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APPLICATION OF SEQUENTIAL GAUSSIAN SIMULATION IN MINERAL RESOURCE EVALUATION: A CASE STUDY FROM A GOLD DEPOSIT

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Keywords: Geostatistics, Resource Estimation, Simple Kriging, Sequential Gaussian Simulation

The accuracy of correct resource estimation is crucial in integrity of a feasibility study as well as the daily running of mining activities. The success of a mine operation depends on the correctness of resource estimation. In order to certify an acceptable level of confidence in resource modeling, it is necessary to construct a high-quality 3D block model, where in each block, the grade of interest is reported. For this purpose, there are generally common approaches as deterministic and stochastic simulation techniques. The deterministic approach assumes that the system is predictable, for which it provides a unique estimated value for the target block location. There are plenty of methods for deterministic technique including well-known implicit modeling and interpolation methods. Deterministic techniques are relatively simple to use and provide credible outcomes. However, each deposit has an exclusive structure and subsurface geology, thus, it is extremely complex to predict and produce such an exact model. A widely used deterministic technique, namely kriging is very popular in industry. This method is easy-to-run, but it suffers from smoothing effect and cannot quantify the uncertainty at target block locations. In contrary to deterministic techniques, stochastic approaches assume that the system is uncertain, and produce several realizations instead of one single estimated value. This is an important aspect in quantification of uncertainty. In addition, the realizations do not suffer from smoothing effect.

This paper utilizes a dataset from a borehole campaign in an Australian gold deposit, where two block modeling techniques are applied to model the Gold and its covariate Silver in the deposit. To do so, kriging and sequential Gaussian simulation (SGS) are implemented over the underlying dataset. The results showed that SGS outperforms the kriging technique for better resource modeling and producing the results without smoothing effect. Moreover, the uncertainty in SGS can be produced, where kriging is unable to do so.

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BARITE-SULPHIDE MINERALIZATION IN GÓRY SOWIE MTS.

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Keywords: sulphides, barite, veins, Góry Sowie

Introduction

Scientific project is studying problems concerning to weakly known barite-sulphide mineralization common in the Góry Sowie Mts. area. This mineralization was a source of barite as well as silver or other metals in the past times. Barite is now critical material and obtained information from the research will give notes to the genesis and occurrences of such interesting mineralization. There are lack of scientific information on fluid inclusions, contents of rare elements (Ag, Ga, Ge, In, Cd, Au) or their bearers. Only few information on mineralogy of individual places are available. Results of the published or non-published data show very interesting mineralogical composition of the veins as well as interesting history of the mineralization forming.

Methodology

Samples were collected in several localities in Góry Sowie Mts.: Bystrzyca Górna, Srebrna Góra, Dziećmorowice, Modliszów. Main part of research was reflected light microscope describing. Results Ore minerals which was identified in the samples are: pyrite, galena, chalcopyrite, tetrahedrite, sphalerite, and quartz, barite. Mineralization is usually disseminated, sometimes forms aggregates or thin sulphides veinlets. Ore minerals usually occur as small individual grains or intergrowths of different size – from 50 up to 500 µm. They rarely could reach few cm in size. Ore mineralization was formed probably in few stages.

This project is a big project which I will be continuing during my doctoral studies. Here is described only part of my results which were obtained. It is first part of my work with this project.

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PRELIMINARY SOURCES IDENTIFICATION OF NITRIC OXIDE (NO) EMISSIONS IN UNDERGROUND MINE

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Keywords: gas hazard, nitric oxide, NO, underground mining, mine ventilation

Gas hazard in Polish underground mines is a major problem for the ventilation service. Ensuring appropriate environmental conditions is becoming increasingly difficult, especially with the introduction of new, more stringent restrictions on the concentration limits of hazardous gases. According to [1], the most dangerous gases in underground mines are carbon monoxide, hydrogen sulfide, nitrogen oxides, carbon dioxide, sulfur dioxide, and methane. Together with the introduction of new limit values for the above-mentioned gases by the European Union, it is necessary to accurately identify the sources of their emission in mine workings in order to select an appropriate reduction method. This article presents daily measurements of nitric oxide (NO) concentrations in the workings of one of the copper ore mines owned by KGHM Polska Miedź S.A. The measurement results were used for preliminary analysis of sources of gas emissions to underground workings. The analysis is carried out through a graphical interpretation of the measured values. Knowing the details of the technological processes carried out in the mine under consideration (blasting, diesel engine machines, natural oxidation of nitrogen to NO) the graphs were interpreted by assigning individual values of NO concentrations over time to a specific technological process.

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DIGITAL TWIN- COOPERATION OF GEOLOGY WITH REMOTE SENSING IN POST-MINING TIME

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Keywords: Digital Twin, Geology, Geomonitoring, Post-Mining, Remote Sensing, Satellite Date

Post-Mining is one of the most important challenge of today's times. The post-mining processes and the preparation of mining plants for tasks after the end of the mining exploitation are the basis for research on the subject of knowledge related to the mining terrain and the upper slopes of the Earth in the future. The "Digital Twin" project is a concept with the theme "Industry 4.0", in which the entire industrial process starting from the idea, through preparation, implementation, maintenance and the final phase of dismantling needs to be ensure for a given mining site. Each design data based on common research techniques should be collected, evaluated and implemented (Figure 1) [1, 2].



Figure 1. Digital Twin – Geomonitoring.[2]

This enables concepts for sustainable and long-term as well as integrated geomonitoring to be developed. Through the further digital development, a "Digital Twin Geomonitoring" is built up, which allows to better understand and to build on the postmining processes and connections.

During the activities of the mining plant, large amounts of technical data on operation are collected. The collected data (geology, tectonics, geophysics, petrophysics, geochemistry, hydrochemistry, structural geology, geomechanics) on the exploration and development of a given extracted raw material. It is worth considering that the data obtained may have a decisive impact after the extraction of the complex and should be taken into account in further studies. [3].

The subsurface reconstruction (Figure 2) is based on archive documents and well data from the well database in North Rhine-Westphalia. After their evaluation, the model is gradually built up from the top to the base. The additional interpretation of geomechanical

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stress and strain relationships also allows conclusions to be drawn about possible subsurface movements. The threedimensional modeling provides important informations about the predominant structures and properties of the mesozoic subsurfaces. In close connection with earth's surface information, it provides important components for the detection of geological structures on the earth's surface.

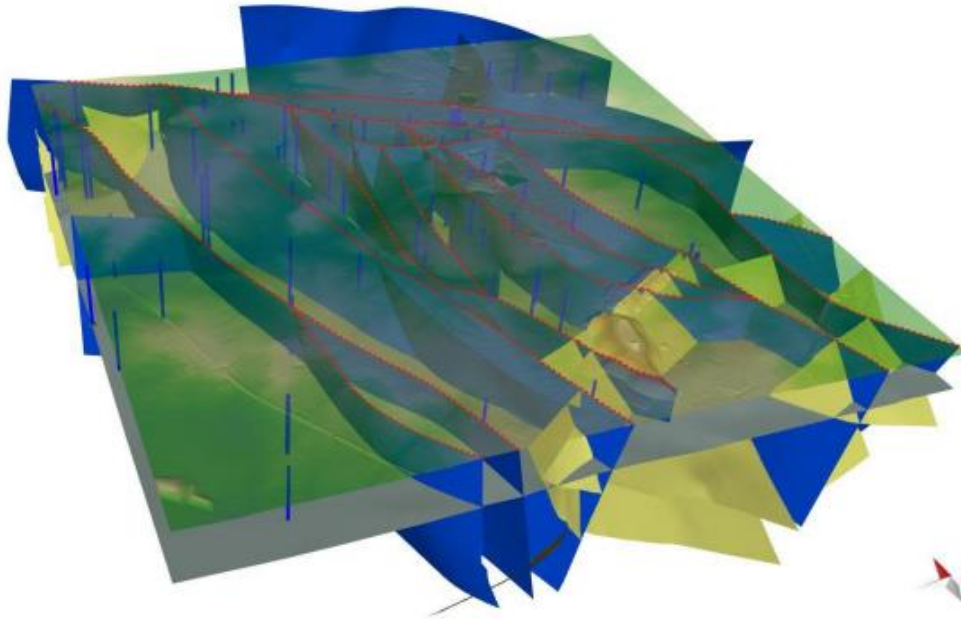
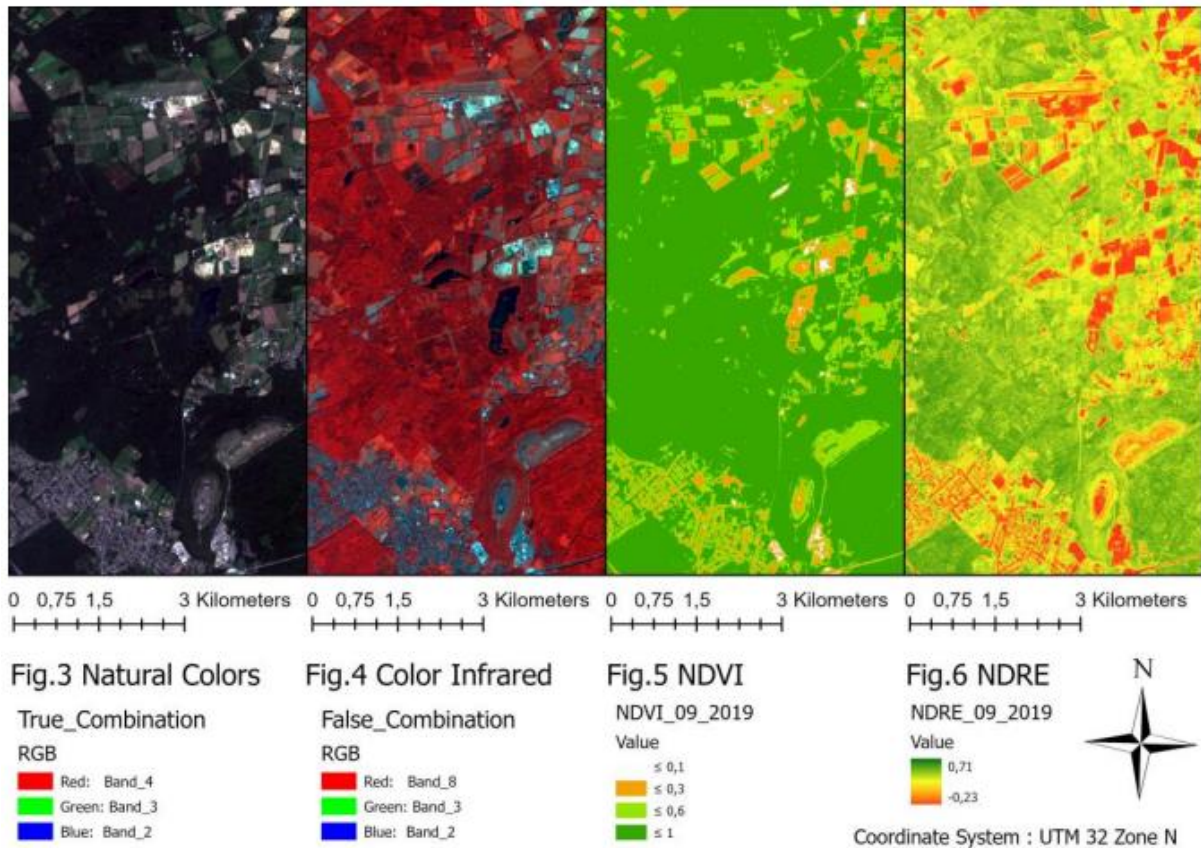


Figure 2. Subsurface Reconstruction

Through remote sensing methods, it is possible to observe processes taking place on the earth's surface like the interaction of the mining processes in the subsurface with the surface. Copernicus and Landsat Data are the bases for this project. The aim of the "Digital Twin" project is to observe the ground motion of the Earth, vegetation indexes or moisture soil and to compile the results obtained with data on the geological structure of the area. Through the given method, it is possible to identify potential places that show affected of vegetation in the mining influenced areas (Figure 3-6). The spatio-temporal analysis of the selected remote sensing data allows to detect trends and changes.



The cooperation of research on the modelling of geological structures along with earth observation by remote sensing methods is an innovative approach to post-mining and it helps to understand the post-montane processes in the subsurface and at the [2].

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FE, NI, CO, AND CU IN FENI ALLOYS OF H CHONDRITES

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Keywords: ordinary chondrite, H chondrite, FeNi alloy, extraterrestrial resources, meteorite

The subject of the research work were chemical analyses of 173 FeNi alloy grains from four selected H ordinary chondrites: Thuathe, Chergach, Gao-Guenie and NWA 4555. Based on performed analyses and calculations, the following average chemical composition of the FeNi alloy was determined [in wt.%]: Fe – 90.75%; Ni – 8.80%; Co – 0.35%; Cu – 0.03%. The content of Cu and Co depends on the nickel content in the FeNi alloy. The low-nickel alloy represented by kamacite is enriched in cobalt (average content 0.38%) and depleted in copper (0.01%), while the high-nickel alloy, represented mainly by taenite, is characterized by a low content of cobalt (0.08%), and a significant enrichment in copper (0.16%). Based on these data, it is possible to approximate the resources of these metals in the parent bodies of these chondrites. For example, for the asteroid (143624) 2003 HM16, which is classified as a Near Earth Object (NEO), such resources are [in Mg]: Fe – $2.4 \cdot 10^9$, Ni – $2.3 \cdot 10^8$, Co – $9.2 \cdot 10^6$, Cu – $7.9 \cdot 10^5$.

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CHLOROPHYLL-A CONTENT IN POST LIGNITE MINING LAKES: A CASE STUDY OF BABINA MINE, POLAND

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Keywords: chlorophyll-a content, Babina mine, anthropogenic lakes, remote sensing index, Landsat program

The waters of post-mining reservoirs, formed at the site of pyrite-rich lignite extraction, are most often characterized by a low pH level and a high content of sulphates and iron. Pyrite, after undergoing physical and biological changes, causes the formation of sulfuric acid. The presence of heavy metals in water reservoirs, as well as low pH level of water, are the main reasons for the absence of fauna and flora in lakes located in the areas of former coal mining. An example of such lakes are reservoirs in the area of the currently closed lignite mine 'Friendship of Nations - Babina Shaft'. The post-mining reservoirs created in the 1970s are characterized by high mineralization, low pH level of water and lack of organic life. However, it should be emphasized that these lakes, like natural reservoirs, are also subject to aging processes, leading to increase of eutrophication. The aim of this study was to analyse the changes of the chlorophyll-a content (which is a component of all algae) in the period of 1989-2019 in the waters of 4 anthropogenic reservoirs located in the Pustków mining field, one of the four fields of the closed Babina mine. The authors, using the spectral index, determined on the basis of Landsat TM / ETM + / OLI images, tried to determine whether organic life has appeared in water reservoirs that had been initially poor in flora. Based on the results of index time series analysis, it was found that in the period of 30 years, a significant increase in the chlorophyll-a concentration was recorded for Turquoise Lake and the post-excavation lake Bronowice located in the place of the former open-pit 'Pustków II'. For these reservoirs, an increase in spectral index value was observed at the level of 0.6 - 0.8. On the other hand, for the Gray Pond, the index increase was insignificant and did not exceed the value of 0.2. In the period of 1989-2019, the spectral index value for the waters of Africa lake did not change. Thus, despite the passage of almost 50 years from the mine closure, the reservoir is still poor in organic life. Summing up, the conducted research indicates that the rate of aging of anthropogenic lakes in the area of the former Babina mine is not the same, but it is certainly visible. In the opinion of the authors, due to the unique character of the study area (belonging to the UNESCO World Geopark - Muskau Arch), the presented research should be extended with other physicochemical features of the waters and be continued in the future, in order to deepen the knowledge about changes in the chemistry of the post-mining lakes water.

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**COUNTING TREES - METHODS OF AUTOMATIC ANALYSIS OF
PHOTOGRAMMETRIC DATA IN FORESTS OF THE CONTINENTAL
REGION**

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Keywords: counting trees, forest management, object detection, template matching, Faster R-CNN

The paper is devoted to the methods of automatic analysis of photogrammetric data in forests of the continental region. It also discusses how automatic tree counting can be used to manage forests. Experimental research was conducted to verify two methods: Faster RCNN and Template Matching to automatically detecting tree objects in the continental region characterized by mixed forests with a large predominance of conifers. The research was done based on photogrammetric data taken in four areas belonging to forest districts subordinate to the Regional Directorate of State Forests in Zielona Góra. Data was collected from drones and small airplanes with a photogrammetric container. The results show that both methods can be used for analyzes in specific cases. Moreover, the level of Recall shows the advantage of Faster R-CNN methods.

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DECOMPOSITION OF LOS DISPLACEMENT TO VERTICAL AND HORIZONTAL COMPONENTS: IMPLICATION FOR THE SOUTHERN QINGHAI M7.3 EARTHQUAKE

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Keywords: DInSAR, displacements decomposition, Sentinel 1A, earthquake, surface displacement

Ground surface displacement can be caused by both natural and induced (e.g. associated with underground mining activity) phenomena. To the first abovementioned may include the earthquake that occurred on May 21, 2021 in southern parts of Qinghai province, in central China. From the geological point of view, the earthquake was caused as the result of strike-slip faulting with a component of normal faulting, had a strength of M7.3 and its hypocenter was at a depth of about 10 km. It is estimated that liquefaction and landslides (the tangible impact on the land surface) triggered by this earthquake are significant (U.S. Geological Survey, 2021). Therefore, satellite radar interferometry (InSAR), as a remote sensing method, appears to be a useful method for detecting this type of occurrence and its influence on the earth's surface.

Aim of this research was to estimate the vertical and horizontal displacements that occurred on the ground surface after the earthquake. For this purpose Sentinel 1A synthetic aperture radar (SAR) data from two paths - ascending (99) (for May, 20 and June 19) and descending (106) (for May 20, 2021 and June 1, 2021) was obtained. Open source software GMTSAR [1] used to generate differential interferograms using the Differential Interferometric Synthetic Aperture Radar (DInSAR) method. Due to the fact that the DInSAR allows to determine only LOS (Line of Sight) displacements, then it was necessary to conduct the process of their decomposition into horizontal and vertical components [2]. It was possible for the reason that the research area was covered by images from both the ascending and descending satellite passes. Obtaining displacements in both planes allowed for a better description of the phenomenon that occurred on the ground surface.

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PRELIMINARY STUDY OF THE COOLING EFFECT OF URBAN PARKS IN THE WROCLAW CITY

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Keywords: urban park, cooling effect, LST, Wrocław

The urban heat island (UHI) effect has become a one of major issue in modern city management and in urban ecology. UHI can be leveled by cooling the urban space. Parks creating cooling island phenomenon (PCI) have such an effect on the temperature in the city. In this study, an attempt was made to determine how parks affect the distribution of temperature in surrounding areas on the case study in Wrocław city in Poland. For this purpose, raster LST maps for the city of Wrocław were created using satellite imagery acquired by Landsat-8. LST maps were developed from Thermal Infrared Sensor (TIRS) data acquired during three hottest weather periods between 2017 and 2019. Then, 4 parks were selected (each from a different size category) for which basic metrics such as: Park Perimeter (Pp), Park Area (PA), Landscape Shape Index (LSI) and Park Land Cover (PLC) were determined. Then, based on the created LST maps, spatial statistics: Park Cooling Area (PCA), Park Cooling Efficiency (PCE), Park Cooling Gradient (PCG), Park Cooling Island (PCI) and Extended Park Cooling Island (PCIE), were determined showing the impact and range of the park's impact on their neighborhood. The determined parameters allowed to indicate which matrices correlate with spatial statistics, and thus which factor is responsible for the cooling of temperature. This study proved that the range and efficiency of cooling are influenced by the park area and the size of the forest area in relation to the entire park area.

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VALIDATION OF THE COPPER ORE NUMERICAL BREAKAGE MODEL

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Keywords: Numerical modeling, Discrete Element Method, Breakage model, Crushing

In order to extract valuable elements from the mined ore, the ore must be processed. The comminution process is the most energy-intensive in the mining industry. The ore is processed to the point where valuable minerals are freed from surrounding gangue particles. Copper ore in LGOM (in Polish: Legnicko-Głogowski Okręg Miedziowy) is one of the most diversified, in terms of lithology, from all mined ores in the world [1].

There are three main rock types in the ore zone: sandstones, shales, and mostly dolomites in the carbonate part of the ore [1]. The main goal of the work was to develop a comprehensive numerical crushing model of the copper ore, originating from the Fore-Sudetic Monocline region (in Polish: monoklina przedsudecka). Limitations in empirical research resulting from process dynamics can be overcome by using numerical methods. In the case of material crushing, the Discrete Element Method (DEM) helps to simulate the simultaneous behavior of multiple bulk material particles. Insight into comminution phenomena of bulk materials needs the implementation of necessary additional breakage model. Several models can be used in DEM simulation, but it seems that the Particle Replacement Model (PRM) has the highest potential when using later in industrial applications. In the PRM model initially proposed by Cleary [2], particles on which acting force exceeds the critical value immediately break down into smaller ones. PRM was successfully used to describe the breakage of particles under confined conditions [3] or in simulating comminution equipment, including crushers [4].

In the work, the PRM method was used for breakage simulation. The copper ore was parametrized with laboratory tests, and validation of the model was performed with the laboratory scale jaw crusher. The simulated particle size distributions were similar to the ones obtained from laboratory tests.

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GEOLOGICAL AND MINING FACTORS INFLUENCING THE METHANE EMISSION CHANGES IN THE RYDUŁTOWY MINE, UPPER SILESIAN COAL BASIN, POLAND

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Keywords: the Upper Silesian Coal Basin, coal mining, methane, geology, tectonics

The Upper Silesian Coal Basin (USCB) is the most industrialized and coal-rich region in Poland. Mined coal in the USCB entirely comes from underground collieries and it is used to heat and power production or, to the metallurgical purposes. The USCB geology is very diversified and consists of regional and small fault tectonics, folds, overthrusts and variable Miocene overburden thickness. Each of the factors influences on gases migration, accumulation and different methane (CH₄) content in the coal seams. Rydułtowy coal mine is located in the western part of the basin, near the Michałkowice-Rybnik overthrust. Local patches of the Miocene overburden did not prevent the strata degassing processes. Methane trapped in the shallow lying Carboniferous sandstones and shales had an easy pathway to migrate to the surface. Consequently, the shallow deposited coals were extracted in methane-free zone. At deeper parts of the Carboniferous strata more methane was accumulated, due to bigger pressure, less porous and permeable rock properties. The coal production in methane-rich seams takes place from 2000 when total methane liberation to coal workings was recorded: around 3 million m³CH₄/year (in 2000) and the emission increased rapidly to almost 35 million m³CH₄/year in 2003 (Figure 1). The mining factors (e.g. volume of extracted coal) have a strong impact on CH₄ emission which was noticed between 2004 and 2007, when coal production slowed down due to many reorganization and preparation works. Consequently, the methane emission decreased to 12 million m³CH₄. In next years, the CH₄ emission increasing trend was noticed. In last years of the studied period (2014-2019) the average methane emission oscillated around 20-25 million m³CH₄/year. In next years, the most dangerous natural hazard in Polish mining – the methane hazard, is going to increase or will remain on similar level in Rydułtowy coal mine caused by unfavorable geological (methane accumulated in deeper coal seams; complex tectonics) and mining factors (concentration and deeper coal extraction).

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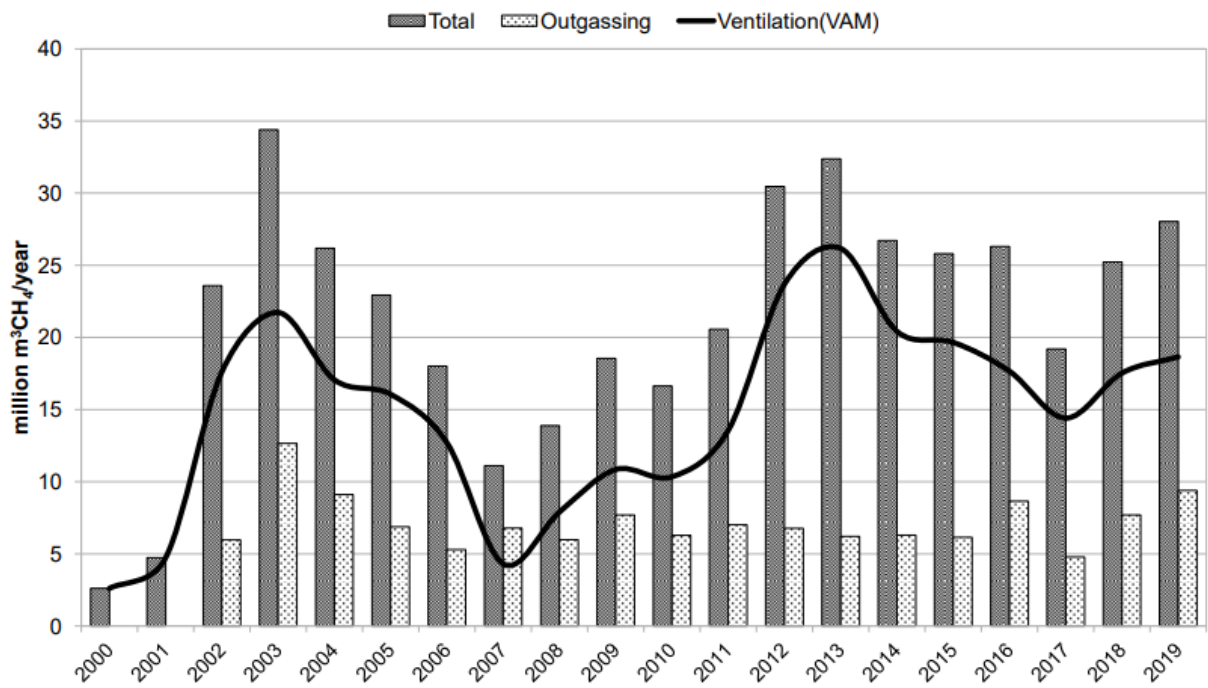


Figure 1. Methane emission changes in Rydułtowy coal mine in 2000-2019

GEOPOLYMERS BASED ON PLASMA INCINERATION WASTE AS A MATERIAL FOR CIRCURAL

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Keywords: geopolymers, plasma incineration waste, fly ash, circular economy

The plasma waste treatment technology is one of the promising methods of reducing problematic waste, but the technology itself create other kind of waste that must be effectively used to recognize this technology as a suitable for circular economy. The aim of the article is to show the possibility of using waste materials from a plasma incineration plant as a raw material for the production of geopolymeric materials. The samples were made based on waste from plasma incineration plant in Liberec (Czech Republic), fly ash from thermal power plants in Skawina (Poland) and sand mixed with an aqueous chemical solution. Next they mechanical properties, microstructure and mineralogical composition have been investigated. The results show the combination of these raw materials can increase the strength of the material and, consequently find applications in the utilization of plasma incineration waste. The article show the geopolymerization could be effective process for using waste materials from a plasma incineration plant as a raw material for creating the products for construction industry.

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**DEFORESTATION IN BORNEO (2010 – 2020)
CASE STUDY CONDUCTED IN A REPRESENTATIVE AREA BASED ON
OPTICAL IMAGES OF THE LANDSAT AND COPERNICUS PROGRAM**

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Keywords: deforestation, Landsat 5, Sentinel 2, open data, remote sensing

A growing population, agricultural and industrial development mean that the human impact on nature is constantly increasing. Deforestation is a serious threat to the environment. In today's world, we are aware of the consequences of deforestation and the current scale of this phenomenon. This topic is often taken up by scientists all over the world, the phenomenon of deforestation is studied on a local and global scale. Platforms are also created, where information about the ongoing changes is updated on an ongoing basis. Monitoring changes is possible thanks to the growing number of observation satellites and the data they collect. This study investigates the potential and limitations of using optical data from Landsat (Landsat 5) and Copernicus (Sentinel-2) to study deforestation over the past 10 years in a representative area of the Indonesian part of Borneo Island.

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DRILL BIT DETERIORATION ESTIMATION WITH THE RANDOM FOREST REGRESSOR

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Keywords: machine learning, Random Forest Regressor, drilling rig, prediction, process performance

Blastholes drilling performance is crucial for ensuring good performance of the whole excavation process, the correctness of which demands a 'healthy' drill bit and appropriate behavior of an operator. Given the large volume of non-linear parameters describing the process, it appears reasonable to employ supervised learning methods to obtain drilling performance insights. Random Forest Regressor model has been trained on the dataset corresponding to correct performance of blastholes drilling and its hyperparameters have been tuned to obtain the highest possible accuracy. It has been later tested on three datasets corresponding to a good performance of drilling, and two cases of its non-optimal execution. Estimation errors are proposed to be used as bit technical state condition indicators (or more generally - process performance indicators). Root Mean Squared Error has been proven to differ significantly when compared estimation based on datasets corresponding to execution of drilling with 'healthy' drill bit, and its execution with worn-off one, however, it has been not sufficient to distinguish non-optimal drilling when additional feed pressure has been exerted by an operator to compensate the reduced pace of drilling. It has been, however, possible when the median of absolute estimation errors has been used.

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MANAGEMENT OF MINING WASTES THROUGH THEIR TRANSFORMATION INTO USEFUL SORBENT

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Keywords: waste processing, carbonaceous shales, calcination, zeolites

Every year a few hundred million or so tons of industrial waste are generated all over Europe. A considerable share is attributable to exploratory wastes from the mining sector and combustion byproducts. Limiting natural deposits of mineral resources leads to the search for alternative solutions, especially in the construction, construction and transport sectors. The process of their reprocessing and utilization fits into the following rules subject to intensive development, viz.: zero waste economy (Zero Waste Europe), effective use of resources (Resource Efficient Europe) as well as closed-circuit economy (Circular Economy). For years, sorbents have played an important role in the processes of retaining, collecting and absorbing various liquids, which are difficult, toxic and environmentally hazardous substances.

The article shows some research results to corroborate the concept of industrial waste processing of carbonaceous shales into sorbent materials. The applied process of carbonaceous shale calcination led to the obtaining of a material containing metakaolinite, then used in the synthesis of zeolites. The specific surface of the sorbent obtained in the aforesaid way exceeded 100 m²/g. The studies have shown that it is possible to obtain synthetic sorbents from waste products, and that the parameters of such sorbents are comparable to those of synthesis products made from raw materials extracted from natural resources. Such activities reduce the negative impact on the environment and reduce the amount of landfilled waste.

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HOW TO ASSESS THE LEVEL OF PLANT INVASIONS? PRACTICAL PROTOCOL BASED ON LANDSCAPE METRICS

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Keywords: anthropopressure, biological invasions, invasion modelling, invasive alien plant species (IAPS), land cover

Invasions of exotic plants have negative effect on functioning of ecosystems, reduce the biodiversity, and caused deterioration or even loss of many valuable ecosystem services. The success of spread of invasive alien plant species (IAPS) depends on three factors: habitat invasibility, that describes their vulnerability to invasions, invader traits and propagule pressure, that refer to the potential for introduction rather than a realized introduction of alien species. Landscape metrics and some socio-economic variables have become widely used as proxy of propagule pressure in recent years.

The main goal of our study was to construct the model, that allows to determine the factors responsible for the distribution of IAPS. Moreover, all necessary analyses can be done using free datasets and software.

The research procedure consists of four steps:

- Collection coordinates of IAPS stands and their percentage cover,
- download the data of land cover/land use (e.g. CORINE Land Cover), line structures (e.g. Open Street Map) and socio-economic attributes (e.g. Local Data Bank),
- visualization the distribution of IAPS using QGIS program,
- identifying variables, that best explain the distribution of IAPS using ordination techniques. Analyses can be done in PAST program (PAleontological Statistics).

The pilot studies have been carried out in strongly anthropogenic transformed river valley and semi-natural forests in the Silesian Upland (south-western Poland) in 2018- 2021 growing seasons. Obtained results showed, that our model is easy to use and applicable for ecosystems, that are differ in level of disturbances. Moreover, all analyses performed using free and open sources databases and software. Therefore, landscape characteristics could be successfully used in the management strategies of IAPS.

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MONITORING THE SAFETY OF CAVERN STORAGE FACILITIES USING SATELLITE AND UNMANNED AERIAL SYSTEM DATA

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Keywords: post-mining, geomonitoring, remote sensing, UAS, GIS

Re-using large-volume salt caverns for the intermediate storage of liquid and gaseous energy carriers is an indispensable step on the way to a sustainable energy economy. Continuous development of methods for monitoring these facilities is a crucial part of the social license to operate. In the research project "Monitoring system for the safety of cavern storage facilities using satellite and unmanned aerial system (UAS) data (KaMonSys)", safety solutions for critical infrastructures are implemented in an interdisciplinary approach of remote sensing and geoscientific methods. Using underground storage facilities (USF) as an example, multisensory approaches are being developed to monitor the facilities as well as their surroundings by satellite and UASbased monitoring to detect possible emissions, such as methane, hydrogen and carbon dioxide.

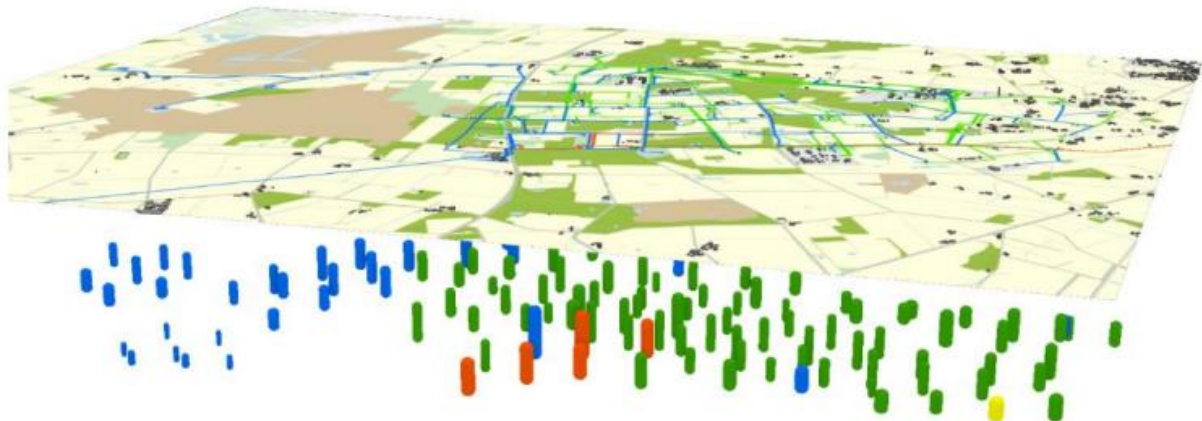


Figure 1. 3D-GIS composed of surface and subsurface data from open and closed sources

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The Research Center of Post-Mining first shows in a subproject of KaMonSys the initial evaluation of available open spatial data (INSPIRE) and such of associated project partners Uniper and Salzgewinnung Westfalen on the surface/subsurface situation (figure 1). Additionally, on site surveying with GNSS equipment and tachymeters provide high accuracy ground control points for upcoming UAS flights with infrared/multispectral sensors and satellite data. Aerial pictures created using an RTK (real time kinematic) UAS could be used to create high resolution orthofotos and 3D point clouds utilizing the open source photogrammetry software OpenDroneMap (figure 2).

Using this integrated development a 3D GIS was established in the first project months for the spatiotemporal evaluation of all available data. The next steps are

- the integration of satellite data from the project partner EFTAS data into the GIS,
- the classification of surface types (if possible by use of machine learning tools) to increase the spectral accuracy of thermal and multispectral sensors and
- the development of 3D UAS flight plans to detect possible gas emissions while avoiding critical infrastructure, explosion safety zones and dangerous leeway.

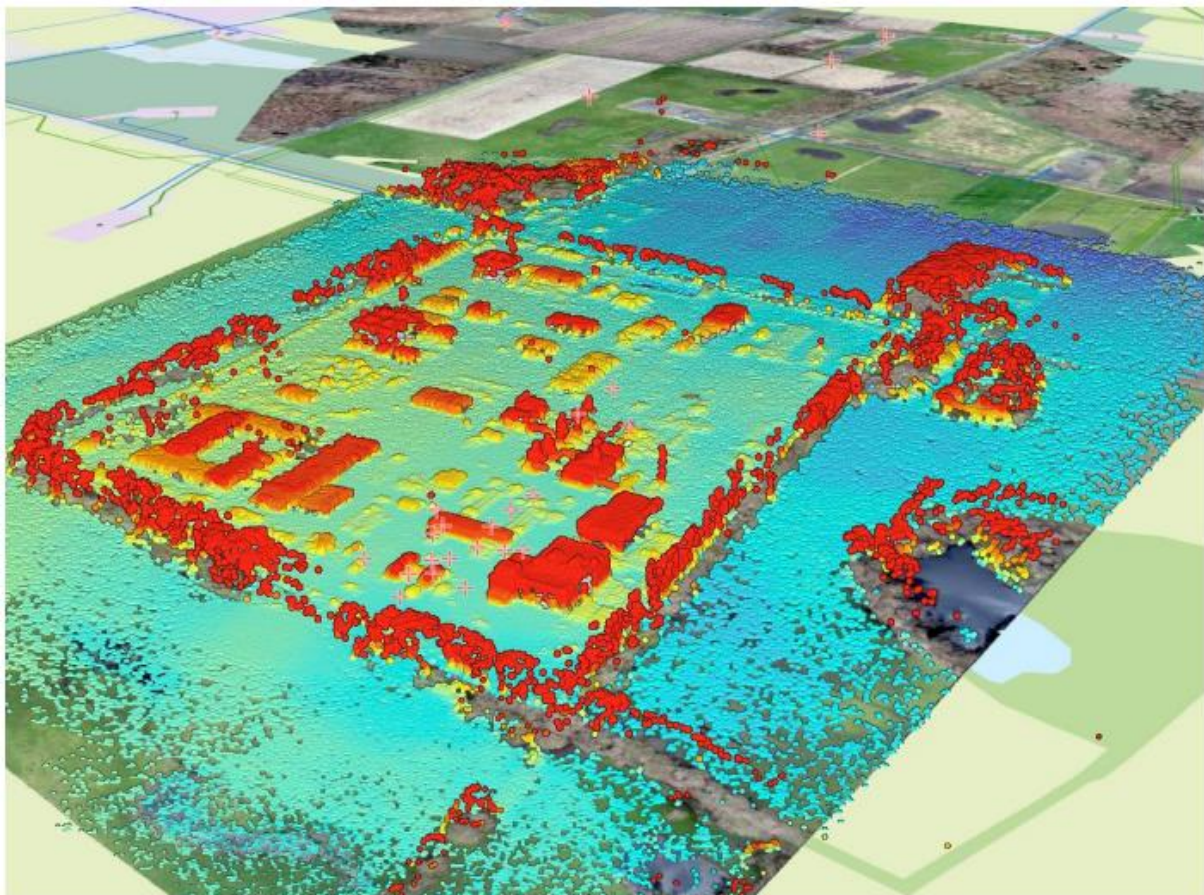


Figure 2. Additional 3D data from on-site surveying and UAS-flights

The lead project partner EFTAS Fernerkundung Technologietransfer GmbH furthermore develops techniques to use open source satellite data from the European Copernicus missions as another subproject. The overall goal of KaMonSys is to link both subprojects in a powerful geomonitoring tool: Satellite data will be used to monitor large areas

for indicators like ground movements, vegetation damages, large scale gas emissions, etc. In case of a critical reading a UAS with thermal and infrared sensors (figure 3) will be activated to locate, evaluate and assess potential emissions using a preprogrammed 3D-flight plan. Initially developed using underground gas storages, this project might also be applicable for other industrial sites like refineries or mining operations.



Figure 3. Research Center of Post-Mining's GeoKopter with GNSS, infrared and thermal sensors (BMBF FKZ 005-1912-0004)

Coupling classical geological methods of subsurface assessment with innovative approaches from remote sensing shows a huge potential for further research. The project is supported by federal funds within the German BMBF funding framework "Research for Civil Security" (FKZ 13N15366).

INVESTIGATION OF SEASONAL BALTIC SEA LEVEL CHANGES

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Keywords: sea level changes, Baltic Sea, satellite altimetry, time series

Sea and ocean level variations are indicators of changes in the climate system. Mean sea level is increasing from year to year and the consequences of these fluctuations are most pronounced in coastal zones. The aim of this research is to determine seasonal Baltic Sea level variability over a period of 26 years (from 1993 to 2018), using satellite altimetry data. For a set of monthly sea level anomalies, time series were created, a linear trend (3.89 ± 0.82 mm per year) was estimated and statistical analysis was carried out. Annual and semi-annual amplitudes were examined, also taking into account the influence of the Sun and the Moon. Research showed Baltic Sea level deviations depend on longitude and latitude. The biggest changes can be seen in the northern part, while the smallest in the south. The results confirm the need for regional research and continuous monitoring of sea levels.

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**INVESTIGATION OF VERTICAL CRUSTAL MOVEMENTS VELOCITIES
ALONG THE ADRIATIC SEA COAST BASED ON SATELLITE
ALTIMETRY, TIDE GAUGE AND GNSS OBSERVATIONS**

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Keywords: vertical crustal movements, satellite altimetry, tide gauge, GNSS, Adriatic Sea

Global climate changes contribute to global sea level research. Sea level changes could be determined by tide gauges (TG) and satellite altimetry (SA) data. Based on their time-series differences, vertical movements of the Earth's crust can be determined.

The main aim of this analysis is to investigate this movements velocities in the Adriatic Sea region. Two different methods were used: differences TG – SA and GNSS observations. Time series were generated and the linear trend was estimated. In analysis, we took into account annual, semi-annual and 18.61-year (lunar nodal) cycles.

In the selected period linear trend was from 3.12 ± 0.31 mm/year to $+3.54 \pm 0.32$ mm/year from the satellite altimetry data. Velocities from differences between satellite altimetry and tide gauge data were compared with velocities calculated using GNSS observations. From TG – SA data sets we received mostly positive values. That indicates land uplift. Velocities from GNSS are mostly negative. That indicates land subsidence.

This research presents the relation between sea level changes and vertical crustal movements and also techniques used to estimate these movements velocities.

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LIFE CYCLE OF TAILING PILES WITHIN THE BIM TECHNOLOGY: THE POTENTIAL FOR IMPLEMENTATION

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Keywords: BIM, tailing piles, life cycle

Building Information Modelling (BIM) is a modern and constantly developing process of collecting and managing data, based on dynamic 3D modelling. This approach already has numerous applications in the construction, architecture and engineering [1-2]. Recently, there are introduced proposals to implement BIM in mining industry [3-4].

Due to the growing demand for raw materials and the growing environmental awareness, the mining waste is becoming an interest of researchers and investors. In Lower Silesia alone, have been documented 576 tailing piles and ponds that require further research, and if positive recommendations are obtained, they may also become the object of exploitation [5-7]. This fact makes allows to look at these sites as the subject of geological-mining projects, which consist of successive stages: inventory, reconnaissance, development, exploitation, processing, closure, reclamation and monitoring (Figure 1). The use of BIM technology throughout the life of this type of projects will allow easier planning of field works at the stage of inventory and reconnaissance, facilitate the design of development and exploitation, and the obtained model may become the basis for planning reclamation and conducting subsequent environmental monitoring. The information collected in this way allows for easier planning of works and their implementation, but in terms of BIM, the issue of cost and time management can also be optimized. The compilation of subsequent data from geochemical, mineralogical, geophysical and remote sensing studies in the form of a 3D model has been used recently as a tool for easier interpretation of these data. BIM might be helpful for better standardization of the data gathering process [8-9].

In the case of operating mines, BIM might be used by miners as the tool supporting the monitoring of the process of creating and operating temporary tailing piles. Moreover, this technology has been already used during the creation of the new southern part of Żelazny Most [10]. The article presents possible directions of using this technology for the management of works related to historical and active tailing piles and ponds.

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IMAGE SEGMENTATION OF ORE CHIP AS INPUT FOR GEOMETALLURGICAL MODELLING

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Keywords: Image processing, Image Segmentation, K-mean clustering, Superpixel Segmentation, Watershed Segmentation

The ability to forecast geometallurgical properties during resource extraction is essential to optimize the mine to mill process. Grade control models thus often incorporate attributes related to processability. The analysis of these attributes in a laboratory can be quite time- and cost intensive. Only a limited number of data may be available. During production, grade control drilling by RC may provide access to many more samples. Conducting laboratory analysis, such as MLA or comminution tests to each of these samples would be not realistic. If there was an opportunity to quickly obtain related proxy data, then these indexes could be estimated, certainly less precise but with a significantly increased spatial density. A rather simple approach to acquire data from grade control drilling is to take digital RGB images from core trays. Although these capture only three spectral band regions, images can contain valuable texture and colour related information. The challenge then is to find statistically robust relations between texture features of the image and geometallurgical properties. To establish such a relation, a first necessary step is to automatically extract objects from an image that can be analysed. This study aims to investigate the performance of different available segmentation methods under field conditions.

First an overview of methods for image segmentation as a basis to create objects is presented. Objects can be related to single grains and minerals within the grains. The aim is to provide a basis for texture feature extraction related to granular rock, such as found in chip trains. Modern image analysis provides a large number of methods for segmentation and classification of objects. This work focuses on evaluating performance on images of 3 levels of complexity of pixel- based segmentation for complex or less noisy images and object-based segmentation (Watershed, Simple Linear Iterative Clustering and Quickshift) as a more advanced and universal method.

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**RESOURCE REGIONS AND THE TRANSITION TO SUSTAINABLE
KNOWLEDGE-BASED DEVELOPMENT: ESCAPING THE RESOURCE
CURSE?**

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According to the economic concept of the “resource curse”, the specialization of countries and regions in the extraction of minerals can have a negative impact on their long-term economic development. The authors of the article propose, that this influence can significantly slow down the transition to development based on knowledge. The article tested this hypothesis using the dynamics of indicators of the knowledge-based economy the group of resource regions of Russia. Of the 12 resource regions of Russia, only two successfully form the knowledge-based economy – Tomsk Region and The Republic of Tatarstan. These regions had a developed education system and research infrastructure even before the discovery of oil here in the 1940s-1960s. For the rest of the resource regions, there is a large lag behind the leading regions of the knowledge economy in Russia, which does not significantly decrease during 2005-2019. At the same time, these regions did not have a developed scientific and educational base by the beginning of the active industrial development of natural resources on their territory. Thus, the formation of the knowledge-based economy in resource regions is strongly influenced by both the resource curse and path dependence effects. The absence of structural economic policies in the regions that are rich in natural resources will hinder their transition to knowledge-based development.

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COMPREHENSIVE COMPARISON OF SOIL AND GEOLOGICAL DATA FOR THE BORÓW MUNICIPALITY IN THE STRZELIN COUNTY

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Keywords: soil-agricultural map, geological map, forest soil-habitats map, database, Borów municipality

Increasing growth of spatial information requires unification of databases by their cartographic editing, which makes them useful for nowadays popular processes of monitoring natural phenomena.

The purpose of this study was to specify and enrich the soil-geological database for further analysis and research, as well as cartographic detailing and generalization. Such an enriched database provides many opportunities for analysis, compilation, obtaining area information and indicating spatial conflicts between overlapping data. The database was created by merging geological and soil data with an extended scope.

The database is based on soil-agricultural maps, soil-habitat maps of forests, geological maps and data from register of lands and buildings. In addition to information about surface geological formations and time of formation (geochronostratigraphy), the data also include information on type, subtype, kind and species of soils in five depth levels, agricultural usefulness complexes and bonitation classes (class-utility). Additionally, the database was enriched with information on soils under forests and forest habitat types, which were derived from soil and habitat maps of forests and which were classified as soils under forests on soil-agricultural maps. In this way, a comprehensive natural database of all soils in the municipality was obtained.

As a result, a database was created that is internally consistent, allowing for multidimensional analysis and compilation, which in turn allows for its use in a satellite-based system for spatial monitoring of agricultural production.

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A REVIEW OF METHODS IN THE FIELD OF DETECTING ILLEGAL OPEN-PIT MINING ACTIVITIES

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Keywords: illegal mining activity, InSAR, supervised and unsupervised classification, image fusion, spectral indices

Illegal open pit mining is a very dangerous activity not only for the environment, but also for the people living in its neighbourhood. This kind of activity is connected with environmental degradation, disruption of sustainable development and lack of the last stage of the mine's "life", i.e. land reclamation. An additional element connected with illegal exploitation is the fact of breaking the law and stealing mineral resources. Monitoring of illegal exploitation is therefore an important aspect. The review was intended to indicate which methods are used directly to detect open pit mining sites and their effectiveness. The authors whose work was reviewed used a wide variety of methods, ranging from manual methods, such as photointerpretation, to a combination of automatic methods and photointerpretation, to fully automatic methods. Based on the analysis, it was indicated that different types of classification (supervised, unsupervised, hybrid) are the most commonly used. Besides, radar interferometry, image fusion techniques, or spectral similarity of images are also used.

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DEGRADATION OF URBAN SPACE AS A NEGATIVE EFFECT OF MINE CLOSURES

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Keywords: mine closure, degraded urban space, post-industrial district

The article presents one of the social aspects of mine closure, which concerns degraded urban space. One of the post-industrial districts of Wałbrzych: Sobięcín was selected as a case study, in which the general condition of the buildings was assessed. The closure of mines is the last stage of mining activity, the result of which should be a permanent minimization of the negative consequences of the impact of the mining industry. The closure of mining enterprises has environmental, social and economic consequences.

The liquidation of the Wałbrzych coal mines in the 1990s resulted in a rapid de-industrialization of the region and did not provide the means to contain the domino effect it caused. At that time, economic and social changes began in Wałbrzych, and unorganized and intense changes took place in the city space. Liquidation processes in the mining industry have led, among others, to the physical and aesthetic degradation of residential buildings and other facilities.

The purpose of this article is to assess the general condition of buildings located in an area affected by the negative consequences of mine closures. To achieve this goal, an inventory of the technical condition of the buildings was made. The external elements of each building were assessed by means of a field interview: the facade, door and window joinery and roof covering. The inventory process was supported by drone flights. The collected data was used for graphic and tabular studies, summarizing the condition of buildings and the degree of degradation of urban space.

The article presents the results of the inventory, during which it was noticed that the urban landscape of the research area is full of abandoned and devastated post-industrial facilities, and that the residential buildings are degraded due to underinvestment and pathological social behavior. As many as 158 multifamily residential buildings (53.7%) show clear signs of degradation.

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EXPLORATION AND MINING ACTIVITIES IN THE SITUATION CREATED BY THE PANDEMIC IN KOSOVO

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Keywords: analysis, decisions, activities

Independent Commission for Mines and Minerals has done an analysis on exploration and mining activities for the period of January - April 2020 as consequence of the situation created by COVID-19 pandemic.

ICMM in compliance with decisions taken by Government on situation created by COVID-19 pandemic has reflected in conformity with situation and in compliance with the said decisions, by being vigilant to the importance that it has the maintenance of continuity of mining activities in the country.

The ICMM Board, in compliance with decision of Ministry of Finance, took decision to postpone until 30 June 2020 all payments and financial obligations of the enterprises to the ICMM.

The general revenues during the period of January – April 2020 were 14,940,538.90 €, comparing with January – April 2019 the revenues were 14,592,514.03 €, so general revenues are for 2.3% higher than for the same period of the last year and this show an increase in financial stability of the ICMM institution.

According to the analysis of activities, a decrease of 19% of activities were in surface blasting whereas there were an increase of 20% of the activities for blasting in underground mines.

50 licenses and permits approved for the period of January – April 2020 were recorded, whereas there were 101 licenses and permits for the same period of the last year, that according to this there is decrease of 50% the issuance of licenses and permits.

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DEVELOPMENT OF THE BARBORA GROUP OF FAUNISTIC PERIODS IN THE CZECH PART OF THE UPPER SILESIA COAL BASIN

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Keywords: Upper Silesian Basin, faunistic periods of Barbora, Jaklovec Member, Frenštát part, Karvina part

The presented article deals with the study of the group of faunistic periods of Barbora in the Czech part of the Upper Silesian Basin, which has long been used as a period separating the Jaklovec and Poruba Member. The article describes a brief geological characteristics of the faunistic period. Borehole profiles were used to process the methodological part, which captured a group of faunistic periods Barbora and information obtained from the borehole database, which is available in the archives of the Czech Geological Survey in Prague and at the University of Mining - Technical University in Ostrava. A clear map of the occurrence of faunistic periods of Barbora in the Czech part of the Upper Silesian Basin, a model of sediment thickness in which faunistic periods occur, a model of sandiness and a model of the number of positions of individual periods are prepared. There are also clear maps that point to the occurrence of marine, freshwater and brackish fauna. The work contains two correlation sections across the Czech Upper Silesian Basin, which show the development of sediment deposition in the faunistic periods of Barbora. The group of faunistic periods of Barbora is spread throughout the Czech part of the Upper Silesian Basin. It is a permanent period in which siltstones, claystones and sandstones predominate. The maximum thickness of the monitored interval is in the area of Dětmárovice in the Karviná part. However, even the minimum thickness was found in the Karviná part of the basin. The smallest powers are in the south of the basin, towards the north the power increases. The highest sandiness was found in the Frenštát part and the lowest on the contrary in the Karviná part. The highest development of the number of positions of the group of faunistic periods Barbora is also in the Karviná part, the opposite is the case in the Frenštát part, where the development of the number of faunistic positions is the lowest. The most common faunal species are *Anthraconeilo rotundatum* and *Anthraconeilo oblongum* of the genus *Anthraconeilo*.

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**IMPROVEMENT OF REAGENT FLOTATION MODES OF SPHALERITE
AND PYRITE FROM DEPOSITS OF COPPER-ZINC PYRITE,
POLYMETALLIC COPPER-ZINC PYRITE AND POLYMETALLIC ORES**

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Keywords: Flotation, sphalerite, iron sulfate, potassium butyl xanthate, sodium butyl dithiophosphate

Copper-zinc pyrite (Sulphide) and polymetallic ores of Russia are complex and difficult to process mineral raw materials. The main technology for the enrichment of this ores are flotation [1]. Currently, the improvement of the flotation technology of this mineral raw materials is carried out in several way [2]. It has been established by the practice of beneficiation of copper-zinc ores that obtaining high-quality zinc and pyrite concentrates is impossible without adding flotation modifiers of sphalerite and pyrite to various flotation operations [3, 4]. This reagent are copper (II) sulfates, zinc and iron (II) sulfates in an alkaline calcareous medium. Therefore, studies on the flotation of sphalerite and pyrite in an alkaline calcareous medium with the addition of one of these metal sulfates to the mineral flotation operation were performed [5]. The effect of each copper (II) sulfates, zinc, and iron (II) on the flotability of sphalerite and pyrite was studied during flotation of the mineral and xanthate and dithiophosphate at pH = 8, 10, and 12. The aim of this work was to study the effect of the flotation size class (- 0.074 + 0.044 mm) sphalerite and pyrite of one of the Russian deposits by sulfhydryl collectors in the presence of copper, zinc and iron sulfates in the liquid phase of flotation pulp [6].

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**STRENGTH PROPERTIES OF BALLAST LAYER, CREATED FROM NEW
AND RECYCLED CRUSHED STONE BALLAST**

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Keywords: new ballast, recycled ballast, specific cohesion of ballast, internal friction angle of ballast

The objective of the research is a railway ballast layer created from new and recycled ballast particles in different ratio. In order to study the possibility of using recycled ballast grains in ballast layer, it is necessary to carry out laboratory triaxial tests of ballast crushed stone with size of the particles 25-60 mm with different grain shape. L.A. abrasive machine allows to reach the effect on new ballast, which is similar to abrasion of ballast particles in the railway track. As a result, it is possible to create ballast samples from (new) mixed and recycled ballast and estimate which proportion has the strength characteristics, which are close to the ones in ballast layer created only with new ballast particles.

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RELIABILITY OF THE BELT CONVEYOR BED WHEN RESTORING FAILED ROLLER SUPPORTS

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Keywords: Belt conveyor, roller support, failure rate, recovery probability, the mathematical expectation of the number of working roller supports

The reliability of modern belt conveyors, whose length reaches tens of kilometers, is primarily determined by the reliability of the roller supports that support the belt and ensure its movement. As they wear out, some roller bearings fail and need to be repaired or replaced.

The dynamics of the number of working roller supports is determined by the system of Kolmogorov equations. Their solution allows us to find the probabilities of finding the system in states with a different number of working elements. The article finds probabilities for two cases. In the first case, when restoring, only one roller support is repaired each time. In the second case, all roller supports are repaired or replaced. In the case of sequential recovery, the mathematical expectation of the number of properly working roller supports may be less than the total number by several units. There are always elements that need to be repaired. If the recovery rate of the elements is many times higher than the failure rate, the mathematical expectation of the number of properly operating roller supports is less than the total number of roller supports by less than one, during most of the time all roller supports are serviceable. In the case of simultaneous recovery of elements, an equally high level of reliability is achieved even with comparable failure and recovery rates.

The results obtained can be used to determine the necessary reserve of spare structural elements and to plan the maintenance of conveyors.

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**METHOD OF SELECTION OF THE TYPE AND CONSTRUCTION OF
ANCHOR BOLTS FOR DIVERSIFIED GEOLOGICAL-MINING
CONDITIONS OF COPPER ORE MINES OF KGHM POLSKA MIEDŹ S.A.
IN THE LGOM AREA**

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Keywords: roof bolting, underground mine, selection of roof bolting, expansion anchor bolt

The presentation is objected to show the assumptions and the results up to this date of testing performed within the PhD implementation dissertation conducted by the author at Wroclaw University of Science and Technology in cooperation with KGHM Polska Miedź S.A.

The author presented briefly the character of his work at an underground mine of copper ore – that triggered undertaking by him the studies concerning roof bolting on the background of a review of the current state of the knowledge in this field. The principal part of the presentation refers to the character of this kind of roof bolting, which is commonly used in the conditions of the LGOM mines and to the results of up to this date studies by the author in this scope.

The most frequently used types of roof bolting used at underground copper ore mines of KGHM Polska Miedź S.A. are the bonded roof bolting and expansion roof bolting, which is illustrated by the presented statistic data. However, for many years attention of the researchers has been focused on testing the bonded anchor bolts. In spite of a substantial participation of the expansion fixing anchor bolts in the overall number of the anchor bolts installed, the analysis performed by the author clearly indicates that the issue of co-working of such anchor bolts with the rock mass seems to be insufficiently surveyed – especially considering the possibility of use for this purpose of the modern research methods, including the numeric ones.

Within the framework of testing performed for the needs of the PhD implementation dissertation, six different constructions of anchor bolt heads have been modelled till now, featuring mechanical fixing (expansion), which were installed in diversified roof conditions characteristic for “Lubin” Mining Enterprises. Due to the implementation character of the performed work, the roof bolting solutions were selected, which were adapted to the machinery park of KGHM Polska Miedź S.A. (currently used in practice).

At the same time, in order to verify the performed theoretical deliberations, verification tests were designed in the real underground mine conditions (in situ). The following testing layouts of anchor bolts/rock mass were proposed:

- diversified anchor bolt constructions – installed in identical conditions,
- the same anchor bolt constructions – installed in diversified conditions.

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On the basis of the analysis of the geological-mining conditions of „Lubin” Mine a selection of underground research testing grounds was performed, which enables execution of the planned experiments in the ‘in situ’ conditions.

Additionally, laboratory tests have been planned that concern co-working of the anchor bolts with the rock mass, which enable reflection of the conditions of the selected underground testing grounds (corresponding to the roof rock characteristics) and are executed with use of identical anchor bolt constructions.

It is assumed that the final effect of the PhD implementation dissertation executed by the author will be verification based both on the results of the theoretical analyses as well as on the underground testing (in situ), which expansion anchor bolting construction coworks best with the rock mass featuring the definite characteristics. Also, you cannot exclude the conclusion that in certain roof conditions the mechanically fixed (expansion) roof bolting does not fulfil the required lifting capacity parameters and is unfitted for application.

GROSS ALPHA AND GROSS BETA ACTIVITIES MEASUREMENTS IN GROUNDWATERS USING LIQUID SCINTILLATION COUNTING (LSC)

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Keywords: gross alpha, gross beta, groundwaters, radioactivity, ISO 11704:2018

In this work Authors describe the methodology of gross alpha and gross beta activities determination in water samples. The chosen method is dedicated to LSC and is based on ISO 11704:2018 and it is suitable for ground waters with low and medium salinity, especially drinking or tap waters as well as medicinal waters (with healing properties, using in health resorts). Authors describe the proper sampling, laboratory preparation including radon removal and measurements conditions. The local and European law regulations showing the limits of radioactivity of drinking waters and medicinal waters are presented. This work presents also selected data of gross alpha and gross beta activities from selected research: the highest levels is measured in Jordanian (gross alpha) and in Brazil (gross beta) and it is respectively 3,58 Bq/L and 5,22 Bq/L.

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HILBERT TRANSFORM USING A ROBUST GEOSTATISTICAL METHOD

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Keywords: Geophysical Inversion, IRLS-FT, Steiner weights

In this paper, we introduced a vigorous inversion method for Hilbert transform calculation which able to eliminate the outlier noise. The Most Frequent Value method (MFV) developed by Steiner merged with inversion-based Fourier transform to introduce a powerful Fourier transform. The Fourier transform process (IRLS-FT) ability to noise overthrow efficiency and refusal to outliers make it applicable method in the field of seismic data processing. At first part of the study, we introduced the Hilbert transform stand on a vigorous inversion, after that as an example we obtain the absolute value of the analytical signal which can be used as an attribute gauge. The method depends on a dual inversion, first we obtain the Fourier spectrum of the time signal via inversion, after that, the spectrum calculated via transformation of Hilbert transform into time range using a vigorous inversion. Steiner weights is used latter and calculated using the Iterative Reweighting Least Squares (IRLS) method (vigorous inverse Fourier transform). Hermite functions in a series expansion is used to discretize the spectrum of the signal in time. These expansion coefficients are the unknowns in this case. The test procedure was made on a Ricker wavelet signal loaded with Cauchy distribution noise in order to test the new Hilbert transform. The method shows very good resistance to outlier noises better than the conventional (DFT) method.

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**ROBUST PARAMETRIC SIMULATOR OF CYCLIC AND NON-CYCLIC
IMPULSIVE VIBRATION SIGNALS FOR DIAGNOSTIC RESEARCH
APPLICATIONS**

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Keywords: vibration data, simulations, autoregressive model, non-cyclic impulsive noise, non-stationary signal

In recent years cyclostationary analysis of vibration signals is considered to be one of the most potent approaches for diagnostics of machines with rotating components. However, it is a subject of an extensive research towards extending its robustness due to its significant inefficiency in the presence of non-cyclic impulsive components in measured data. This problem is especially visible in datasets measured on machines such as ore crushers, where the high-energy impacts are a natural phenomenon. Unfortunately, due to practical inaccessibility, real-life datasets necessary to properly study this problem are extremely difficult to obtain. To address this issue, the authors propose an easy to use simulator of impulsive components. It covers both cyclic components that can describe various types of fault signatures, and non-cyclic ones that can represent impacts occurring naturally due to the nature of machine operation. Simulated signals have been compared with real ones to ensure a high similarity degree, which in turn guarantees a relatively high level of realism.

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**ECONOMIC DEVELOPMENT AND ENVIRONMENTAL FACTOR UNDER
PARADIGM OF THE "REAL WEALTH AND GENUINE SAVINGS"
CONCEPT**

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Stable development of the economy of any level is impossible without taking into account the environmental and social components. It is especially noticeable on the example of commodity-dependent territorial entities, which include not only separately considered, industrialized regions, for example, Kemerovo region - Kuzbass, but also the entire Russian Federation. Various approaches to assessing the socio-eco-economic state are discussed in the article, but the priority approach is to use the international technique of "genuine savings", with the help of which the calculation was made for the studied region and the economies taken for comparison.

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CHARACTERIZING BUBBLE-PARTICLE ATTACHMENT AND MICROPARTICLE WETTABILITY USING AN AUTOMATED CONTACT TIMER APPARATUS (ACTA)

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Keywords: Flotation, Mineral Processing, Bubble-particle attachment

Material characterization is the basis on which mineral processing operations are designed and optimized. It is essential to understand the properties governing the performance of materials in a unit process in order to run it efficiently. Bubble-particle attachment in particular is a fundamental micro-process critical for the success of mineral flotation. Traditionally, it has been accepted that wettability of mineral surfaces correlates with the time needed to produce stable bubble-particle attachments (t_{att}). Consequently, induction timers have become the main tool for detecting t_{att} . However, typical induction timers can only carry out a limited number of attachment events and define t_{att} using an arbitrarily proposed 50% probability of attachment (P_{att}) [1].

Our research group developed the Automated Contact Timer Apparatus (ACTA), a characterization device with the ability of performing hundreds of bubble-particle attachment events in a short time, thus producing statistically relevant information of P_{att} [2]. ACTA is versatile and offers the possibility of quantitatively analyzing bubble-particle attachment under varying conditions in the pulp and mineral particles, while controlling bubble size, approach and receding speeds and particle-bubble distance. Using ACTA, our research group has corroborated that P_{att} is not only a function of t_{att} , but also of the distance between a bubble and particle. These results allowed us to quantify the wettability of microparticles in objective terms for the first time, producing values of contact angles in butyl-coated silica, similar to those measured using the sessile drop method [3].

Subsequently, we hereby present the analysis of silica glass beads functionalized with triethoxy(ethyl)silane. The silica glass beads are in four size fraction ranges of 106-125 μm , 125-150 μm , 150-180 μm and 180-212 μm . Using ACTA, we determined P_{att} and derived wettability data of the functionalized silica beads. Consequently, the contact angle for the ethyl-coated beads was calculated as 76.3° in comparison to 78.6° measured by the sessile drop technique on identically coated glass sheets, thus demonstrating the accuracy of the method for substrates with different hydrophobicity.

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AUGMENTED REALITY IN THE DYNAMIC WORLD OF VIRTUAL TOURISM

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Keywords: augmented reality, cultural heritage, engine Unity, structure from motion, virtual tourism

The issue of virtual tourism penetrates the consciousness of many current explorers and visitors to interesting sites and local attractions. Is it really necessary to physically travel to the chosen location, sacrifice time, money and increase your carbon footprint? The article deals with the issue of creating an application using augmented reality for the presentation of 3D models of cultural monuments. The application is designed for mobile devices, on which museum visitors can view digital copies of selected objects of interest. They can also take a virtual tour of the museum through their mobile devices from the comfort of their home. The introductory part of the article describes surveying of shape and visual properties in situ using photogrammetry and laser scanning. The sequent chapters are an analysis of the creation of 3D models in real scale with photorealistic textures and their presentation in a mixed reality environment. In our case, we will specifically focus on the augmented reality application and its development in the Unity multiplatform game engine. The presentation aims to describe the development of a mobile marker-based AR application briefly, to demonstrate the possibilities of augmented reality and to indicate the potential benefits resulting from the integration of X-reality into our lives. Specifically, we will focus on the application of AR to cartographic works and the enrichment of the content of classical 2D map works and plans with virtually designed 3D models on their surface.

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ANALYSIS OF THE DIGITAL TERRAIN MODEL ON THE ARCHAEOLOGICAL SITE LOCATED IN THE CHODEL BASIN

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Keywords: laser scanning, LiDAR, archaeology, settlement

One of the methods of massive geodetic data collection is laser scanning, which is becoming more and more popular. Three types of scanning can be distinguished: terrestrial, aerial and satellite.

Aerial Laser Scanning (ALS) is often used in archaeological work, first of all for the location and identification of potential archaeological sites. It gives a detailed picture of the terrain, allowing to detect and identify its unnatural changes. On the other hand, Terrestrial Laser Scanning (TLS) is particularly useful for an inventory of excavation sites, mainly due to the possibility of taking measurements during archaeological work and creating models of subsequent layers.

This work aims to compare numerical models of selected archaeological sites made based on aerial and terrestrial laser scanning.

As part of the work, LIDAR measurements were obtained from an outside company and ground measurements were made. Based on the above data, Digital Terrain Models of the archaeological site were built and their mutual comparison was made. The obtained results show that the distances between models developed with two techniques are at the level of several centimetres.

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EMPLOYING THE DIGITAL PLATFORM FOR CONTROLLING SYSTEM DEVELOPMENT ON COAL MINING ENTERPRISE

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Keywords: mining industry, digital twin, Industry 4.0, Energy 4.0, digital platform

In order to digitize mining enterprises, it is necessary to use digital platforms designed to increase production efficiency while ensuring a high level of personnel safety. In the scientific and technical literature, several options for using a digital platform are considered: when designing digital coal mines, when organizing a system for diagnosing equipment and monitoring the safety of a mining enterprise. However, the amount of research on digital platform creation is very limited.

The paper examines the directions of sustainable development of the infrastructure of a mining enterprise, among which it is necessary to highlight the use of digital twins, taking into account the relationship of technological processes with the processes of transport of electrical energy, the development of small generation and the use of renewable energy sources.

Taking into account the identified lines of sustainable development of the infrastructure of a mining enterprise, a structural diagram of a coal mining enterprise was formed with the integration of distributed energy resources and the cloud level of a digital platform (Figure 1). The proposed scheme assumes the use of a digital platform for managing intelligent distributed energy resources "VPlatform" [1].

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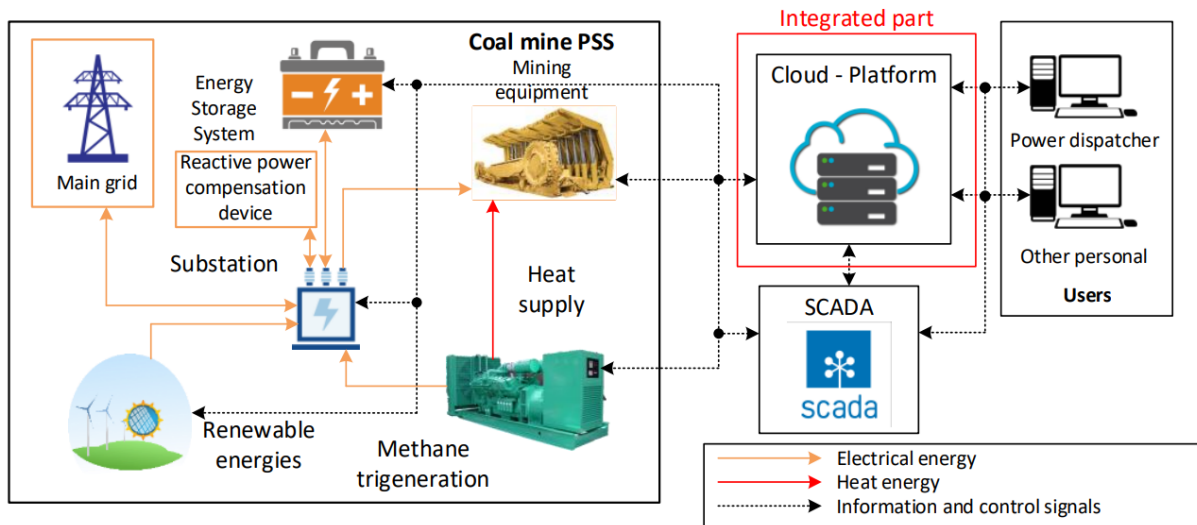


Figure 1. Block diagram of a coal mining enterprise with the integration of distributed energy resources

As a part of the presented structure of a coal mining enterprise with the integration of DER the digital platform can be used in the following business scenarios:

1) Demand response. In this case the platform provides automation of demand response - information exchange, planning and implementation of demand management events, selection of the optimal control algorithm, taking into account the characteristics of the technological process.

2) Commercial dispatching of consumers (EMS). In combination with the SCADA-system, the Platform makes it possible to create an energy consumption management system that ensures the optimal use of power consumers-regulators and active energy resources. The platform provides modules for forecasting the consumption / generation of electricity and modules for optimal management of active energy resources and power consumers.

Along with the aforementioned scenarios specific to the field of application of the digital platform, it can be provided with components that allow the implementation of scenarios associated with the technological process. In particular, it is possible to use the platform to optimize the technological process, coordinate equipment operation modes, and perform predictive equipment diagnostics.

The authors considered the main ways of using digital twins in a mining enterprise. It is noted that to ensure the unity of information support, it is most expedient to use an ontological [2]. It is noted that such an approach makes it possible with minimal costs to make changes to the information support of the platform, which, taking into account the rapid development of mining equipment, makes it possible to reduce the cost of forming an automated process control system (APCS).

The authors proposed a two-level architecture of a coal mine control system, the implementation of which is possible with the introduction of IoT devices. It includes the EDGE object layer and the Cloud / on-premise layer, which implement the corresponding functions. In the future, such control system will make it possible to implement the concept of unmanned mining with the effective use of machine learning methods.

In conclusion, it was noted that it is important to ensure the synergy of the developed platform solutions in the electric power industry and the mining industry in order to reduce the

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total costs of creating digital mining enterprises and step-by-step implementation of the «Industry 4.0» concept.

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A COMPLETELY NEW LOOK AT THE SUITABILITY OF LAND FOR DEVELOPMENT AFTER THE END OF COAL EXPLOITATION

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Keywords: building design, ground deformation, mining damage, post-mining area, reclamation

The paper presents the environmental impact of mining operations in the Upper Silesian Coal Basin (USCB) on the example of two recently closed mines: „Nowy Wirek” in Ruda Śląska and „Makoszowy” in Zabrze. The reasons for the formation of ground deformation caused by underground coal mining were analyzed and their division due to the displacement of rock mass elements was presented.

In addition, it has been shown that even after the cessation of mining activities, there are lowering and deformation of the ground surface and the activation of the influence of the former exploitation of shallow goafs.

Furthermore, the method of determining the category of land suitability for development after the end of coal mining and for future periods was also analyzed. Moreover, guidelines for the development of the post-mining area were also presented.

Based on the analysis of the assessment of the suitability of the areas for development after the end of underground mining operations and the occurrence of further deformations of the area, a new method of straightening buildings in the areas of mining damage was proposed. As well as formulated conclusions regarding the possibility of its use in engineering practice.

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DEVELOPMENT OF DISPLACEMENTS CAUSED BY MINING TREMORS

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Keywords: induced seismicity, terrain deformation, Small BAseline Subset, Rudna mine

Seismic activity is an important aspect of the underground mining of copper ore, which presents the threat of rock bursts in exploited fields. The analysis of seismic activity carried out in recent years in the area of LGOM shows that the Rudna mine is the most seismically active. Over the past 40 years, the frequency of tremors with an energy ≥ 106 J in the Rudna mine has remained at a high level - on average, there were about 73 such seismic events per year. One of the effects of such tremors are terrain deformations, therefore this research focused on determining their size and spatial-temporal development for 2 selected seismic events. For this purpose, the Small BAseline Subset (SBAS) method was used, which enables the detection of surface deformation based on the time series of satellite imagery. This method is an extension of the algorithm of the Differential Interferometric Synthetic Aperture Radar (DInSAR) method used to determine LOS displacements, i.e. in the line of sight of the satellite. In the case of SBAS, interferograms are generated that are characterized by small time intervals and small spatial baselines. Applying this principle reduces the effect of signal decorrelation and increases the number of coherent pixels in terms of time. For the purposes of the study, several dozen Sentinel-1 imagery from paths 73 and 22 for one time periods were used from September 2017 to March 2018. As a result, cumulative LOS displacements for two data sets were obtained. LOS displacement after the two shocks: 10 November 2017 and 26 December 2017 were respectively -18 mm, -75 mm. The analysis focused on the behavior of the surface in the epicenter region in specific time series of data and the prevailing mining conditions and geological and tectonic conditions. The tremors epicenters were located within the mining fields, where tectonic faults also occurred. In general, a significant increase in deformation was noticed immediately after the seismic event. The analysis also showed that the surface was lowered both before and after the shocks. In addition, it has been noticed that the troughs formed by earlier tremors deepen as a result of later seismic events.

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ANALYSIS AND DISTRIBUTION OF NOISE ON THE CONVEYOR BELT

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Keywords: belt conveyor; acoustic camera; noise

One of the most important elements of environmental prevention used by mines is the reduction of industrial noise emissions. In the case of opencast mines, the main source of noise is the routes of belt conveyors. Due to continuous transport, noise emission standards are exceeded primarily at night. The control of noise at the source consists of changing the parameters of the machine, changing the structural elements and equipment and maintenance. This is only possible with good identification of specific noise sources. In the research, an acoustic camera was used to identify the main sources of laboratory noise of a conveyor belt in particular frequency ranges.

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IMPACT OF RELIGION LANDMARKS ON URBAN LANDSCAPE USING VISIBILITY ANALYSIS

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Keywords: religion landmarks, visibility, lidar, urban

The urban landscape, despite its great variety, is usually dominated by buildings. In the case of historic city, most often the historic buildings constitute the unique character of the urban silhouette. The impact of individual buildings on the landscape based on their visibility can be studied using GIS tools. Visibility analyses define the area visible from a given field location, which allows to estimate the observer's field of view. The conducted research was aimed at investigating the relationship and influence of landmarks on Cracow's landscape. The main focus of the study was to verify the visibility of religious landmarks due to the large accumulation of such objects in the central part of the city. Visibility analyses require the creation of a faithful model of the city. Due to the complexity and large area of the analysed area, lidar data were used for this purpose. Based on these data, a DSM was generated in the form of a GRID. Due to the purpose of the study, it was decided to use inverse visibility analysis - landmarks are observers instead of targets. This allows to identify all potential locations from which they can be seen. In this way, it is possible to verify how often they can be seen in the study area, and thus assess what impact they have on the urban landscape.

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DYNAMICS CONTROL OF POWERED HYDRAULIC ROOF SUPPORTS IN THE UNDERGROUND LONGWALL MINING COMPLEX

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Keywords: hydraulics, dynamics, pressure peak, safety

The study presents the dynamic analysis of the hydraulic cylinders operated in the powered roof support sections as an important part of the longwall underground mining complexes. This type of hydraulic units is subjected to frequent shock impacts from the significant rock masses released on the top of mined caverns. Hydraulic props are equipped with safety valves with steel helical springs, which intend to reduce peak loads by the relief of internal pressure. These valves respond to shock with a time delay due to the limited velocity of the pressure wave inside the cylinder and an additional pipe of a small section, which restricts fluid flow in outer space. The new approach represented in this paper is based on mathematical modelling of the interaction of the hydraulic and mechanical parts and using additional signals to control safety valves. Detection of shock in advance (0.02-0.05 s) allows reducing pressure peaks by 30% and avoid failures. The challenges are the development of a "smart valve" with optimised control functions by the signals from additional sensors (vibration, deformation, piston position) and providing fast reaction time with a high flow rate under pressures up to 100 MPa.

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**LITHOLOGICAL, STRUCTURAL AND HYDROTHERMAL ALTERATION
MAPPING UTILIZING REMOTE SENSING DATASETS: A CASE STUDY
AROUND UM SALIM AREA, EGYPT**

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Keywords: Landsat 8 OLI, Earth Observing-1 Advanced Land Imager, Lithological mapping, Hydrothermal alteration

Remote sensing datasets have introduced remarkable advancements in mapping rock units, structural elements, and hydrothermal alteration zones. This study applied Landsat Operational Land Imager (OLI) multispectral dataset in discriminating the intricate basement of Um Salim area, Central Eastern Desert (CED), Egypt. Moreover, a panchromatic 15m pixel size band is implemented to extract the study area's linear structural features. Several image processing methods including False Color Combination (FCC), Band Ratio (BR), Optimum Index Factor (OIF), and Density slicing were utilized in lithological and alteration mapping. The widely used, LINE module of the PCI Geomatica is applied for lineament extraction. Results reasonably discriminate the complicated rock units using selected composites depending on OIF results. A photo-geological map is constructed and shows greater coincidence with recently published maps. Lineaments map and its density revealed the preponderance of NE-SW and WNW-ESE structural trends. The spatial relationship between the resultant hydrothermally-altered zones and the detected structural features strongly recommends further detailed examination for ore deposits within the study area besides manifesting the efficiency of the utilized data and methods.

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ANALYSIS OF THE SOUND SIGNAL TO FAULT DETECTION OF BEARINGS BASED ON VARIATIONAL MODE DECOMPOSITION

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Keywords: Sound, Damage, Bearings

Damage detection in rotating machines is well established for vibration signals. Unfortunately, there are situations, where usage of vibration is not possible. Then, acoustic signal could be used instead. Unfortunately, usually acoustic signal are more noisy and require special treatment for obtain successful damage detection. In the paper we propose to use Variational mode decomposition (VMD) to omit noise for finding de-noise signal. We use vibration data to validate acoustic signal based procedure. The experiment was done on test rig with damaged bearings.

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APPLICATION OF THE SOFT STARTER FOR THE ASYNCHRONOUS MOTOR OF THE BELT CONVEYOR

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Keywords: Belt conveyor, asynchronous motor with a short-circuited rotor, soft starter, pulse-phase control system, speed control system of the conveyor belt

The article considers and justifies the need for a smooth start of the belt conveyor. Based on the technological features of the transportation process, a direct start of the conveyor with a loaded undercarriage entails an increase in inertial forces, overloading of the traction chains and the drive. Due to the increased starting torque, there is a risk of slipping, the occurrence of an oscillatory transition process of the escaping branch of the belt, slipping between the belt and the drive drum. This leads to significant wear of the tape and breakage of other equipment, which requires high repair costs. With a smooth start of the conveyor, the acceleration lasts longer, but the movements of the concentrated masses are more consistent, less oscillatory, which indicates less dynamic forces in the belt. Also, with a smooth start, energy losses in the engine and its heating are reduced. In the future, the results obtained can be used in the development of a system for controlling the speed of the belt movement, depending on the amount of cargo flow entering the conveyor.

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**NON-OBVIOUS GEO-ENGINEERING - CLIMATE IMPROVEMENT
THROUGH ENVIRONMENTAL EDUCATION OF THE YOUNG
GENERATION**

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Keywords: geo-engineering, environmental protection, environmental education, education, school gardens

The nineteenth century brought many benefits to mankind. Technological development and new directions in the industry are the beginning of the path leading to the analysis and creation of new solutions in the field of environmental protection. Geoengineering poses a question about the legitimacy and ethics of innovative solutions. Caring for the environment should be a key factor and a habit that becomes ingrained in the preschool / school period. This is a key path to improving the climate and stopping human damage. The school garden and its values teach ecology and the basics of caring for the environment, which should become the principal foundation for cooperation with nature.

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FOODSHIFT2030 - REDUCTION OF GREENHOUSE GAS EMISSIONS ON THE EXAMPLE OF A LOW-CARBON CIRCULAR ECONOMY MODEL

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Keywords: foodshift2030, school garden, environmental protection, greenhouse gas emissions, low-carbon economy

The advantages of environmental education are getting noticed and appreciated by the society. Thanks to the increasing awareness of the environmental damage caused by human activity, urban agriculture is maintaining a good streak by attempting to regenerate the planet. The European project FoodShift2030, created by a consortium of nine European cities, has responded to the social and nutritional needs of their inhabitants, further supporting a low-carbon, circular and local economy. The developed solutions are designed to promote environmental protection and support education of residents - including activities aimed at reducing greenhouse gas emissions to the atmosphere in Europe. Each of the laboratories, including the one in Wrocław, tests innovative solutions, sharing experience and research results with other Accelerator Labs. On the example of school vegetable gardens in Wrocław, one can observe the involvement of the academic community in educational activities that increase environmental awareness. The presented examples of developed school areas are an element of supporting the slow-food movement and the idea of climatarianism, promoting the selection of local products and reducing their carbon footprint. Innovative methods of environmental protection and implemented activities result in a positive reception by the society, which becomes an active participant of the project. The benefits of the program will be analyzed and assessed using the prepared indicators.

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ENERGY EFFICIENCY OF BELT CONVEYORS IN OPEN PIT MINE ANALYSIS BASED ON REAL DATA SET

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Keywords: belt conveyor, energy efficiency, specific energy consumption, open pit mine

Belt conveyors are widely used for bulk material transportation because of their durability, reliability, and efficiency. Although they are considered to be more environmentally friendly than trucks, they are still significant consumers of electric energy in mines. Taking into account Sustainable Development Goals and Energy Policy requirements, energy-efficiency of belt conveyor (BC) transportation systems is of great importance and needs to be improved.

Therefore, this research investigates real data obtained from the mining company in order to specify directions for energy-efficient transportation system improvements. The main aim of the work is to analyze electric energy consumption (EEC) and specific energy consumption (SEC) values for selected belt conveyors working within the mine transportation system. Performed preliminary analysis and recognition of existing relationships between variables (EEC~Capacity and SEC~Capacity) in analyzed data set reveal that elimination of some parameters such as conveyor inclination angle is crucial for proper results interpretation.

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**DYNAMICS OF GLASS WINDOWS IN MINING VEHICLES UNDER THE
IMPACTS OF ROCK PIECES: NUMERICAL AND ANALYTICAL
COMPARISON FOR COMPUTATIONAL MODELS VALIDATION**

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Keywords: underground machines, safety, glass, FEM, impact loading

This study represents the results of linear dynamics analysis of glass plates subjected to rock pieces impacts occurring in underground machines' windows. The aim of the work is to provide analytical and numerical solutions, obtain frequencies and plate displacement, and compare results of stress calculation for different models. The work performs finite element method (FEM) computations within a modal analysis in 3D statement including a mesh-size convergence analysis. Given approach is a basement for estimation of safety work conditions for operators in cabins of underground mining vehicles when glass windows are subjected to rock bursts and damages.

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LIDAR-BASED SIMULTANEOUS LOCALIZATION AND MAPPING IN AN UNDERGROUND MINE IN ZŁOTY STOK, POLAND

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Keywords: simultaneous localization and mapping, mobile robot, laser scanning, point cloud

The mining sector is one of the most promising areas for implementing advanced autonomous robots. The benefits of increased safety, robot actions' repeatability, and reducing human presence in hazardous locations are especially important in underground mines. One of the core functionalities of such a device is the robot's ability to localize and navigate itself in the working environment. To achieve this, simultaneous localization and mapping (SLAM) techniques are used. In selected cases, they also allow the acquisition of dense spatial data in the form of 3D point clouds, which can be utilized for various 3D modeling and spatial analysis purposes. In this work, a mobile robot, equipped only with a compact laser scanner, is used to acquire spatial data in the adit of a closed mine in Złoty Stok, Poland. This data is further processed with selected SLAM algorithms to create a homogeneous 3D point cloud. Results are visualized and compared to a model obtained with a survey-grade laser scanner. Accuracy evaluation shows that employing SLAM algorithms to process data collected by a mobile robot can produce a reasonably accurate 3D geometrical model of an underground tunnel, even without incorporating any additional sensors.

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**SELF-HEALING OF ASPHALT MIXTURE: THE IMPACT OF THE
MINERALS FORMING THE AGGREGATES IN THE EFFICIENCY OF THE
HEATING BY MICROWAVES**

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Keywords: Self-healing, Microwaves, Roads, Aggregates, Minerals

The current concern for the environment and the need to reduce greenhouse gas emissions has led to the development of new technologies related to microwave energy. One of these technologies is the self-healing of asphalt mixtures, which consists of repairing pavements through microwave application on the surface, avoiding premature failure of the road. Asphalt mixtures for roads are made up of more than 90% by weight of aggregates of different compositions and origins. From other studies, it is known that the physical behaviour of aggregates is a function of their composition, that is, of their minerals and their proportions. Microwave heating of aggregates has proven to be an effective technique, but there are gaps in understanding how microwaves interact with aggregates and the reasons for their differential heating.

This research has studied 18 minerals that are commonly part of the rocks used as road aggregates to identify the minerals that present higher heating rates and thus find the causes for the differential heating of the aggregates. The results are promising, facilitating the understanding of microwave heating of minerals. Regarding chemical composition, elements such as MgO, MnO, TiO, Al₂O₃, Fe₂O₃, and CaO (in silicate minerals) favour the heating of minerals and other elements such as SiO₂ and K₂O Na₂O, and CaO (in carbonate minerals) retard the heating. Regarding the physical properties, density and habit of the minerals do not influence the heating, but other properties, such as the diaphaneity and the size of the crystals, influence the heating with microwaves.

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IMPROVEMENT OF TECHNOLOGICAL APPROACHES TO THE ELIMINATION OF SINKHOLES OVER MINE WORKINGS: A COMBINED METHOD

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Keywords: sinkhole, combined technology, mine working, elimination

Analysis of projects for the elimination of emergency workings showed that most accidents associated with damage to the earth's surface are caused by critical values of mountain pressure in empty spaces, a decrease in the bearing capacity of supports or their absence, as well as the loss of stability of support structures. Rapid removal of the formed sinkholes does not always provide positive results, since often the material for filling them is burnt rock without studying the properties of the earth's surface, where it is laid. This circumstance leads to the fact that the sinkholes are re-activated, especially when flooding. In this regard, the justification of the parameters of the method of eliminating sinkholes is an urgent scientific and practical task. The problem of the stability of the eliminated mine workings, and consequently, the geomechanical and environmental safety in the places where they are laid, can only be solved using a systematic approach, which involves solving a set of issues to minimize the impact of each factor of the formation of sinkholes both in space and in time. This article describes the approaches to determining the technological parameters of the combined method of eliminating the sinkholes of mine workings, applied taking into account the geological characteristics of rocks and the mining and technical conditions of their location, the use of which will provide a reasonable calculation of the complex of engineering indicators for guaranteed removal.

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Keywords: risk-based approach, explosion, safety management, industrial safety

The problem of studying the occupational risks of the negative impact of hazardous and harmful production factors on personnel as a result of accidents at coal mining enterprises is the area of joint functioning of the occupational health and safety management system and the industrial safety management system. In order to meet the requirements for the analysis and forecasting of occupational injury risks in methane and dust explosions under conditions of uncertainty of the initial data, there is a need for a methodological approach based on the modeling of fuzzy logical inference with a hierarchical structure. The use of retrospective analysis does not make it possible to take into account dangerous factors that are not detected by the accumulated experience, which is of great importance for the safety of working conditions created in a dynamic and subject to a set of specific factors in the production environment. This disadvantage can be eliminated by the principles of a priori analysis, which takes into account the potential risks for this system and the factors of their occurrence. Its implementation consists in conducting a systematic analysis of threats, assessing and predicting their occurrence in the context of a risk-based approach. This article describes a methodology that will ensure the implementation of the requirements in the field of complex analysis and forecasting of occupational injury risk in methane and dust explosions with the detection of dangerous situations and areas, as well as take into account the results of complex analysis and forecasting.

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THE INFLUENCE OF DIFFERENT FLY ASH-CEMENT REPLACEMENT RATIOS ON THE PRESSURE DROP OF A HORIZONTAL BACKFILLING PIPE

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Keywords: Fly-ash, Cement, Replacement ratio, Pressure drop

Fly ash (FA) is a kind of harmful by-product in thermal power generation plants, and finding a way to enhance the utility of fly ash has been widely discussed among civil engineering and mining sectors. To investigate the possible optimal ratios of replacing usually used bind agent namely Portland cement (PC) with fly ash, this paper designed different test groups with varying PC-FA replacement ratio (PCFARR). To identify the physical and chemical characteristics of mixing materials used to produce the backfilling slurries, a rheological experiment and X-ray diffraction test have been conducted. Rheological tests show all these three replacement ratio groups (60 %, 65 %, 70 % respectively) are yield pseudoplastic fluid. Computational fluid dynamics as an efficient and money-saving method also has been introduced in the present research to duplicate the flow behaviors and calculate the pressure drop (PD) in the backfilling pipe circuits. The simulation results tell that all these three RR categories experience an increasing tendency in pressure drop with increasing flow velocity, but in the velocity range of 2 m/s – 2.4 m/s, the increasing tendency is gentle until flow velocity reaches 2.6 m/s, the PD increase evidently. Furthermore, when the RR = 65 %, the pressure drop is significantly lower than that of RR = 60 % or RR = 70 % at all the corresponding investigated flow Particle sizes have significant impact on the pressure drop across a pipe and is dependent on solid fraction and flow rate. velocities. Therefore, we can conclude that a proper dosage of FA in mixing backfilling slurries can reduce pressure drop obviously and thereby decrease the expenses in bind agent. Given the FA's significant effect on pressure drop, and comprehensive considering the backfilling capacity and backfilling cost, the combination of RR = 65 % and velocity = 2.6 m/s is optimum.

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**FAULT-RELATED IMPULSIVE COMPONENT DETECTION FOR
VIBRATION-BASED DIAGNOSTICS IN THE PRESENCE OF RANDOM
IMPULSIVE NOISE**

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Keywords: vibration signal, nonnegative matrix factorization, cyclic spectral coherence, fault detection, decomposition

In this paper, the authors propose the methodology for vibration-based diagnostics towards local damage detection in rolling element bearings in the presence of non-Gaussian noise. In real-life cases, the main obstacle lies in the non-Gaussianity of the high-energy noise present in the operational environment. Hence popular impulsiveness-related techniques cannot be used. In the presented article, a real-life industrial scenario will be presented and a proposition of an approach to cyclic component extraction will be discussed. The proposed approach takes advantage of the Cyclic Spectral Coherence (CSC) map as multidimensional data representation. However, due to the limitations of statistics used in CSC map calculation impacting the quality of CSC map in the presence of non-cyclic impulsive behavior in the signal, Nonnegative Matrix Factorization idea is used as a method for component separation. The presented method allows for obtaining carrier-related and modulation-related features of the component of interest. As a consequence, the time series of the component can also be reconstructed based on the carrier feature.

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HEAT BALANCE DETERMINATION METHODS FOR MINING AREAS IN UNDERGROUND MINES - A REVIEW

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Keywords: underground mining, mine ventilation, heat balance, thermal hazard

Mine operation in presence of aerological hazards is a challenging issue for mine ventilation services. Increasing depth of exploitation and growing level of mechanization, due to the demand for intensification of extraction, makes it even more difficult regarding thermal hazard. As air temperature is a decisive factor shaping underground thermal working conditions it is extremely important to predict its value. This task determines the possibility of carrying out works in regions with the highest thermal hazard, where, due to the applicable regulations, it is necessary to use air conditioning to ensure appropriate working conditions for people. To determine the required cooling capacity for mining regions, it is crucial to identify the individual heat sources, as well as to define the amount of heat they generate. For this purpose, heat balances need to be set, taking into account the mentioned issues. The main goal of this paper is a presentation of methods available in the literature for determining the thermal balances of mining areas. The article also presents and characterizes the most important heat sources in underground mines. In addition, methods of determining heat fluxes from individual sources were indicated, as well as potential difficulties in the applicability of the above-mentioned methods for mining areas heat balances determination, in which, due to the current depth of exploitation, the thermal hazard is the most important natural hazard that determines the possibility of mining works.

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DRILL BIT STATE-ORIENTED DRILLING PROCESS CLASSIFICATION WITH TIME-SERIES DATA FOR WHEELED DRILLING RIGS

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Keywords: underground drilling, classification, threshold-based segmentation, dendrogram

This paper represents an analysis of the wheeled drilling rig's drilling process. Thanks to data from the onboard measurement unit of the machine, the characteristics of the drilling process regarding state of the drill bit are identified and calculated. The aim of the work is to provide a comparison between different drill qualities and process classification using Threshold-based segmentation with feed pressure levels and duration of single hole drilling. Second methodology is hierarchical clustering to create cluster analysis. Thanks to the seapproaches, it is possible to detect the time when the drill bit should be changed. The obtained results state that the average drill time for a new drill bit is shorter approximately by 50% than for the worn-out bit in terms of average drilling duration. Moreover, these changes are visible in the subsystem pressure level of the machine under specific drilling regimes.

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ANALYSIS OF THE VIBRO-ACOUSTIC DATA FROM TEST RIG - COMPARISON OF ACOUSTIC AND VIBRATIONAL METHODS

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Keywords: acoustic signal processing; vibration; rotating machines; UAV; amplitude demodulation

Detection of damage is a significant issue in providing efficiency and safety in industrial processes. In underground mining much research effort is made for developing an automatic system of diagnosing the machinery using robots. One of the major groups of equipment utilized and maintained in the mines is rotating machinery. Local damage occurring in such machines commonly have a cyclostationary character as any change in their characteristics is expected to repeat periodically. In most cases they can be easily detected based on vibration signals measured with contact sensors (accelerometers). However if mobile robots such as UAV (unmanned aerial vehicles) are supposed to be used, remote measurement is firmly preferred. In this paper we compare vibrational detection with a novel approach based on analysing an acoustic signal recorded by a microphone.

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**DETECTION OF A PREDEFINED ACOUSTIC PATTERN BY A
MEASUREMENT SYSTEM ON A DRONE AND ITS APPLICATION TO
SEARCH FOR A MISSING MAN IN AN UNDERGROUND MINE**

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Keywords: UAV; acoustic signal processing; time-frequency analysis; search and rescue; novelty detection

Due to the very difficult working conditions and a certain number of hazards that do not occur in other industries, the operation of rescue units in underground mines is necessary. The area of exploitation is usually very large, thus determining the location of a person, which may be in need due to the accident, is not an easy task. As the time for reaching such a person is crucial, there is a strong need for a solution that would provide a quick establishment of the victims' location. Moreover, conducting a rescue mission is always associated with risk exposure for rescuers' life and health. Thus, in this paper, we propose a solution based on an unmanned aerial vehicle (UAV) for a predefined acoustic pattern detection to support rescue units in human location assessment in the underground mine. The presented method is based on measuring the dissimilarity between the subsequent short-time power spectra and the referential spectrum characterizing the UAV's ego-noise. This relatively general and data-driven approach is applied both to generated narrow-band harmonic impulses and to the human voice. As the analyzed signals of interest are of specific frequency content they can be selected from the background noise with the use of band-pass filtering.

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