been discovered over four hundred years ago, and has been mined on a small scale ever since. In 1883, the concession was transferred to the Imperial Government, and various improvements in methods of mining and transportation were introduced, gradually increasing the production. In 1888, it was put in charge of the Mitsui Mining Company, by whom modern improvements and appliances were introduced, and now, with the completion of improvements in its harbour facilities, the colliery has become the largest in Japan. Five pits and one inclined adit are in operation, the production of recent years together with that of each fifth year since 1874 having been as follows:

Fig 21



1874	63,781 tons.
1879	142,240 "
1884	246,063 "
1889	465,882 "
1894	674,863 tons.
1899	724,002 "
1904	1,252,235 "
1907	1,497,476 "
1908	1,537,684 "
1909	1,551,343 "
1910	1,799,489 "
1911	2,052,312 "

Topography and geology.—The field is a low undulatory plateau, fringing hills of basement granite 400 to 600 m. in height. Generally the field is higher in the eastern part, near the granite hills, especially in the north-eastern part, where the highest elevation, Takata-yama, only 145 m. in height, is situated. It gradually lowers to the west, with a height generally 40 to 60 m., ending in a narrow plain along the coast or being covered by terrace deposits, though Manda-yama, almost in the centre of the field, attains a height of over 100 m. It is cut by many rivers and rivulets, the largest of which, the Suwa-gawa, runs in a nearly east-west direction near the boundary of the two provinces. The sea is shallow, and before the recent improvements in the harbour it was not easy for steamers to approach the shore.

The coal-bearing formation consists of shale, sandstone and conglomerate, the thickness of each layer being very variable. Fossils abound in the formation but their evidence is not sufficient to determine the geological age, though one, recently discovered, seems to represent the Eocene. The strike is nearly east or north-west in the north, to the east of Ōmuta, but changes to a nearly north-south direction in the east, where the formation rests unconformably on granite. There the beds have been much contorted and the dip is steep or sometimes even reversed, so that the lower horizon can be examined. Westwards the dip becomes very gentle, being only 5° to 6° to west-south-west.

Faults are frequently met with, but, except those in the east where the formation is severely disturbed, they

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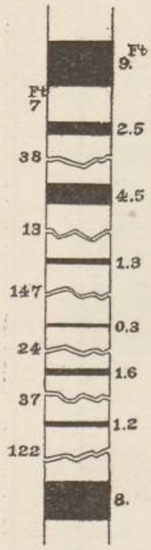
are all small and have little effect on mining operations. They run almost parallel in a north-east direction. There seems to be one fault in the north-western part running nearly east-north-east, beyond which the coal has not been examined.

Coal-seams.—Eight coal-seams (Fig. 22) are said to exist, but the upper two only are productive. The uppermost seam is the most important and furnishes the well-known "Miike coal." It extends over the area with a rather uniform thickness, though it sometimes varies from 5 to 25 feet. It can be traced from the extreme north to the south, and is known as the 8-foot seam. In the south, where the formation forms a very gentle anticline, the thickness is only 4.5 feet, and in Kachidate it parts into two. As above stated, it is much contorted in the east where outcrops can be examined, and strikes north-south, dipping with steep angles; but to the west it dips W.S.W. 5° in the north and W. 5° in the south. Numerous small faults are met with underground.

Fig. 22



Scale 1:500

The second seam, 6 to 10 feet below the main or 8-foot seam, is 5 feet thick on an average, but its development seems to be limited to the eastern part of the field, though borings for it have not been tried in the western part. The lowest seam is 9 feet thick or 4 feet of good coal, and has recently been proved to extend throughout the area with a rather uniform thickness, though it is not yet mined. The other seams are of very irregular thickness and extent, and it is not expected that they will be mined in the near future.

Quality.—The coal is a good caking bituminous variety, belonging to Class C. An average proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal.	B.T.U.
0.66%	41.74%	48.24%	9.36%	3.64%	7,460	13,427

Quantity.—The extension of the coal-seams has been proved by numerous borings, but there remains to be examined a wide tract as well as the submarine area. The amount calculated as actual reserves is 60,000,000 tons with 700,000,000 tons estimated for the probable reserves.

The Tertiary extending south of the Miike coal-field contains thin coal-seams. The coal was formerly mined between Miike and Takase, where the formation is much contorted. The correlation with that of the Miike coal-field has not yet been studied.

The Karatsu Coal-Field

Situation and history.—The Karatsu coal-field (Plate 4) lies in the central part of the province of Hizen. The area is about 20 to 27 km. in length and 2 to 13 km. in breadth, the longer axis having a north-west—south-east trend. A main railway line, with a branch line, connects the field with the three sea-ports of Nagasaki, Moji and Karatsu, the latter being the main shipping port. The coal is said to have been discovered about two hundred years ago[1] and, even before the Restoration of Meiji, it was used as fuel for local industries or exported as bunker-coal for steamers, though the total output must naturally have been insignificant. Soon after the Restoration, the mines were operated under the direction of feudal lords, and afterwards the greater part of the concession was transferred to the Imperial Naval Department. In a few years the mines came again into the possession of companies and private individuals. After 1885 large mining plants and improvements were successfully introduced, and the railway to Nagasaki and Karatsu was completed in 1898. The wars with China and Russia marked two epochs in the progress of the coal-mining industry. Four large collieries and forty-four small ones are now working. The production for each fifth year and, recently, for each year, was as follows:

1889...........	130,463 tons.	1908..............	1,017,214 tons.
1894...........	....	1909..............	859,602 "
1899...........	492,581 "	1910..............	909,727 "
1904...........	954,722 "	1911..............	1,112,548 "
1907...........	1,027,415 "		

Topography and geology.—The field is hilly and undulatory, the highest point, Kishidake, being 338 m. in height. Volcanic rocks, such as andesite and basalt, which overlie the coal-bearing formation, form somewhat higher ranges or solitary mountains, culminating in Hachiman-dake with an elevation of 737 m. Three rivers, the Taku-gawa, the Takeo-gawa and the Matsuura-gawa, drain the field, leaving narrow plains along their courses.

The basement complex is composed of crystalline schists, consisting mainly of hornblende schist, with rare occurrences of sericite-graphite schist. It underlies two small areas in the north-east; while granite occupies a wide area, bounding the field to the north. The Tertiary, which has been deposited on these rocks unconformably, may be divided into the lower and upper series. The lower series consists of alternating strata of sandstone and shale with coal-seams. The fossils found in the shale tend to prove that the formation represents the Miocene. As a whole the formation forms a symmetrical synclinal fold, though the strike is very variable, as a result of tectonic disturbance which has formed dome-like or basin-like structures and has caused the faults. Nine large faults running nearly north-east, north-west, or east-west, are known, the throw of the largest one reaching several hundred feet. The strike is usually between north-east and east, the angle of dip being generally less than 20°, but steeper near the basement complex and the granite.

The upper series consists also of shale and sandstone with conglomerate. The sandstone forms thick beds and is widely distributed, shell remains being found in it. The series underlies a wide area from the north-west to the south-east, bordered by the lower series, owing to faults, or overlying it conformably

Andesite and basalt, besides covering wide areas in the field, have been found, at several places, as sheets and dykes in the Tertiary, or in small patches.

Coal-seams.—The coal-seams that may be traced for any distance are thirteen in number (Fig. 23), their thickness varying from 1 foot to 6 feet. Of these, three are productive in the north and one in the south.

The northern section.—This section is drained by the Taku-gawa and the Matsuura-gawa. The four collieries which yielded over 50,000 tons in 1911 are as follows:

	1909	1910	1911
Yoshinotani	239,142 tons.	250,478 tons.	311,989 tons.
Ōchi	224,350 "	261,519 "	319,049 "
Kishidake	90,342 "	95,732 "	88,050 "
Iwaya	3,270 "	40,256 "	88,250 "

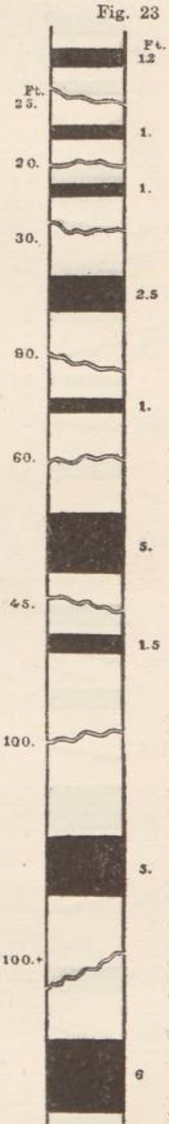
Of fifteen seams, nine have been traced throughout the section for nearly 19 km. and dip at a low angle, from 8°-15°. The average thickness of the seams, beginning with the uppermost, is 1.2, 1, 1, 2.5, 1, 5, 1.5, 5, and 6 feet, the others being all thin, generally less than 2 feet. The important seams are the fourth, sixth, eighth and ninth which have been productive in the past and will be in the future, while the other seams are workable when locally developed. The fourth seam is thin in the north, being only one foot thick, but to the south it gradually thickens, attaining a thickness of over 5 feet in the extreme south. It is worked in the middle and southern parts at the collieries of Yakushi-dani, Sunabaru, etc. The thickness is 2 feet in the middle of the section and 4 feet in the south, and future mining is expected to be in the south. The sixth seam has relatively numerous partings and a variable thickness. It is fully developed both in the north and in the south, being 7 feet thick; but is thin in the middle of the field. It is worked in the middle part of the area by the collieries of Noguchi, Nanamagari, etc., where the coal is only 1.5 ft. thick; and in the south by the collieries of Saigō, Uyenobaru, Susubayama, Sunabaru, etc., the coal there being 2.7 feet thick. The eighth seam is 5 feet thick with 2.5 feet of good coal, becoming gradually thinner toward the south, while the ninth is 6 feet thick with 4.5 feet of good coal, but is thicker to the south. These are the most actively worked seams in the field, especially in the north, at the collieries of Ōchi, Yoshinotani, Kishidake, etc. To the south, the eighth seam is worked at the Iwaya and Shōindani collieries, and the ninth at the Kiuragi colliery. Farther to the south they have scarcely been examined and are unexplored, though in a few places their existence has been proved by borings, so that they are expected to be mined in the future.

The southern section.—This section covers an area about 6 km. long drained by the Takeo-gawa, and two collieries yielded over 50,000 tons in 1911, as follows:

	1909	1910	1911
First Kijima	73,080 tons.	42,483 tons.	62,538 tons.
Second Kijima	58,232 "	79,565 "	168,399 "

Four coal-seams can be traced throughout the section. The average thickness in descending order is 3.5, 1, 2.5, and 3 feet, while the other seams are generally thin (less than 2 feet). The strike is west or north-west, dipping north or north-east at a low angle (less than 10°). The uppermost seam is the best and is the only one worked. It is thickest in the east, being over 5 feet in the environs of Ōmachi, and becomes gradually thinner to the west, diminishing to 3.5 feet near Kitakata. It has been actively mined in the district between Ōmachi and Kitakata, but owing to large faults which cut off the seams at both ends, the Akasakaguchi and Kitakata collieries had to be abandoned. To the east of Ōmachi the seams may still be followed, but to the west of Kitakata they appear to become thin, and are cut off by dykes of volcanic rocks. To the north-west they are covered and further exploration is highly necessary. The correlation of the coal-seams in the northern and the southern sections has not yet been ascertained, but it is probable that the seams in the southern section will correspond to the lower group of the northern.

Fig. 23



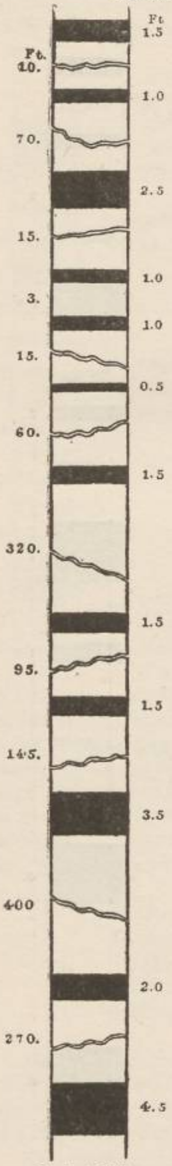
Quality.—The coal is bituminous and caking, belonging to Class C. An average proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U
3.03%	42.71%	46.15%	8.11%	2.51%	1.315	7,035	12,662

Silicified wood is sometimes found in the coal-seams, especially in the ninth seam in the northern section. In the southern section a part of the coal has been metamorphosed to natural coke by contact with volcanic rocks, but this does not frequently occur.

Quantity.—For the estimation of the actual amount of coal it will be necessary to carry out a more detailed and minute survey of the coal-field. From the known data, however, an estimate of 17,000,000 tons for actual, and 112,000,000 tons for probable, coal reserves has been obtained.

Fig. 24



Scale 1:200

The Sasebo Coal-Field

Situation and history.—The Sasebo coal-field (Plate 4) occupies the western part of the province of Hizen, covering an area about 35 km. in a north-south and 28 km. in an east-west direction. The Sasebo naval station is situated in the southern part of the field and has railway connections. The date of the opening of the field is not known, but it is quite certain that coal was mined before the Restoration of Meiji. As in other parts of the Empire, coal mining gradually became active after 1875 and numerous collieries were opened near the coast; but owing to the thinness of the seams, mining has in many cases failed, and abandoned adits are very commonly met with, especially near the coast. There are more than a hundred collieries now working, of which only the Matsuura colliery has yielded over 50,000 tons a year (63,403 tons in 1911). The total output of the field in recent years, together with that of each fifth year previous to 1907, was as follows:

1899...........	235,353 tons.	1909............	367,180 tons.
1904...........	216,133 "	1910............	321,848 "
1907...........	290,254 "	1911............	361,380 "
1908...........	356,596 "		

Topography and geology.—The coal-field is a hilly tract, capped by a basalt plateau with the highest peak, Kunimi-dake, rising to 795 m. in the eastern part. The basalt plateau, ranging from Kunimi-dake west-north-westward, forms the watershed of the field and gradually decreases in elevation towards the sea, ending generally in cliffs. The rivers are all small and narrow, while the coast abounds in bays, and islands are scattered along the coast, testifying to tectonic disturbance and deep erosion.

The field is underlain chiefly by the Tertiary and basalt, a narrow alluvial plain developing along the rivers and coast. The Tertiary consists of shale and sandstone, with interbedded coal-seams, but the correlation with those of the Karatsu coal-field has not yet been thoroughly established. Stratigraphically the Tertiary beds seem to represent the upper horizon of Karatsu, but the fossils found in them are not sufficient to determine the geological age. The dip and strike vary considerably, but in the north-eastern part of the field the strike is nearly north or north-west in general and the dip west or south-west at low angles (5°-20°), while in the south-western part it is north-east or east and the dip north-west or north at low angles (3°-20°), forming, apparently, a synclinal basin. There are numerous faults, of which ten are believed to be large, striking, as a rule, in a north-north-west or north-west direction. The throw of the larger faults is in some cases over 300 feet. Basalt underlies a wide area in the middle of the field besides patches scattered throughout the field.

From the geological relations, the coal in the western section seems to occur at the top of the series, while that in the north-eastern section occurs near the base. The total thickness of the coal-bearing series is estimated to reach 2,300 feet.

Coal-seams.—There are numerous coal-seams, and twelve can be enumerated when best developed (Fig. 24). The thickness is very variable, being mostly from 0.5 ft. to 6 feet.

The north-eastern section.—In this section the seams outcrop along or near the coast. The strike is nearly north-south along the western coast of Imari bay, dipping W. 5°-20°, while to the north-west the strike is variable, being generally north-west with the dip S.W. 5°-18°. Five coal-seams are known to occur, the middle or third, and the lowest, being productive. The middle seam is mined by the collieries of Kusuku, Kuhara, etc., and is 4.7 feet thick on an average. The lowest seam is mined, in the north, from Haze to the Inari-yama colliery and can be traced still farther. It is also mined on the southern coast of Fuku-shima. The thickness is 1.5 to 2 feet.

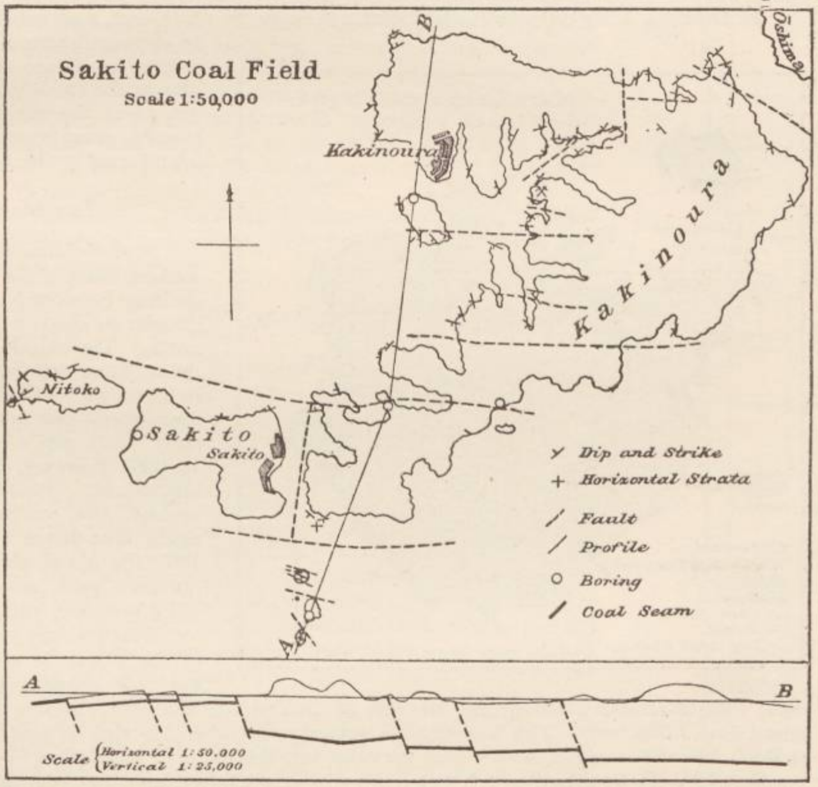
On the eastern coast of Imari bay, two coal-seams, 1 and 2 feet thick, are worked on a very small scale, their correlation with those of the western coast having not yet been ascertained, though, taking a fault into account, they seem to correspond to the upper part of those of the western coast.

The coal-seams of the northern coast, in the north-western part of the above area, are all thin, being 1.2 ft. when best developed, so that they are only worked intermittently, when conditions favour mining.

The southern section.—Along the middle course of the Ainoura-gawa, north of Sasebo, there are five thin seams. The fourth seam is 2.2 feet thick and is worked by small collieries, while the fifth is 3 feet thick, but of inferior quality. The dip is N. 5°-15° to the north of the river and N.W. 5°-10° to the south. A great fault dipping south, defines the course of the river and has a throw of over 300 feet. Near the top of Eboshi-yama, to the north-east of Sasebo, one seam 1.2 ft. thick is worked, dipping north-west at a low angle. Four seams to the east of Sasebo, strike north-west, bending like an arc in the middle; in all of them the thickness is less than 2 feet, the uppermost, 2 feet thick, being the one generally worked, though it is disturbed and metamorphosed by basalt dykes. Four seams dipping N.W. 3°-10° outcrop on the mountain flank west of Sasebo, at an elevation of about 220 m. The third seam is the one usually worked, being the thickest, though only 1.5 ft. thick.

The central section.—Twelve seams are found in the north, between Fukui and Yarimaki, near the edge of the basalt, and of these, the lowest four are productive, their thickness in descending order being 1.5, 1.5, 1.5, and 2 feet. They are worked by several collieries. The dip is north or north-west at a low angle. In the area west of the Saza-gawa, the coal-seams run north-easterly along the boundary of the basalt, the dip being N.W. 35° in the north, and W.N.W. 15° in the south. Of six seams, the fourth is important, being 2.5 feet thick, and is worked by the collieries of Ūno, Hiratayama, Saza, etc. On Enoshima, Yake-shima and other islands to the south, seven coal-seams are found, dipping N.W. 13°. Of these, the lowest, over 6 feet thick, is worked by the Mikumi colliery. Two others above it are 2 to 3 feet thick, but the coal is of inferior quality.

Fig. 25



The western section.—In this section coal-seams outcrop near the coast, and almost parallel to it, in a north-north-east direction, dipping W.N.W. 12°-20°. Eleven seams have been enumerated and the second is worked at the collieries of Kirinoki, Fukaura, Ōnakiri, etc. It is thin in the north, i.e., in Emukai, but thickens to the south, and at the Kirinoki colliery is 2.5 feet in thickness; generally it is 1.5 ft. thick. There are three other seams of the same thickness but with numerous partings.

Quality.—Generally the coal is of the caking, bituminous variety and belongs to Class C. An average proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Cal.	B.T.U.
3.41%	36.67%	44.24%	15.68%	1.40%	5,943	10,699

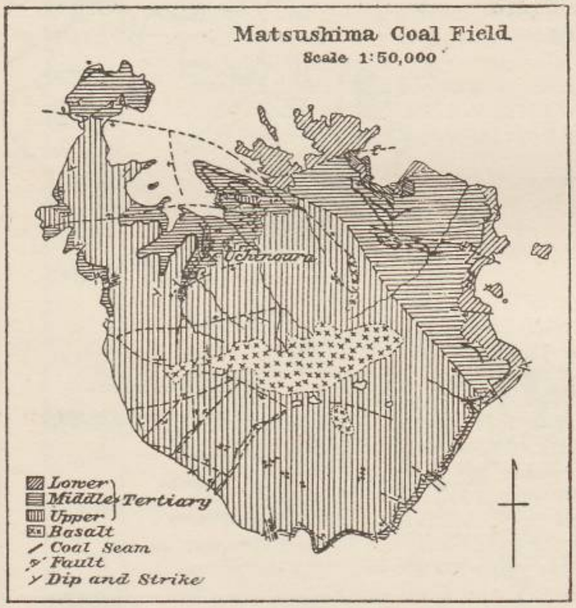
Quantity.—The coal-seams are all thin and their exploration has been incompletely carried out, so that it is exceedingly difficult to estimate the amount of coal in reserve, but, from the area considered to contain coal, 90,000,000 tons have been calculated as the probable reserves.

The Sakito Coal-Field

The Sakito coal-field (Fig. 25) includes a group of islands, the chief of which are Kakinoura-jima, Sakito-jima and Mitoko-jima, situated about 4 km. north of Matsu-shima. Mining in Sakito-jima was commenced only three years ago, the production being 1,775 tons in 1910 and 57,048 tons in 1911. The island is hilly, being higher along the southern and eastern part and sloping gradually to the north and west. It is underlain by shale and sandstone, with tuff occurring in a few places. One basalt dyke is found in the north-eastern part of the island. Owing to numerous faults, the strike is very variable, but, in the north, it is generally north-south, and in the south, east-west. The dip is west in the north and north in the south, the angle of inclination being very low, often less than 5°. The largest fault is found in the north-eastern extremity of the island and separates it from Ō-shima, the throw probably reaching over 1,000 feet. Four other faults, running in an east-west direction, are found to the south, their throws ranging from 80 to over 300 feet. For mining in the submarine area, the same conditions hold here as in the Matsushima coal-field. Although boring has proved the presence of one seam with a thickness, including partings, of 15 to 20 feet, no outcrops occur. During the sinking of the shaft, three seams, above the main one, were met with that were not struck in the bore-hole, their thickness being 3.5, 3 feet, and 1 foot, respectively. They are probably only a local development, though further exploration is necessary. As to the coal-seams far underground, they can only be proved by borings. The amount estimated is 16,000,000 tons for the actual, and 40,000,000 tons for the probable reserves.

In Ō-shima, lying adjacent to Kakinoura-jima on the north-east, coal is believed, from geological evidence, to occur underground, but the outcrops found in the eastern coast are of inferior quality. Coal occurs also in the small islands near Ō-shima but has not yet been thoroughly examined. In a group of islands, ranging west from Sakito-jima to Gotō island, coal is also known to occur.

Fig. 26



The Matsu-shima Coal-Field

Matsu-shima (Fig. 26) is an island near the western coast of the province of Hizen, lying almost midway between Nagasaki and Sasebo. It is nearly circular in shape with a peninsula projecting to the north. The island is a low plateau, with the highest point, Tōmi-dake, about 220 m. high, lying almost in its centre. Coal is said to have been discovered there about one hundred and thirty years ago, and sixty years ago a mine was successfully working. In 1883, however, mining became difficult and was abandoned. Four years later the mine was re-opened, but, on account of mine water, it was again abandoned after three years' working. In 1906 the Matsu-shima colliery was opened in the northern part, and yielded 86,103 tons in 1909, 127,356 tons in 1910 and 156,827 tons in 1911.

The Tertiary, which constitutes the foundation of the island, is covered by basalt in the middle part. It consists of shale, sandstone and conglomerate with interbedded coal-seams, and can be divided into the upper, middle and lower series, the total thickness being 1,500 feet. The formation is severely disturbed, so that it is difficult to determine the general strike. The dip is consequently very variable, but the angle of inclination is generally very low, being often less than 10°. Six large faults, each with a throw of over 100 feet, have been examined. In and near the sub-marine area, mining is interfered with by the inflow of mine water through cracks in the sandstone and faults. The coal-seams are found only in the middle series. Of nine seams, five are important; the other four are thin, being one foot or less in thickness. The first seam is 3 feet thick with 1.5 ft. of good coal. It was formerly worked, but owing to its thinness and inferior quality it is not mined at present. The second seam varies from 0.7 to 2 feet, and is sometimes worked. In the Matsu-shima colliery it unites with the third seam and is worked under the name of the 5-foot seam. The third seam is most important, being over 10 feet thick, with partings, or 4 to 5 feet of good coal. It thickens in places to 15.5 feet or 14 feet of good coal. The lowest two seams are also worked, their thickness being 4 to 6 feet or 2.5 to 4 feet of good coal (Fig. 27). From known data we get 10,000,000 tons for the actual, and 28,000,000 tons for the probable reserves.

In Seto, on the western coast of the province of Hizen opposite Matsu-shima, the Tertiary, considered as a continuation of that of Matsu-shima, outcrops in a narrow area along the coast. The strike is north-north-east, and the dip east or west, the angle of dip being often less than 10°. No coal is found, as the formation seems to represent the upper series of Matsu-shima and exploration by boring is very desirable.

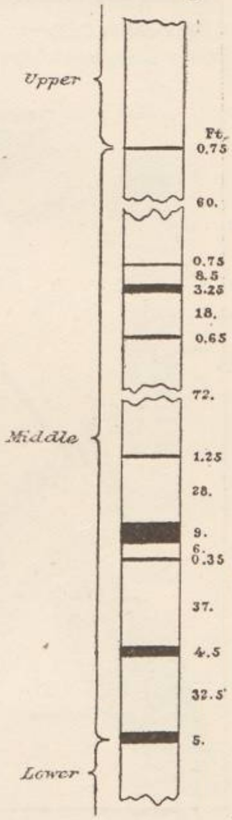
Fuku-shima, an island near Seto, on the south, consists of shale and sandstone, dipping E.S.E. 15°-20°. One coal-seam, 2 feet thick, of inferior quality is found in the western part. The upper series and the upper part of the middle series only seem to outcrop there, so that further exploration will be necessary.

THE TAKA-SHIMA COAL-FIELD

Situation and history.—In the Taka-shima coal-field (Fig. 28), we include the small islands lying south-south-westward of Nagasaki harbour, along the western coast of the province of Hizen. The famous coal in Taka-shima is said to have been discovered and mined about two hundred years ago, and after 1817 was mined under the direction of the feudal lord. European mining methods were first introduced in Japan at the Taka-shima colliery by an English engineer in 1868. Six years later the concession was taken over by the Imperial Government; but in the next year it was again transferred to private citizens and in 1881 to the Mitsubishi Mining Company. The coal in Kōyagi-jima was discovered about ninety years ago and has been worked on a small scale.

Topography and geology.—The coal-field consists of a group of small hilly islands, built up of Tertiary shale and sandstone with coal. In Taka-shima the geological structure is much complicated. Generally the strike is north-north-east dipping W.N.W. 25°, but, in the north, the formation is cut by two large faults, beyond which it forms half of a synclinal basin in the submarine area, though it is disturbed by faults. In the submarine area, west of the island, separated by a large fault from the island, the strike is generally north-west, dipping south-west at a low angle (15° to 25°), and a large fault traverses it in a north-west direction. Small faults are also frequently met with, their direction being mostly north-south, or north-west—south-east. In Ha-shima the strike is north-north-east, and the dip west-north-west, the angle of dip being 20° in the north and 60°-70° in the south. In Nakano-shima also the dip is west-north-west, but in Ha-shima a large fault seems to run in a north-west direction. In Kōyagi-jima the strike is generally east-north-east and the dip north-north-west, the angle varying from 5° to 20°.

Fig 27



Scale 1:1,000

The Taka-shima colliery.—This concession includes the islands south of Taka-shima, and mines are operated in Taka-shima and Ha-shima. The production of recent years and of each fifth year before 1904 was as follows:

1894	127,587 tons.	1908	187,784 tons.
1899	167,884 "	1909	182,593 "
1904	231,429 "	1910	214,377 "
1907	185,839 "	1911	239,382 "

There are numerous coal-seams, of which six are important and productive, being relatively uniform in quality and thickness (Fig. 29). Most of the coal in the islands has been taken out and mining is now carried on in the submarine area. In Taka-shima six seams are mined, but, probably owing to faults and for fear of approaching the sea bottom, mining toward the strike and up the dip has been suspended. The thickness of the seams, beginning with the uppermost, is 6.5, 10, 5, 3, 17 and 5 feet. In Ha-shima the lowest one has not yet been reached. The thickness of five seams, in descending order, is 8, 7, 5, 3 and 9 feet. The fourth seam is often mined with the fifth. Owing to bad ventilation and much mine water, mining toward the strike and up the dip has here also been suspended. In Nakano-shima only the uppermost seam was worked but, owing to mine water, mining has been abandoned. In the island, however, the presence of the second seam has been ascertained by borings. From known data it is evident that the submarine area between these islands is underlain by productive coal, but future mining will be rendered difficult by mine water, bad ventilation and the presence of faults. Plans are being made for mining coal to the dip by a slope from Futago-shima.

Kōyagi-jima.—Coal is mined in the southern part of the island. Fifteen seams are known, their thickness, in descending order, being 4, 3, 5, 2, 4, 3, 2, 4, 3, 5, 3, 2, 7, 1.5 and 3 feet. In the south-eastern part of the island the formation dips N. 6° and the upper beds have been wholly eroded away, so that the sixth, seventh, eighth and ninth seams are worked there, with a thickness of 3, 2, 5, and 2 feet, respectively. In the neighbouring district, on the north-west, the dip is N.N.W. 20°. There a large part of the upper seams has already been worked out, so that the eleventh and thirteenth seams are being worked at present.

Yoko-shima.—This small island lies very near Kōyagi-jima on the south and is underlain by three seams which have been proved to exist by borings. The thickness in descending order is 5, 3, and 3.5 feet. In 1895 a shaft was sunk and completed the next year. It yielded some coal, but is now abandoned. The strike is east and the dip N. 25°.

Quality.—The coal is one of the best bituminous varieties in Japan and is caking. An average proximate analysis of it is as follows:

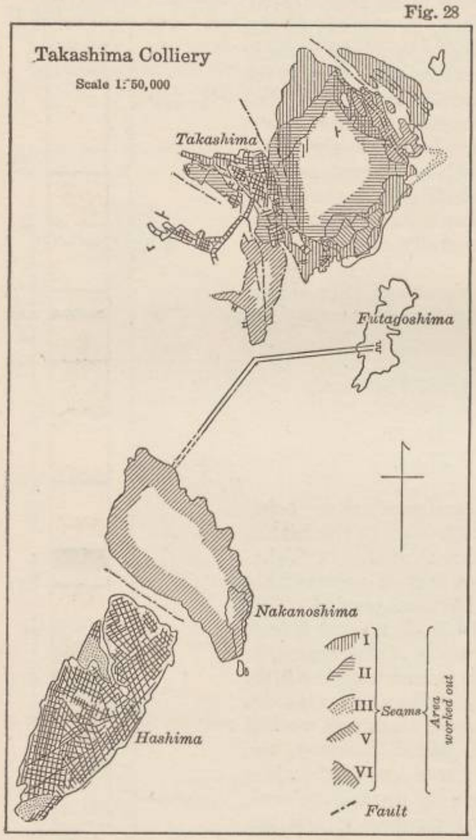
Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
1.16%	38.83%	54.43%	5.58%	0.82%	1.297	7,211	12,979	C

Quantity.—As the coal remains unworked in the submarine area it is difficult to ascertain the amount with any degree of accuracy, but the known data make it possible to estimate the coal in the Taka-shima colliery at 25,000,000 tons for the actual, and 121,000,000 tons for the probable reserves; and that in Kōyagi-jima at 8,000,000 tons for the actual, and 25,000,000 tons for the probable reserves.

Coal in the South-eastern Part of the Province of Hyūga

The Tertiary, chiefly consisting of shale and sandstone, underlies a hilly, undulatory tract along the eastern coast, in the south-eastern part of the province of Hyūga. The coal is interbedded in the Tertiary and is generally thin. In Ōdōtsu, on the eastern coast, one coal-seam, with a variable thickness of from 1 foot to 4 feet, with partings, was formerly worked. As the formation is severely disturbed it is not possible to trace the seam for any distance, and it is probably lenticular in form. In the environs of Fuku-shima, on the southern coast, two coal-seams were formerly worked. The thickness is variable, being generally 1 foot to 2 feet, sometimes increasing to from 4 to 5 feet with partings. The formation has suffered from tectonic disturbances, making it difficult to trace the seams, which appear to form lenticular masses.

Fig. 28



The coal is semi-bituminous and caking. The result of a proximate analysis of it is as follows:

Moist.	Vol mat.	Fixed C.	Ash	Sulph.	Class
0.68%	23.06%	57.35%	18.01%	3.50%	B_2

In Tanega-shima, an island south of the province of Hyūga, coal occurring in a similar manner to that in the province of Hyūga, was formerly worked. The thickness is often less than 1 foot.

The Yaeyama Coal-Field

Yaeyama is a group of small islands to the extreme south-west of Ryūkyū and near Taiwan. Coal is found in Iriomote-jima, Kobama-jima and Yonaguni-jima, but in the latter two islands it is thin and unimportant. Iriomote-jima is underlain mainly by the Tertiary, the Palæozoic occupying a small area on the eastern coast, which is fringed here and there with coral reefs. The Tertiary consists chiefly of sandstone with thin shale beds and, in general, strikes north-north-east, dipping west at a low angle. Seven seams are said to occur but only the second is important and is being worked near the coast on a small scale. The thickness is 3 to 4.5 feet in the middle part of the island, but only 1 foot in the north. The other seams are thin, being only 1 foot or less in thickness. The coal is a caking semi-bituminous variety, belonging to Class B_2. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.
0.68%	23.06%	57.35%	18.01%	3.50%

The production was 10,036 tons in 1910 and 11,396 in 1911. The coal reserves are small, being estimated at 3,000,000 tons.

5. TAIWAN (Formosa)

Coal is known to occur in the northern part of Taiwan, interbedded in the Tertiary rocks. Lignite of very inferior quality is found in the diluvium here and there on the island but is not important.

The Taiwan coal-field (Fig. 30) occupies an extensive area in the northern part of Taiwan extending from the north-eastern coast south-westward to the south-east of Byōritsu, with a total length of about 145 km. and a breadth of 2 to 8 km. The date of discovery is not recorded, but it is said that in 1848 coal was already known near Kiirun. About forty years ago coal near Kiirun was mined and the Hatto colliery opened by the Chinese Government on a rather large scale. After the island was ceded to Japan, mining gradually became active and the output increased. The production before the union is not well known but the exports from 1891 to 1894 have been roughly put at 20,000 tons. As suggested by these figures, the total production did not exceed 50,000 tons. In 1895 the production decreased, owing to the Sino-Japanese war. The production of recent years and that of each fifth year since 1895 is as follows:

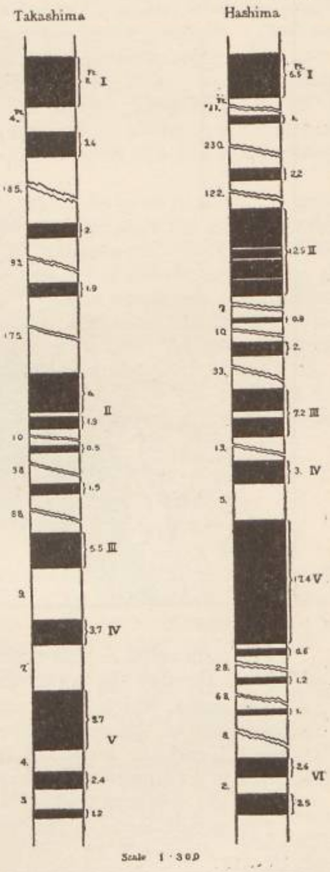
1897	19,425 tons.	1908	154,293 tons.
1899	30,051 "	1909	183,375 "
1904	82,660 "	1910	231,595 "
1907	135,232 "	1911	254,870 "

The coal is, generally, of the caking, bituminous variety. The result of a proximate analysis is as follows:

Moist.	Vol. mat.	Fixed C.	Ash	Sulph.	Sp. gr.	Cal.	B.T.U.	Class
3.92%	38.97%	52.05%	5.06%	1.99%	1.278	6,772	12,190	C

The field forms a narrow belt fringing the north-western flank of the main mountains of the island and slopes gradually to the north and west, being covered by diluvial hills in the west, and ending at the sea, or cut off by volcanic rocks in the north. The coal-bearing Tertiary consists chiefly of sandstone alternating with shale. Abundant fossils are found in the formation, by which it has been proved to represent the Miocene. The coal-seams are very numerous and generally interbedded in the shale, sometimes in shale and sandstone, and rarely in sandstone. They may be grouped into twelve series each containing from five to nine seams, of which from two to three are workable. The vertical interval, between the workable seams, varies from 3 to 450 feet and is generally from 20 to 160 feet, while the thickness of the different series ranges from several hundred to several thousand feet. Although faults and flexures have greatly disturbed the formation and although it is intruded by volcanic rocks, such as andesite and basalt, many of the seams may be traced for over a hundred kilometres. The thickness of the seams is generally 0.6 to 3.5 feet, rarely reaching to 7 or 9 feet. The angle of dip is generally from 20° to 35°, sometimes as steep as 70° or 80° or as low as 3°. The seams reach their greatest development to the north of Taihoku; from there southwards the seams are often covered by diluvium.

Fig. 29



The coal-field has been surveyed only roughly, so that the amount of coal calculated, i.e., 385,000,000 tons, is an approximate estimate only.

The first series.—This series represents the lowest group of coal-seams and is found in the form of an anticline to the north of Kinpōri. Two seams in the northern wing, the upper being 1.2 and the lower 0.8 ft. thick, may be traced for about 2 km. and strike N. 50° E., dipping N.W. 65°. Only one seam, 0.8 ft. thick, is known in the southern wing. The series is cut off by the volcano Daiton and reappears to the north-west of Hokutō, beyond it. The coal is being worked west-north-west of Kinpōri, but the production is insignificant.

The second series.—This series outcrops in a valley at Intanshi, about 4 km. south of Kinpōri. Two coal-seams, about 30 feet apart, are 1.2 and 0.8 ft. thick and were formerly worked. The strike is nearly east-west, dipping S. 20°. Eastward the series dips beneath the sea at Hattoshi, where it is now being worked, though the production is small. Westward it is cut off by volcanic rocks but again outcrops at Sankakuho and Kiriganshō, south-east of Hokutō, striking N. 80° E. and dipping S. 12°. The total distance it has been traced is estimated at 3 km.

The third series.—This series is best examined in the valley of Kankyaku, about 8 km. west of port Maso. Two coal-seams, about 40 feet apart, the upper 4 feet and the lower from 0.5 to 0.6 ft. thick, are found striking nearly north-south, and dipping E. 8°-10°. Eastward they bend to the north-east, dipping S.E. 10°-20° to the sea. To the west they are cut off by volcanic rocks, and reappear at Sōkei and Shirin, where two seams, the upper 3 feet and the lower 0.5-2.0 ft. thick, are found and are being worked here and there on a very small scale. The total distance along which they outcrop is said to be 20 km. The Kankyaku concession, about 13 sq. km., is expected to contain a large amount of coal.

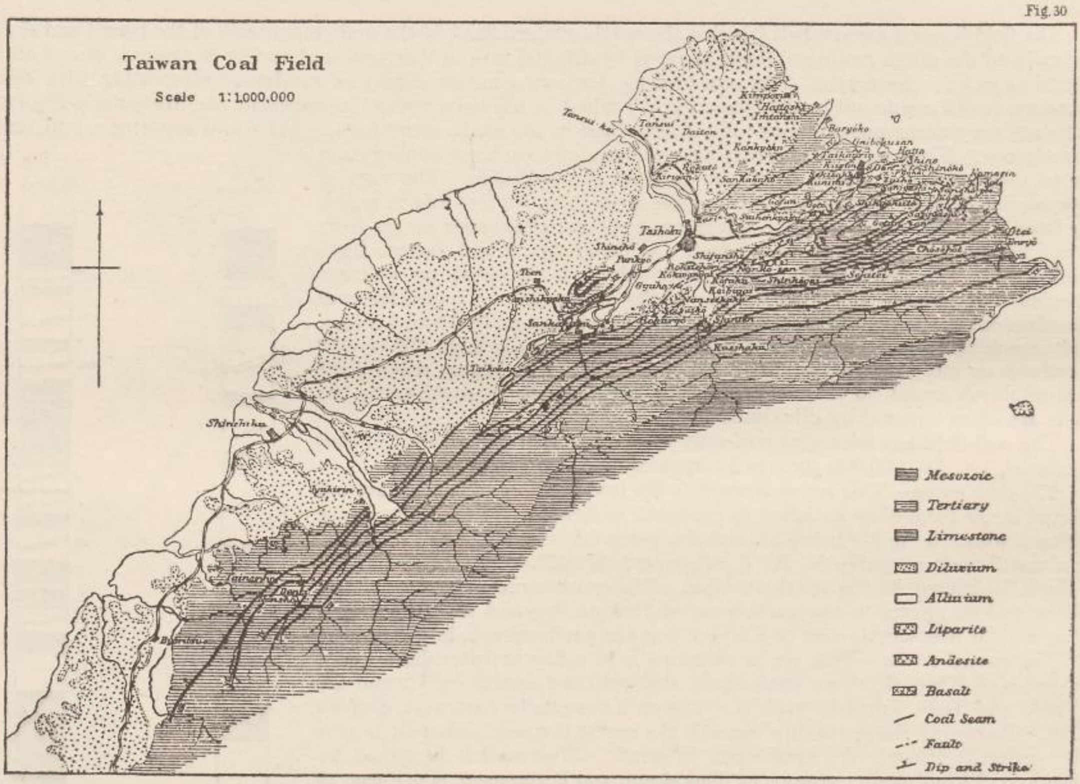
The fourth series.—This series outcrops in Baryōkō and strikes N. 60° E., dipping S.E. 20°. Three coal-seams are known, the upper being 0.5, the middle 1.3, and the lower 1.8 ft. thick. They can be traced along the strike for about 10 km.

The above four series are all cut off at the Tansui-kei, or disappear under its drainage plain, beyond which they are supposed to lie under a deep cover and no outcrop can be found for examination.

The fifth series.—This series is found on the coast of Gaibokuzan, about 4 km. north of Kiirun, where it strikes N. 42° E., dipping S.E. 25°. South-westward it turns to a nearly east-west direction, dipping south at steep angles and sinks beneath the Taihoku plain with a total length of about 16 km. Three coal-seams noted are, in descending order, 1.2, 2, and 1.2-3 feet thick. Of these the middle and lower seams are mined, as the coal is fitted for the manufacture of coke. The coal of this series is being worked in several places, the largest colliery being that at Taikanrin, about 4 km. north of Kiirun, where three seams occur, the upper and lower being from 1 to 2 feet thick while the middle seam is over two feet thick; the strike is N. 42° E., dip S.E. 27°. The production was 4,984 tons in 1908, 5,127 tons in 1909, 7,554 tons in 1910 and 16,899 tons in 1911.

Beyond the Taihoku plain the series reappears in hilly land west of the plain and north of Sankakuyū. To the north the strike is generally N. 50° E., dip S.E. 40°, but southwards it bends so as to form an irregular gourd-like dome, dipping steeply, often with angles of 80°. The coal-seams, three in number, have been traced for 12 km., the upper being 1.2 ft., the middle 2.5 feet and the lower 0.4 ft. thick. The second seam is important for its size and quality, and is suitable for coke making. It is worked on a small scale.

Fig. 30



The sixth series.—This series consists of two thin seams outcropping from the south of Hattoshi to the east of Kiirun, through the north end of Denryōkō, with a total length of about 4 km. It is not important.

The series, which forms an elongated irregular dome with Gofunsan in the centre, probably represents the reappearance of the sixth coal series, as a result of folding. It consists of three seams, the upper being 1, the middle 1.5, and the lower 0.8 ft. thick. In the southern wing only a few outcrops are known, while in the northern wing it is being mined in several places and the coal is generally used for the manufacture of coke. The outcrops on the northern foot of Nankō-zan and north-west of Kōkwangai seem to represent the series.

The seventh series.—This series is very important and outcrops on the coast of Hattoshi, where it strikes N. 70° E., dipping S. 18°. Westward the strike gradually bends to the east and the dip is southward with angles of 30° in general, until the series sinks under the Taihoku plain, with a total length of about 28 km. Of four coal-seams, the upper and the lower ones are thin, being from 0.5 to 1.2 ft. in thickness, while the middle two are generally 2 to 3 feet thick. The coal of the series is now worked very actively, the Denryōkō, Kiirun, Shinō (Hatto), Sekisakkō, Kunimi, and Gofun collieries being noted. At the Denryōkō, about 1 km. east of Kiirun, three seams occur, in descending order, 0.6, 1.2 ft. and 3 feet thick, the lowest being the chief one mined. It strikes nearly east with the dip S. 25°. The Kiirun, to the east of and adjacent to the Denryōkō, and the Shinō, about 8 km. east of Kiirun, are working the same seams. At the Shinō the strike is N. 68° E., dip S.E. 18°, but in the Kiirun, it is variable owing to faults. In the neighbouring Sekisakkō and Kunimi collieries, about 3 km. north and 6 km. north-west of Schichito station, respectively, three coal-seams are known, the middle one, 3 feet thick, being mined. The strike is N. 70° E. to nearly east and the dip is S. 20°. At the Gofun colliery, about 6 km. north-east of Nankō station, only two seams are known, the upper being 1.3 ft. and the lower 2.8 feet in thickness, striking N. 82° E. and dipping S. 28°. The production of these collieries in recent years was as follows:

	1908	1909	1910	1911
Denryōkō	11,841 tons.	12,926 tons.	19,423 tons.	17,385 tons.
Kiirun	13,089 "	24,914 "	32,944 "	40,036 "
Shinō (Hatto)	6,911 "	8,547 "	7,528 "	17,642 "
Sekisakkō	4,219 "	2,061 "	3,507 "	2,743 "
Kunimi	1,800 "	1,062 "	4,186 "	2,050 "
Gofun	2,250 "	4,434 "	4,787 "	4,236 "

A series of seams outcrops from the south-western flank of Nankōzan across Sanchōri and Rokuchōri, to the south of Kōkwangai, where it disappears beneath the Taihoku plain. Three coal-seams are found, the upper 1 foot, the middle 1.7 ft., and the lower 3 feet in thickness. The correlation of the series is not known, but it appears to correspond to the seventh, which might outcrop here as a result of folding.

After the series has sunk beneath the Taihoku plain, it again appears in the west of Taihoku with the fifth series. It forms a half dome, the total length being roughly 16 km. The angle of dip is S.E. 55° to S. 40° in the south-eastern wing of the dome, while, in the north-western wing, it is generally steep, being 70° to 80° or even vertical. Of eight coal-seams, three are important, their thickness, beginning with the uppermost, being 1.2, 2.5, and 2 feet. The upper and lower seams are of good quality and nearly constant in thickness, while the middle is rather avoided, as it varies in thickness from 1 foot to 7 feet, and the coal is often badly crushed. The series is worked in several places, the Sanshikyaku colliery, about 1 km. west of Sanshikyaku station, being well known; it yielded 4,477 tons in 1908, 3,958 tons in 1909, 4,789 tons in 1910, and 6,953 tons in 1911. At this colliery there are three coal-seams, the upper being 1-2, the middle 3 and the lower 2 feet thick. They strike N. 50° E. and dip S.E. 50°. Numerous faults are met with and the coal in the south-western wing, owing to disturbances, seems impossible to mine. As the lower seam is of good quality and constant in thickness it is the most actively mined, though the other two are also worked.

The beds which outcrop in the form of an elongated dome surrounding the similar outcrop of the sixth series, represent the seventh series, and can be traced for 50 km. Good coal is found west of Zuihō, in the northern wing, where it is actively mined. Westward the series dips with steep angles and is often disturbed, the coal being often badly crushed and at last cut off by volcanic rocks. At Kodō at the eastern end of the southern wing, the dip is gentle, but farther west it increases to 70°. Two or three coal-seams have been examined, the thickness varying from 0.7 ft. to 3 feet. Sanjyashi and the First Zuihō are the principal collieries. In the Sanjyashi colliery, about 1¾ km. south-west of Zuihō, the series strikes N. 68° E. and dips N.W. 50°. Three coal-seams occur, with thicknesses, in descending order, of 1.2 ft., 3 feet, and 1.5 ft., the middle one alone being worked. In the First Zuihō colliery, lying on the north-western foot of Sanshō-rei, the series strikes N. 60° E. and dips S.E. 40°. Two seams, the upper one foot thick and the lower over 2 feet thick, are being worked. The production of recent years was as follows:

	1908	1909	1910	1911
Sanjyashi	723 tons.	4,561 tons.	3,246 tons.	3,351 tons.
First Zuihō	1,154 "	3,632 "	4,583 "	2,500 "

The eighth series.—This series is best studied where it outcrops in the environs of Shinōkō, about 6 km. east of Kiirun, where it is mined. The general strike is N. 65° E., dipping S.E. 20°. To the south of Daisuikutsu, south of Kiirun, the series has suffered severe distrubance and can be traced no farther. It reappears in the environs of Goto, east of Suihenkyaku and forms an anticline and two synclines, and is also cut by faults. It outcrops still farther westward and sinks beneath the alluvial plain to the north of Keibigai. It is most fully developed in the east, where three coal-seams are found, the upper being 1.2 ft. thick, the middle 3.3 feet and the lower 1 foot. The general strike is N. 70° E., dipping S.S.E. 10°-15°. In the environs of Kōfuku the lower seam has not been found, but the upper is 1.3 and the middle 2.3 feet thick. Shikyakutei, the most important colliery, is situated about 3½ km. south-east of Kiirun, in a synclinal basin. The dip is gentle, being often 20°. There are three seams, the upper being 1.2 ft. thick, the middle 3.3 feet and the lower 1 foot.

As a result of folding, the series appears in the south, where it forms an elongated dome, the outcrop surrounding that of the seventh series. In the northern wing the coal is mined at several places, especially in the eastern part, where it dips N. or N.N.W. 50°. The series is often disturbed by volcanic rocks in the west. To the south-east of Nankō-zan, the outcrop swings sharply to the north-east and becomes the southern wing of the anticline. In the southern wing the coal along the upper Kiirun-gawa, eastward from Sekitei, is expected to be mined in the future, and three seams, from 0.5. to 3.3 feet thick, strike almost east, dipping S. 10°. To the east the series is cut by volcanic rocks and turns to the north to unite with the northern wing. The coal has suffered contact metamorphism by volcanic rocks and is changed to anthracite. The total length of the outcrop is about 60 km. Two collieries, the Second Zuihō and Shifunshi, are noted. In the Second Zuihō colliery, about 2 km. north-east of Zuihō, two coal-seams are found, the upper being 1 foot thick and the lower 2 to 7 feet or an average of 2.5 feet, the strike being N. 58° E. and dip N.W. 58°. In the Shifunshi colliery, about 4 km. south of Nankō station, two coal-seams 1 to 3 feet thick are found. As the colliery is on the western end of an elongated dome, the dip is different in both wings, being N.N.W. 40° in the north and S.S.E. 25° in the south. The production of these collieries was as follows:

	1908	1909	1910	1911
Shikyakutei.............	14,007 tons.	18,699 tons.	41,327 tons.	50,327 tons.
Second Zuihō...........	2,262 "	3,283 "	3,036 "	4,075 "
Shifunshi................	3,742 "	3,458 "	4,200 "	4,148 "

A coal series outcropping on both wings of an anticline at Nanseikaku and running south-westwards, seems to represent the eighth series. The anticline continues to the south of Byōritsu, and outcrops of coal are found here and there on both wings; the length of it from Hatto exceeds 120 km. In Rokuryō three seams, the upper 1.8 ft. thick, the middle one 1.5 ft. and the lower 1.8 ft. thick, strike N. 45° E., dipping S.E. 23°. From Seifuku east of Sankakuyū, southward, the seams become thin and mining is not active, being on a very small scale here and there, though in Tainanho an outcrop of coal 4 feet thick strikes N. 30° E., with the dip W.N.W. 65°, and a seam 9 feet thick is found in Hokka.

Two collieries, Gyūho and Seisuikō, are noted. At the Gyūho colliery, about 5 km. south-east of Pan-kyō station, three coal-seams are found, 0.7 ft., 1 foot and 1.5 ft. thick, in descending order. As an anticline traverses the area, the dip is reversed in the north and south, the angle in both cases being from 15° to 20°. In the Seisuikō colliery, about 6 km. south of the same station, three seams are found on both wings of an anticline which traverses the area. The strike is N. 45° E., the angle of dip being 20° to 60°. The thickness of the seams, beginning with the uppermost, is 1.8, 1.5 and 1.8 ft., respectively. The series suffers slight disturbance through volcanic intrusion, though the coal is scarcely influenced by it. The production of these collieries was as follows:

	1908	1909	1910	1911
Gyūho..................	4,211 tons.	7,199 tons.	6,041 tons.	5,439 tons.
Seisuikō................	52 "	509 "	3,386 "	3.299 "

The ninth series.—This series outcrops on the coast of Namarinshō, about 4 km. east of Kiirun-san, where the coal is being mined. It strikes south-westward, gradually approaching an east-west direction, until it strikes nearly east at Shinkōgai and Keibigai and is covered by alluvium at Keibigai. In the east the series forms an anticline and a syncline, and may be traced for about 20 km. It again appears in the south of Nanseikaku and runs south-west, the coal being mined at several places, among others at Jyūsanshō, south of Sankakuyū; Sansōshō, south of Taikokan; Denbi; and Nanshō. Near Denbi and Nanshō a small anticline and syncline are also to be seen. The total length of the outcrop of this series is about 120 km. Two seams are known to occur. At Namarinshō two coal-seams, the upper 0.7 ft. and the lower 1.8 ft. thick, strike N. 20° E., and dip E.S.E. 20°. Near Keibigai the strike is nearly east, dip S. 30°-40°, the upper seam being 1.5 ft. and the lower 2 feet thick. In Denbi the strike changes to N. 30° E. with the dip E.S.E. 45°, the size of the seams remaining the same. Thus it will be seen that the series bends with the mountain system and contains two coal-seams. As the seams are rather thin and transportation is not easily available, mining is unimportant.

The tenth series.—This series outcrops near the coast of Ōtei and runs west-south-west to Shinten through the north end of Chōsōkei and Sekitei and the south end of Shinkōgai. From Shinten the outcrop bends south-west and strikes almost parallel to the ninth series to the south of Nanshō, where it can no longer be followed. Its total length is estimated at about 120 km. The dip is south-south-east to south-east and the dip is in general 50°, although a small anticline and syncline occur in the environs of Denbi and Nanshō and end south of Jyukirin, forming an elongated dome. Two coal-seams are known, the upper being from 0.7 to 1.2 ft. thick and the lower 2 to 2.5 feet. They are worked on a very small scale in several places.

The eleventh series.—This series outcrops from south of Chōsōkei eastward to the coast of Enryō, where two coal-seams, the upper 0.8 ft. and the lower 1.8 ft. thick, are found, striking N. 10° W. and dipping S.W. 30°. To the west of Chōsōkei, outcrops are seen only here and there, appearing to run south-west, almost parallel to the tenth series. The total length of outcrop is about 100 km.

The twelfth series.—This series runs from south of Chōsōkei, nearly westwards, to the south of Taikokan through the north end of Kusshaku, forming a syncline with dips of from 30° to 60°. Its total length of outcrop is about 80 km. Two coal-seams are known, the upper being 0.4 and the lower 1.5-2 feet thick.

THE COAL RESOURCES OF THE FEDERATED MALAY STATES

COMPILED BY

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An important discovery of coal was made in 1908 on the southern boundary of the Rantau Forest Reserve, south of the Selangor river, about latitude 3° 20′ N. and longitude 101° 28′ E. It lies about seven miles west of Rawang railway station. The coal-bearing series, consisting of shales and sandstones, rests unconformably on a foundation of quartzite and slates which also form the surrounding hills. The prevailing dip is 15° west of south at 15°, but the beds are sometimes horizontal. They appear to be later than the Cretaceous granites and are probably of Tertiary age. This is confirmed by the evidence of the plant remains, which have been identified with types now living in the Federated Malay States. The coal is largely composed of a reed-like plant not sufficiently preserved for determination.

There appears to be two seams, though up to the present they have not been met with in the same bore. The larger and upper seam is more than twenty-four feet, and possibly fifty feet, in thickness. The coal extends for more than half a mile along the strike, and may be found at still greater distances. It is black and lustrous, does not soil the fingers, has a distinct conchoidal fracture, and burns with a long, smoky flame.

The following analyses have been made:

	Imperial Institute	F. Dent	J. B. Scrivenor		B. J. Eaton
			Mean of Four Analyses	Best Coal	
Water	18.23%	21.21%	56.05%	20.16%	21.00%
Volatile matter	35.50	44.33		33.53	38.70
Fixed carbon	41.19	28.42	39.50	45.00	39.26
Ash	5.08	6.04	4.45	1.31	1.04
Sulphur	0.38	.....	.....	.....	0.50
Calorific value, small calories	5,466	.....	.....	.....	5,432
Evaporative power	10.20	10.3	.....	.....	10.14

In addition, Eaton and Mungo Park made six tests of the evaporative power of samples from different points of the principal seam, and these gave a mean value of 9.97.

It will be seen that the coal has a high percentage of water and volatile matter, and a low percentage of fixed carbon and ash. The amount of water has a marked effect in diminishing the calorific value and evaporative power.

For further particulars see J. B. Scrivenor, *Report on the Rantau Panjang Coal-Measures*, 1911.

THE COAL RESOURCES OF SIAM

FROM NOTES BY

JOHN H. HEAL

Inspector-General, Royal Department of Mines and Geology

COAL has been reported to occur in several districts in Siam, but no work has been done, with the exception of a little prospecting in the province of Gherbi, on the west coast of the Malay Peninsula. The beds there are thick and appear to be of fair extent, but the information available is so meagre that it is impossible to give any figures in regard to the probable or possible coal resources.

The fuel is a brown coal which, on exposure to the air, disintegrates to a fine powder, and its economic value is doubtful.

THE COAL RESOURCES OF INDIA

BY

H. H. HAYDEN, C.I.E.

Director, Geological Survey of India

(With One Map in the Atlas)

INTRODUCTION

The development of the coal resources of India is still in an early stage, and much exploratory work must be done before it will be possible to make an accurate estimate of the country's stores of this fuel. The first attempt to do this was made nearly fifty years ago by the late Dr. T. Oldham, Superintendent of the Geological Survey, and although our information is now, in certain respects, considerably more precise, we are still far from being in a position to ascertain, even approximately, our total resources; the figures embodied in this note do not pretend to do more than give an idea of the approximate order of magnitude of the coal supplies of India.

Of the total number of possible fields, only 18 are at present being worked, whilst 3 alone produce 89 per cent. of the whole annual out-turn. The question of quality also introduces an additional and important element of uncertainty into any attempted calculations. For commercial purposes, the material obtained from the chief Indian fields is classified roughly into first and second class; the latter, being of inferior quality and high in percentage of ash, is at present mined only to a limited extent where the better quality is available. Very few Indian coal-fields are sufficiently developed to permit of any attempt at apportioning their resources between these two grades. Mr. R. R. Simpson, Inspector of Mines in India, has, however, recently endeavoured to estimate the quantity of first-class coal in the two chief fields of Bihar (Raniganj and Jherria), but the figures so obtained naturally cannot be employed as criteria for similar estimates with regard to other coal-fields. Consequently, although we are safe in asserting that the total coal resources of India are enormous, we are not yet in a position to form even a rough estimate as to the percentage of them which can be regarded as meeting the present-day requirements of a satisfactory steam-coal.

Furthermore, the total depth to which the seams extend is quite unknown. Even in the three chief fields, work is still confined to comparatively shallow depths of about a thousand feet. Consequently, the estimates included in the present note, except in the case of Baluchistan and the Margherita mines of Assam, refer only to coal at depths considerably less than 4,000 feet.

Detailed descriptions of the various fields are not given in this note, since these will be found in a memoir (now in the press) by Mr. R. R. Simpson, on the coal-fields of India (*Memoirs, Geological Survey of India*, Vol. XLI); this is based on an article by the late Professor V. Ball, but has been largely rewritten and completely brought up to date, and I have made extensive use of it in the present note. Those desirous of obtaining more detailed information than is to be found in this note are recommended to consult Mr. Simpson's memoir. As the latter is also furnished with a complete bibliography, references to literature are omitted from the present note.

For detailed information as to the resources of certain fields, I am greatly indebted to colliery owners and managers, who have supplied me freely with the necessary figures; amongst these I may mention Messrs. T. H. Ward and G. C. Lathbury, of the East India Railway Company's collieries at Giridih; Mr. G. E. Harris, of Margherita (Assam); Mr. A. Mort (Khost Colliery, Baluchistan); Mr. A. H. Parry and Messrs. Shaw, Wallace & Co. (Pench Valley, Central Provinces); Mr. B. J. Davies (Ballarpur, Central Provinces); Mr. H. W. Trotman (Singareni Collieries, Hyderabad); Mr. F. L. G. Simpson (Mohpani, Central Provinces); Mr. R. J. W. Oates (Rewah State Collieries, Umaria, Central India), and Messrs. J. W. Jervis and W. L. Phillips (Palana, Bikanir).

Before dealing with the question of the amount of coal available, it may be well to explain briefly the nature and disposition of the Indian fields. They fall, firstly, into two broad categories, viz.:

(1) the Gondwana fields, the coal of which occurs in the lower portion of the Gondwana system and is approximately of Permo-Carboniferous age;

(2) the Tertiary fields, the coal of which is in some cases of Eocene, in others of Miocene age.

There are also a few fields in which the coal belongs to the Cretaceous system, and others in which it is Jurassic, but these are small and still unexploited, and may, for the purposes of the present note, be conveniently grouped with the Tertiary fields.

THE GONDWANA FIELDS

Of the above fields, the Gondwanas are by far the most important, and contribute over 96 per cent. of the annual Indian output. Their distribution is peculiar; they "are preserved as small patches let down, mostly by faulting, into the great crystalline mass of the Peninsula. Originally they must have covered a much wider area; but as the Peninsula has been exposed ever since to the free action of weathering agents, the Gondwana formations have been cut into, like the older formations, and the Coal-Measures thus preserved in India now form but a fraction of those that once existed. Isolated patches of Gondwana rocks, including coal-beds, have been involved in the folded extra-peninsular area, in the Darjeeling district, and in Northern Assam. The string of Gondwana patches which determines the direction of the river Damuda includes our most valuable deposits of coal."* They are found also in the valleys

* Sir T. Holland in *Imperial Gazetteer of India*, Vol. I, (1907), p. 81.

of the Mahanadi and Godavari rivers on the eastern side of India, in the Mahadeo and Satpura ranges on the western, and also under the great basic lava flow known as the Rajmahal trap in the Rajmahal hills of Bihar.

The Gondwana system, which consists chiefly of alternating beds of sandstone and shale, is classified broadly into two subdivisions, Upper and Lower, but it is only in the Lower that coal-seams of importance have been found, and we need, therefore, only deal with it in the present note. It is divided into three series, of which the middle series is again subdivided; these various divisions are, in descending order:

Panchet series	
Damuda series	Raniganj stage Ironstone shales Barakar stage
Talchir series	

The Talchir series invariably lies unconformably on all older beds, and is never found in contact with any rock younger than Vindhyan (Keweenawan). It consists chiefly of sandstone; the basal bed, however, being a very remarkable boulder-slate or tillite, which is universally regarded as of glacial origin.

The Damuda series is the only important one from an economic point of view, and supplies all the Gondwana coal that is being exploited. It consists of three stages, the Barakar below and the Raniganj above, separated from one another by the Ironstone shales, which, as their name implies, contain clay ironstone, but no coal.

The principal Lower Gondwana coal-fields are found in the following provinces: Bengal, Bihar and Orissa, Central India, Central Provinces and the Nizam's Dominions. The most important are those of Bengal and Bihar and Orissa, known as the Giridih, Raniganj, and Jherria fields. In addition to these, there are several other fields still unexploited.

The following list includes the chief Gondwana fields arranged according to provinces:

BENGAL*—

1. Raniganj (in part).

* The first ten fields were originally all in the province of Bengal, and have long been known collectively as the "Bengal coal-fields"; owing to the recent territorial redistribution and the creation of the new province of Bihar and Orissa, most of these, with the exception of the eastern portion of the Raniganj field, have been transferred to the new province.

Bihar and Orissa—

2. Giridih.
1a Raniganj (in part).
3. Jherria.
4. Bokaro.
5. Karanpura.
6. Auranga-Hutar.
7. Daltonganj.
8. Rajmahal.
9. Darjeeling.
10. Talchir.

Central India—

11. Umaria.
12. Sohagpur.
13. Singrauli.

Central Provinces—

14. Jhilmili and other fields of the Sirguja and Chattisgarh basin.
15. Mohpani, Pench, Shahpur (Satpura basin).
16. Ballapur and other fields of the Wardha valley and Godavari basin.

Nizam's Dominions—

17. Singareni.

BENGAL, AND BIHAR AND ORISSA

Of the group formerly known as the Bengal coal-fields, only three have been developed to any appreciable extent; active operations have long been carried on in the Raniganj and Giridih fields, whilst the exploitation of the Jherria field is of comparatively recent date.

Raniganj Coal-Field

The Raniganj coal-field has an extent of about 500 square miles. It has the characteristic faulted boundaries on all sides except the east, where the Coal-Measures pass under the alluvium, and although a certain number of borings have been sunk through the latter, the extent of the field in this direction has not been ascertained. Coal occurs both in the lowest (Barakar) and in the uppermost (Raniganj) stage of the Damuda series. In the Barakar stage, four of the seams have an aggregate thickness of 69 feet, whilst in the Raniganj stage there are at least ten aggregating 110 feet. A rough estimate of the total amount available has been made on the basis of these figures, but assuming only a thickness of 50 feet over 400 square miles. This amounts to a total coal reserve of 22,000 million tons. Much of this, however, is of poor quality and falls into the category of "second-class" coal. The best seams are known as the Dishargarh, Sanctoria, and Sibpur, and these probably contain about 518 million tons of first-class coal, corresponding in composition to class B_3. Three other seams of not quite such good quality are estimated to contain 360 million tons, whilst, as pointed out above, the total supply of the field, including both first and second class, is over twenty thousand millions.

Jherria Coal-Field

The Jherria field is approximately a shallow elliptical basin, of which the lengths of the axes are 23 and 10 miles, respectively. The coal-bearing area covers about 150 square miles, and consists chiefly of beds belonging to the Barakar stage, in which there are 18 coal-seams. The seams of the Raniganj stage are, on the whole, thinner and poorer, although one seam is of value. Of the Barakar seams, the nine lowest are, as a rule, of poor quality, and work is confined chiefly to Nos. 10 to 18. It has been estimated that about 500 million tons of first-class coal are available, whilst the quantity of second-class coal is very large, being comparable to that available in the Raniganj field. The coal belongs to the classes B_2 and B_3.

Giridih Coal-Field

The Giridih field is a very small one, covering only 11 square miles, but much of the coal is of excellent quality. The seams fall into two groups, an upper group of inferior fuel known as the Hill seams and a lower seam known as the Karharbari. The annexed table* shows the actual reserves of the Karharbari seam. In addition to this, the Hill seams are believed to contain about 8 million tons which will be worth extracting.

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)		
	No.	Thickness	Area	Class of Coal	Metric Tons
Giridih........................	1	9 ft. to 21 ft.	2.604 sq. m.	B_2	39,000,000

The estimates of quantities available in these fields are, in each case, liable to error, since large quantities of coal have been completely destroyed by dykes and sills of igneous rock (basalt and mica-apatite-peridotite) which have been intruded into many of the seams.

A fourth field, that of Daltonganj, has recently been opened up, but development has not yet reached a stage comparable to that of either of the other three.

The subjoined list includes the chief prospective coal-fields of the provinces of Bengal and Bihar and Orissa:

* Prepared from information kindly supplied by Messrs. T. H. Ward and G. C. Lathbury.

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons
Daltonganj............	1	9 ft.	1 sq. m.	B_2	9,000,000			
Hutar................	3	8 ft., 8 ft., 13 ft., 8 in.	....	B_3	......	20 sq. m.	....	9,000,000
Aurunga..............	..	....	....	Low Grade	......	......	....	20,000,000
North Karanpura......	..	Agg. 35 ft.	....	....	......	250 sq. m.	B_2	8,900,000,000
South Karanpura.......	..	Agg. 50 ft.	....	....	......	15 sq. m.	B_2	75,000,000
Bokaro...............	..	Agg. 12 ft.	....	....	......	180 sq. m.	....	1,525,000,000
Rajmahal Hills........	..	5 ft.	....	....	......	70 sq. m.	C	210,000,000

The Possible Reserves in these districts are large.

Outside the Peninsular area, the Gondwana fields are, so far as we know at present, of no economic value. Gondwana rocks have been found at intervals along the base of the Himalaya, from the Tista valley below Darjeeling to the gorge of the Dihong in the Abor country. The belt has not been proved to be continuous, but has been crossed at various points in Bhutan, and in the Aka and Dafla hills. The coal is badly crushed and of little value.

CENTRAL INDIA

In Central India, the coal-bearing Gondwana rocks occupy a large area known as the Rewah basin, lying in the southern part of the native state of that name. In this basin a number of distinct fields have been recognized, the chief being those of Umaria, Korar, Johilla, Sohagpur, and Singrauli. At present the only field being worked is the first, which has an annual output of about 150,000 tons.

District	Coal-Seams	Probable Reserves (Approximate estimate)		
	Thickness	Area	Class of Coal	Metric Tons
Rewah State (Umaria, etc.)...	7 ft. 8 in. to 12 ft. 4 in.	2,000 sq. m.	B_3	22,657,000,000

CENTRAL PROVINCES

The coal-fields of the Central Provinces lie in three apparently separate basins of Gondwana rocks, viz., basins of Sarguja and Chattisgarh on the north-east, the Satpura and Chhindwara basin on the north-west, and the Godavari basin extending for nearly three hundred miles from the south-western corner of the province, down the valley of the Godavari and its tributaries, through the Nizam's Dominions, into the Madras Presidency. Although apparently separate, it is possible that the coal-bearing rocks of the Sarguja basin may be continuous, beneath the intervening mantle of Deccan trap, with those of the Satpuras, whilst these latter again may pass beneath the trap of the districts of Betul and Amraoti into the great belt of Gondwanas of the Godavari valley. Enormous reserves of coal may, therefore, have been preserved beneath the Cretaceous lava flows which cover such a large part of the Indian peninsula.

The Sarguja and Chattisgarh Fields

These form the south-easterly continuation of the great spread of Coal-Measures known as the Rewah Gondwana basin. Several fields, such as Ramkola-Tatapani, Jhilmili, Bisrampur Korba, Rampur, have been more or less cursorily examined, but sufficient development has not been done on any one of them to form the basis of even an approximate estimate of the amount of coal available; the Coal-Measures, however, extend over an area of several thousand square miles, and it is safe to say that the reserves are very large.

The Satpura Basin

The Satpura basin contains a number of isolated fields, of which the best known are those of Mohpani, Shahpur (Betul) and Pench (Chhindwara). The Mohpani field is believed to extend over a very considerable area, but has been proved only for a small part of this; the probable reserves are shown in the annexed table, which has been compiled from information supplied by Mr. F. L. G. Simpson, the manager of the colliery:

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)	
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Metric Tons
Mohpani..........	4	Agg. 50 ft.	½ sq. m.	B_3	11,800,000	24 sq. m. 50 sq. m.	58,000,000 100,000,000

In the Shahpur field the coal-bearing beds cover an area of about 26 square miles, but there is no reliable information as to the thickness, number, or quality of the seams.

The Chhindwara group of fields cover an area of about 100 square miles in the valleys of the Tawa, Pench, and Kanhan rivers. A considerable amount of exploitation has been carried out in the Pench valley, and I am indebted to Messrs. Shaw, Wallace & Company, of Calcutta, for the figures embodied in the the table shown below, which, however, embraces only a small portion of the total area of the Chhindwara group of fields.

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
			Acres			Acres			
Pench Valley	3	14 ft.	650	D	14,470,000				
	2	13 ft. 6 in.	436	D	9,400,000				
	3	11 ft. to 24 ft.	....	......	....	2,870	D	64,664,000	Large
Pench River	1	8 ft.	506	D	6,170,000				
	1 to 2	8 ft. to 23 ft.	....	......	....	1,402	......	31,500,000	
Central Pench	2	13 ft.	736	D	16,000,000				
	2	10 ft.	....	......	....	1,012	......	16,700,000	
Pench Consolidated Company's property	1 to 2	6 ft. to 9 ft.	....	......	....	1,981	......	24,200,000	Large
Jatachapa	2	Agg. 13 ft.	820	D	16,240,000				

Godavari Basin

The Godavari belt of Coal-Measures embraces a very large area, and includes various fields in the districts of Chanda and in Berar, and others again in the Nizam's Dominions (Hyderabad State). The following list, shown on page 361, includes such information as there is about the probable coal resources of this belt; it is very imperfect, since there may be considerable reserves below the cloak of alluvium and Deccan trap which prevails throughout the area, and it is safe to assume that the estimated amounts constitute only a fraction of the whole quantity available.

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
Warora........	1	30 ft.	......	....	....	3 sq. m.	D	*60,000,000	
Wun..........	1	15 ft.	......	....	....	80 sq. m.	....	2,130,000,000	
Wun-Papur....	1	15 ft.	7 sq. m.	D	53,000,000				
Junara-Chicholi	1	30 ft.	5 sq. m.	D	76,000,000				
Ghugus........	....	30 ft.	....	....	....	3 sq. m.	B_3	45,000,000	
Ballarpur † ...	1	20 ft.	2 sq. m.	D_1	31,000,000				
Paoni and Sasti	1	40 ft.	$1\frac{1}{2}$ sq. m.	C	30,000,000				
Singareni......	1	3′ 6″ to 7′ 6″	4 sq. m.	B_3	12,200,000				
	1	6 ft.	......	....	....	......	....	10,000,000	
Madavaram...	1	5 ft. 6 in.	......	....	....	10 sq. m.	....	25,000,000	
Lingalla.......	1	4 ft. 6 in.	......	....	....	5 sq. m.	....	8,000,000	

* Part of this has been lost by fire in a mine now closed down.

† Figures kindly supplied by Mr. B. S. Davies, manager, Ballarpur Colliery.

THE MESOZOIC AND TERTIARY FIELDS

Assam

The Coal-Measures of Assam fall roughly into two groups, (*a*) a belt of coal-bearing rocks running along the north-eastern frontier for some ninety miles, and (*b*) scattered fields in the Khasia, Garo, and Jaintia hills.

The former group is the only one in which any serious exploitation has been carried on, a small group of collieries in the neighbourhood of Margherita turning out about 300,000 tons annually. The seams being worked here have an aggregate thickness of 80 feet. The workings are situated in hills, and are still above free drainage level. The coal is friable and rather high in sulphur-content, but is otherwise of excellent quality. The total reserves at present in sight are estimated at $34\frac{1}{2}$ million tons, with the probability of a further supply of some 27 millions above a depth of 4,000 feet.

Some 30 miles farther to the north-east, on the Namchik river, another large field, probably comparable to that of Margherita, has recently been discovered; in 350 feet of strata there are 60 feet of coal, but there are no materials on which to base an estimate of the total amount available, since the extension of the seam along the strike is unknown.

To the south-west of Margherita the belt of Coal-Measures runs along the outer hills for more than 50 miles. It has only been examined in a few places, and certain parts, such as the Jaipur and Nazira fields, roughly explored. No serious mining has been undertaken yet in either of these fields, and the amount of coal available in them is unknown, but has been estimated roughly as approximately 60 million tons.

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)		Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Class of Coal	Metric Tons	
Namchik.......	..	Agg. 60 ft.	......	..	......	C	......	Large
Margherita......	1	80 ft.	549 acres	C	35,000,000	..	27,000,000	
Borhat.........	4	18½ ft.	......	C	2,700,000		......	Large
Nazira: Bor Jan	3	8′ 6″ and 4′	......	C	1,500,000	..	......	Consider-
Wakting Jan....	2	13 ft., 6 ft.	......	C	800,000			able

The amounts given above for Margherita, Jaipur, and Nazim probably constitute only a small fraction of the total resources of the coal-belt of N.E. Assam.

The coal-fields of group (*b*) occur mostly at high elevations in the mountains of the more southerly parts of Assam; they are enumerated in the following table:

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)			Probable Reserves (Approximate estimate)			Possible Reserve
	No.	Thickness	Area	Class of Coal	Metric Tons	Area	Class of Coal	Metric Tons	
						sq. m.			
Daranggiri (25° 25′; 90° 48′).	1	3′ 6″ to 7′ 6″	20 sq.m.	C	77,000,000				
Langrin (25° 12′; 91° 14′)....	3	Agg. 12 ft.	......	....	......	30	C	......	Large
Cherrapunji (25° 17′; 91° 47′)	1	3 ft. to 9 ft.	⅓ sq.m.	C	1,200,000				
Lairungao (25° 19′; 91° 48′)..	1	3 ft.	½ sq.m.	....	1,000,000				
Maosandram (25° 18′; 91° 39′)	1	2 ft.	⅓ sq.m	....	50,000				
Maobelarkar (25° 28′; 91° 18′)	1	3 ft.	......	C	53,000				
Lakadong (25° 10′; 92° 20′)..	1	2 ft.	......	....	......	5-12	....	850,000	

Although each of the above fields has been treated as a separate basin, the seams of two or more of them may be mutually continuous, in which case the total amount of coal available will have been considerably under-estimated.

Baluchistan

Coal occurs in thin seams and small quantities in various parts of Baluchistan, but is seriously worked only at the Khost colliery, where the out-turn is a little over 40,000 tons annually. The probable reserves of Baluchistan, for details of which I am indebted to Mr. A. Mort, Colliery Superintendent, Khost, are shown in the annexed table:

District	Coal-Seams		Probable Reserves (Approximate estimate)			Possible Reserves
	No.	Thickness	Area	Class of Coal	Metric Tons	
Khost, (including Shahrig, Harnai, Mach and Zhob)............	1	2 ft.	10 sq. m.	D_1	20,000,000	Considerable
Digari and Sor Range...........	1	3 ft.	7 sq. m.	D_1	25,000,000	Perhaps equal to probable reserves

The above amounts have been calculated on the assumption that the coal can be worked to a depth of 5,000 feet on the dip, but the seams are thin and working expenses high, and were it not for its geographical position, the coal would not be considered worth the cost of exploitation.

Burma

Although coal occurs in various parts of Burma, the quantity known is small and the quality poor. The most promising occurrence is that in the valley of the Tenasserim river, where two seams of 15 feet and 4 feet, respectively, have been estimated to contain about one million tons.

Kashmir and Jammu

Tertiary coal occurs in considerable quantity in the hills of Jammu, the chief fields being Ladda, Sangar Marg, Siro valley, Mehowgala, and Kalakot. About $3\frac{3}{4}$ million tons have been estimated to occur above free drainage level and considerably more below, but the ash-percentage is very high, the material frequently approaching a carbonaceous shale rather than coal; the fields cannot, therefore, be regarded as of much potential value.

Punjab

The coal of the Punjab is found below the nummulitic limestone of the Salt range, in the districts of Jhelam and Shahpur. The seams crop out along the southern scarp of the range at an elevation of about 2,000 feet above the plain; they are thin, and the coal is of poor quality; they have, however, been worked for some years at Dandot, where an extensive colliery was opened by one of the railway companies. The gradual exhaustion of the more readily accessible material has led to the abandonment of the colliery by this company and to the replacement of local fuel, both on the railway and for steam-raising purposes generally, by coal imported from the Bengal fields. The use of the coal mined at Dandot and at the smaller collieries of Pidh and Chittidand in the same neighbourhood, is now confined chiefly to brick and lime-burning. Owing to the variable nature of the seams, it is impossible to make any estimate of the amount of coal available in this part of the Salt range, but the total amount is probably small. It was thought that the seams might extend far to the north beneath the plateaux of the central part of the range, but borings recently put down on one of these plateaux afforded no justification for such a belief.

Farther westward, at Isa Khel on the right bank of the Indus, a seam $2\frac{1}{4}$ feet thick has been proved over an area of $\frac{2}{3}$ square miles, the amount of coal available being $1\frac{1}{2}$ million tons.

Rajputana

The only coal mine in Rajputana is that of Palana in Bikanir, where well-sinking operations some years ago resulted in the discovery of a band of lignite in Tertiary sandstone, at a depth of a little over 200 feet below the surface. The following figures have been supplied to me by Mr. Jervis:

District	Coal-Seams		Actual Reserve (Calculation based on actual thickness and extent)		
	No.	Thickness	Area	Class of Coal	Metric Tons
Palana	1	20 ft.	$\frac{1}{7}$ sq. m.	D_1	1,250,000

COAL IN COUNTRIES ADJACENT TO INDIA

Afghanistan

Coal occurs in considerable quantity in the neighbourhood of Chahil and Shisha Alang in Afghan Turkistan. Numerous outcrops have been recorded over a large area, but no exploratory work whatever has been done. So far as is known, the quality of the coal is good, and certain seams are said to be over ten feet thick, but nothing more is known about them.

Tibet

From a geological point of view Tibet is still, to a large extent, a sealed book, but no coal is known in such parts as have been visited; did any occur in the country, it is highly probable that one or other of the many travellers would have heard of it.

THE COAL RESOURCES OF PERSIA

FROM NOTES BY

H. L. RABINO

Vice-Consul

In Persia coal is mined at many places, but on a very small scale only and in a primitive manner. The usual method employed in mining is to sink shallow shafts, which are abandoned as soon as the crude hoisting apparatus in use, consisting of hand windlass and bucket, is unable to cope with the inflow of water.

A—THE TEHERAN COAL-FIELD

The Teheran-Kazvin valley contains an area of about 1,000 square miles and is to a great extent deeply covered with alluvium. The Elburz range borders the valley on the north and is built up largely of coal-bearing rocks which, however, are highly disturbed. If it is assumed that these rocks extend throughout the valley beneath the alluvium and are less disturbed than in the mountains and that they contain an aggregate thickness of two feet of coal, a total possible coal reserve of 1,858,000,000 tons is obtained:

(*a*)—North-western Coal District

The output from this district was estimated in 1890 to be about 11,000 tons yearly. The following localities where coal is known to occur may be mentioned:

1. Sapidaran and Kelinrut. Five seams are known.
2. Feshend. The thickest seam known here is nineteen inches thick with a shale parting. An analysis shows 7.08 per cent. of ash.
3. Abyek. Two seams occur here 2 feet 2 inches and 18 inches thick, respectively. All the known coal above water-level has been mined. The coal is said to be of excellent quality, analyses showing 1.2 per cent. of ash in the larger and 1.9 per cent. in the smaller seam.
4. Hiv. At two points in this neighbourhood, Aga-Chah and Chamburek, coal has been mined, at the former locality a seam 30 inches thick was worked down to water-level and three other seams are said to occur, the chief one being also 30 inches thick. At Chamburek there are said to be six seams ranging from four feet to less than two feet in thickness.
5. Khur. Coal much crushed.
6. Safidarek. A seam over two feet thick is said to occur here.

(*b*)—North-eastern Coal District

The output from this district was estimated in 1890 to be about 4,000 tons annually, since then it has greatly increased, but no statistics are available. The following localities, among others, where coal is known to occur may be noted:

1. Shamsek. Situated abut thirty-three miles north-east of Teheran. The strata here are much disturbed and the dips are high. Three seams are known, the main one being three feet thick with a parting. The following is an analysis from the three-foot seam:

Volatile matter	16.65%
Fixed carbon	72.21
Ash	11.14

2. Vergedar. Two seams, 10 and 20 inches thick, occur here, the coal being very earthy and brittle. The yearly output is about 40 tons.

3. Sefidab. Six seams are found here, varying from 30 to 5 inches. The coal burns with a clear flame and is suitable for gas or coke making as well as for domestic purposes. The annual output is about 490 tons.

4. Gil-i-Gach. The coal is similar to that at Sefidab. Output, 325 tons yearly.

5. Piazek. This mine is situated at an altitude of 7,000 feet. The seam is 30 inches thick and the yearly output 325 tons.

6. Div-i-Siah. A 20-inch seam of good coal is mined here, the output being about 175 tons.

7. Alaru Valaru. About 30 tons a year is produced at this point.

8. Bastan and Fil-i-Zamin. The output from these localities amounts to about 175 tons annually. The coal is of good quality and the seam about 20 inches thick.

9. Khasunek. Coal of a quality similar to that of Sefidab is found here in two seams varying from 10 to 20 inches in thickness.

10. Yunesar. Yearly output 325 tons.

11. Khatun Bargah.

12. Garmabdar.

13. Lalun. Operated by a sugar factory until 1906.

14. Rudek. The combined yearly output from this and the three last named localities is about 1,300 tons.

B—KHORASAN COAL-FIELD

Coal was mined on a very small scale in this district from ten to fifteen years ago, but the mines are now all abandoned, the shafts having been flooded in most cases. Although the coal is reported to be of good quality, the seams are thin and the total output during the period it was worked amounted to a few hundred tons only.

C—ASTRABAD, SHAHRUD, BASTAM AND SEMNAN DISTRICTS

Coal has been reported from many places in these districts but little is known of the extent of the areas or size of the seams. The following localities may be mentioned:

1. SHAVER, east of Tash. The Hon. G. C. Napier, in 1874, says: "At Shahkuh bala there are said to be seams of coal never worked. At Tash there was a mine which had been worked for some time, the coal being carried to Gez to supply the Russian steamers."

2. PIR-I-KHAN. A seam, 1 foot thick, is known here. The coal is bituminous, of good quality, light and hard.

3. TAZARIEH. This point is situated at an elevation of 7,022 feet. Four seams of good coal occur with thicknesses of 1 foot 10 inches, 6 inches, 5 feet and 2 feet, respectively.

D—MAZANDERAN DISTRICT

Coal is reported from several places in this district. At Galugah three seams are known, 1 foot, 2 feet, and 3 feet thick, respectively; the coal, however, is of poor quality.

In addition to the above mentioned districts coal has been reported from the districts of Ispahan, Shiraz, Ahwaz and Azerbijan, but no particulars as to the extent of the areas, the size of the seams or the quality of the coal are at hand.

Anthracite of good quality, but in thin seams, is said to occur in the districts of Kerman and Yezd.

LES GISEMENTS HOUILLERS RECONNUS EN INDO-CHINE

PAR

H. LANTENOIS

Ingénieur en Chef des Mines, Chef du Service des Mines de l'Indo-Chine

(Avec une carte dans le texte)

Des gisements de houille anthraciteuse et de houille grasse ont été reconnus au Tonkin et en Annam. Les gisements de houille anthraciteuse sont de beaucoup les plus importants.

HOUILLE ANTHRACITEUSE

Tonkin

Les terrains houillers appartiennent à l'âge rhétien et occupent la zône qui a été marquée sur la Carte jointe à la présente Note.

La Section I est celle comprise dans l'île de Kébao.—Le terrain houiller est recouvert transgressivement et en discordance au Nord par une formation de grès rouge, où l'on trouve de mauvaises couches de houille attribuées encore à l'âge rhétien par les plantes fossiles.

La Section II constitue le domaine houiller de Hongay dont l'exploitation est la plus importante du Tonkin (300,000 tonnes par an). Le terrain houiller est limité au Nord partie par de grès rouge, partie par le terrain primaire.

Les Sections III et IV constituent le bassin dit du Dong-Triêu. Ces deux sections sont séparées par une bande de terrain primaire apparaissant sous le terrain secondaire grâce à une vallée d'érosion.

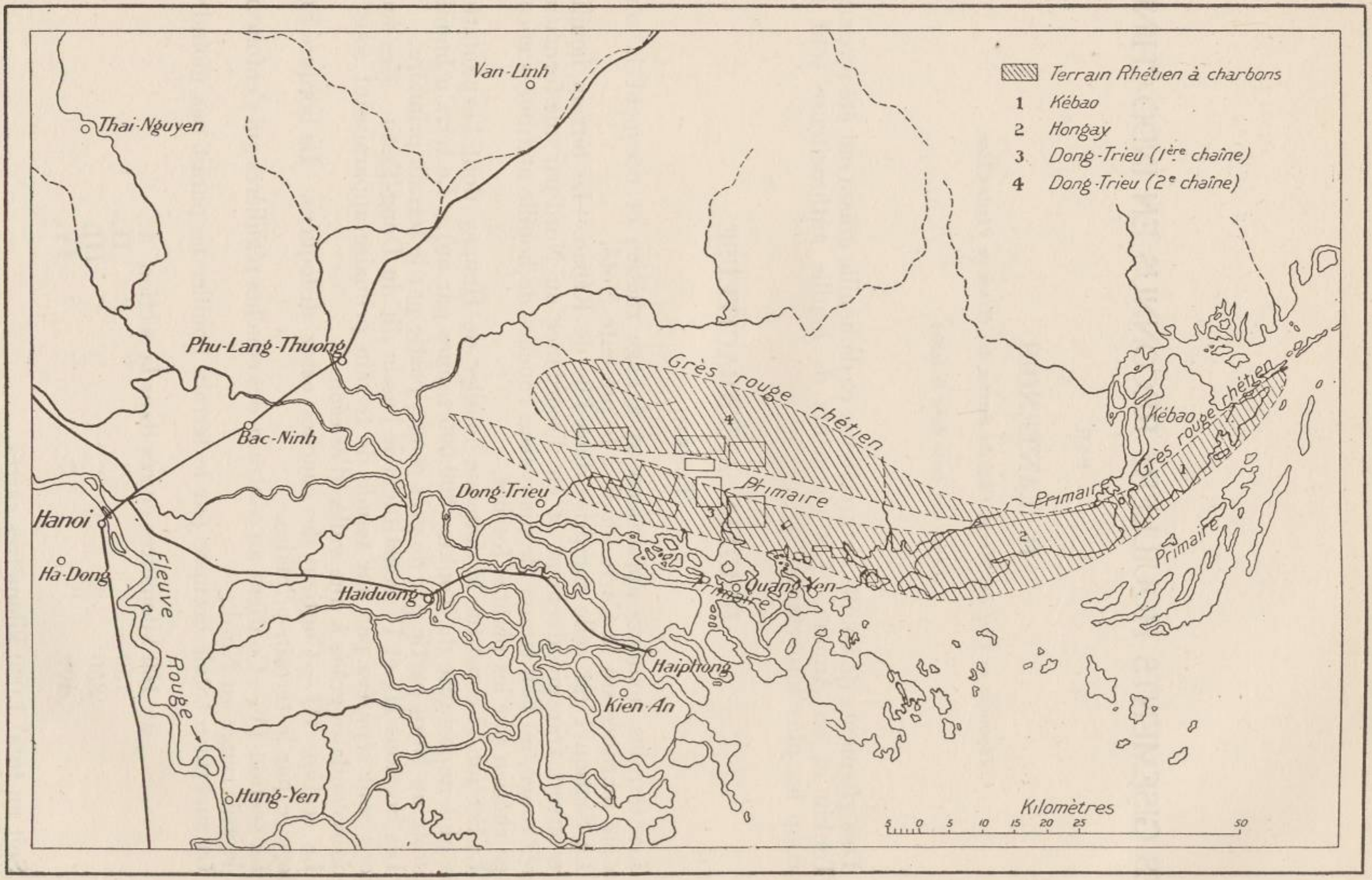
La section III.—Contient des couches assez disloquées. La bordure Sud est formée par le terrain primaire.

La section IV.—Contient au contraire des couches régulières qui s'enfoncent sous le grès rouge au Nord.

La superficie totale occupée par le terrain houiller ne parait pas moindre.

de 100	kilomètres	carrés	dans la	section	I.
150	"	"	"	"	II.
350	"	"	"	"	III.
400	"	"	"	"	IV.

Soit au total 1,000 kilomètres carrés.



Service des Mines de l'Indo-Chine. Carte montrant l'extension du terrain Rhétien à couches de Houille anthraciteuse au Tonkin

La réserve de charbon est certainement considérable. L'épaisseur totale des couches n'étant pas moindre de 30 mètres, on peut l'évaluer à vingt milliards de tonnes.

Annam

Le bassin de Nong-Son en Annam est beaucoup moins important.

HOUILLE GRASSE

La houille grasse n'a été encore reconnue que dans des bassins presque sporadiques près de Thai-Nguyên, Cho-Bo et Phu-Ly.

Il est difficile d'en apprécier actuellement l'importance; celle-ci ne parait pas devoir dépasser quelques millions de tonnes.