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SIMPLIFIED MODEL WITH A SINGLE DISCONTINUITY OF THE BEARING CAPACITY ON ANISOTROPIC ROCK MASSES

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Keywords: DLO method; bearing capacity; foundations; Hoek and Brown failure criterion; anisotropic rock.

The most widely used failure criterion in rock mechanics is the Modified Hoek and Brown nonlinear criterion [Hoek, 1997]. However, its use in applications is limited to a set of hypotheses, among them the homogeneous and isotropic medium. Therefore, in the case of media with a marked family of anisotropy, as is typical for example in metamorphic rock masses such as slates or schists, the application of the failure criterion requires the modeling of the discontinuities in the calculation model.

These rock masses typically have a large number of discontinuities making the numerical analysis difficult and, in most cases, unapproachable.

In this research, to calculate the ultimate bearing capacity of foundations on anisotropic rock masses (Figure 1) a single discontinuity simplified procedure is proposed maintaining the accuracy of the full model. Numerical models using the proposed procedure can represent the different possible failure mechanisms that may occur in the rock mass. Besides, the ultimate bearing capacity of a particular case is checked against the available analytical solution [Serrano, 2016].

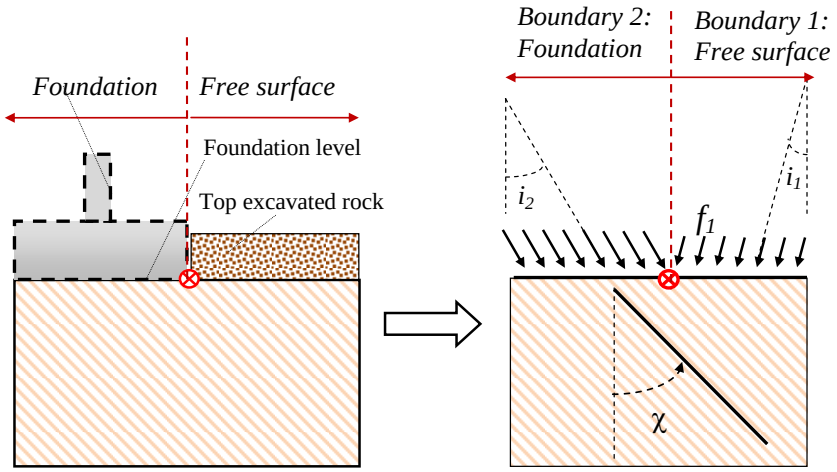

Fig. 1. Calculation model of a shallow foundation on anisotropic rock mass

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The problem represented in Fig. 1 is assessed, showing a shallow foundation on a rock mass including the presence of a family of planes of weakness with measured inclination from the vertical axis "χ". The rock media shows a clear anisotropic behavior that follows the Hoek & Brown failure criteria [Hoek, 1997] with associative flow rule (with geomechanical parameters: m_0, GSI, σ_c), except for the planes of weakness where a Mohr-Coulomb criterion is considered (with geomechanical parameters c, φ).

In general, the four different failure modes (Isotropic Mechanism: MI; Boundary 2 Mechanism: M2; Boundary 1 Mechanism: M1; Complex Mechanism: MC) of the problem of the bearing capacity of a foundation on anisotropic media can be correctly addressed using a single discontinuity located conveniently. In the Figure 2 it is shown schematically how the failure for each of these mechanisms is conditioned by a single discontinuity of the family in a specific position within the medium.

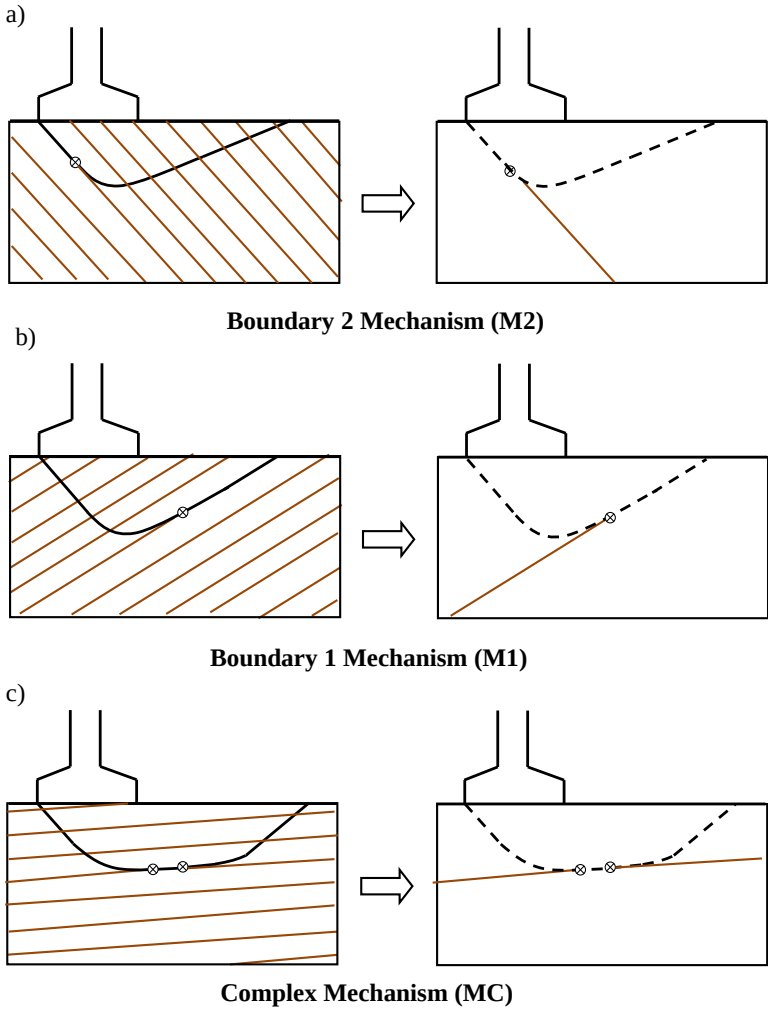

Fig. 2. a) Simulation of the bearing capacity problem on anisotropic media with failure mechanism M2; b) Simulation of the bearing capacity problem on anisotropic media with failure mechanism M1; c) Simulation of the bearing capacity problem on anisotropic media with failure mechanism MC.

To prove the hypothesis of the simplified model the bearing capacity of a shallow foundation on anisotropic media is calculated using a DLO numerical model [Smith, 2007; LimitState, 2019] with a single discontinuity (Figure 3) and checking the results against the well-known analytical solution [Serrano, 2016] (Figure 4).

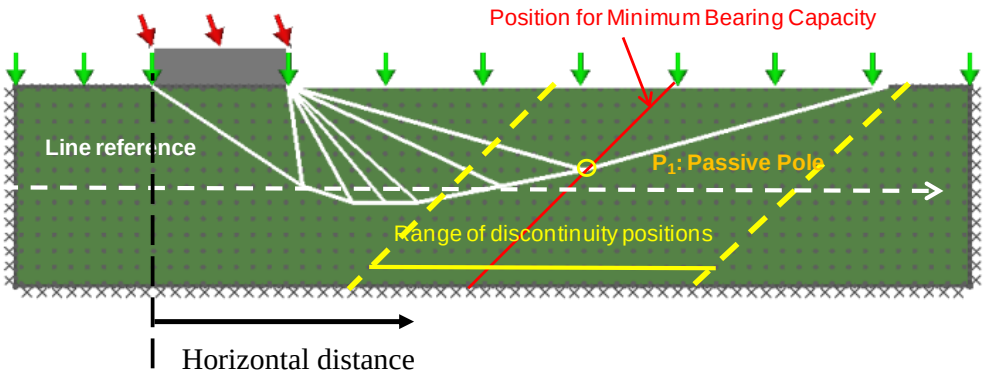

Fig. 3. Analysis of the position of the discontinuity of inclination χ=120º that produces the minimum bearing capacity in the DLO anisotropic model obtained under a load of 20º of inclination on the foundation and a load of 52 kN/m^2 on the free surface with a rock mass of properties $\sigma_c = 20\ MPa;\ GSI = 65; m_0 = 14$, and a horizontal discontinuity with a friction angle of 30º: Position for the discontinuity of minimum capacity

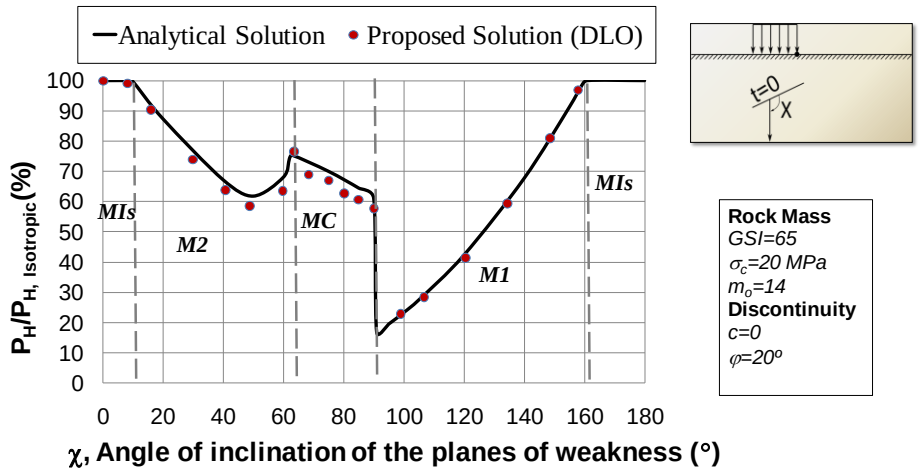

Fig. 4. Comparison of the bearing capacity of anisotropic masses (P_h) between the analytical solution [Serrano, 2016] and the proposed simplified DLO solution: Case of study: Vertical load on the foundation, free surface without load, a rock mass of properties $\sigma_c = 20\ MPa;\ GSI = 65; m_0 = 14$, and a discontinuity with a friction angle of 20º and no cohesion.

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JUSTIFICATION OF THE PARAMETERS OF THE SUMP IN THE MACHINE CHANNEL

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Keywords: Hydroabrasive erosion, Amudarya, Amu-Bukhara channel, pumping station, turbidity

As a result of studies conducted in 2017-2020, the erosion and erosion of the banks of the Amudarya, which occur as a result of rapid and uneven changes in its channel, requires large expenditures for bringing water to the Amu-Bukhara channel with a damless water intake. An analysis of the data from pumping stations shows that the uninterrupted movement of water in the system water intake-distribution-canal-sediment retention system-system-fore-chamber-suction pipes-pumping unit-pressure pipes-consumer largely depends on the reliable operation of the structures that make up the system. As a result of the rise of water with a high content of turbidity, hydroabrasive erosion of pumping units occurs, and their service life is reduced. The article discusses the installation of settling tanks in the water supply channel to the pumping station to reduce the amount of turbidity in the water, it is determined that in order to take the effective value of the number, the sweep angle k has a boundary condition $a_{p.s.} = 180^{\circ}$ bottom of the zone behind the traverse dam. The angle at the outlet of the sump is determined $a_{p.s.} = 180^{\circ}$ and corners $a_{p.s.} \leq 44^{\circ}$ on the compression zone of the dams on the concreted part at the entrance to the fore chamber of the pumping station. Sumps built on these parameters provide a reduction in water turbidity.

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HFSE BEARING MINERALS IN THE METASOMATISED ROCK BODIES OF BÜKK MTS., NE HUNGARY

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Keywords: HFSE, metasomatism, alteration

A formerly unknown high field strength element (HFSE) mineralization was found in the Bükk Mts., NE Hungary recently. The enriched elements are the rare earth elements (REE), Zr, Nb, Ta and Th. These elements are usually immobile during metamorphism and weathering, but deposits can be developed due to hydrothermal mobilization from carbonatite and alkali magmatic bodies (fenitisation). Most of the enriched elements belong to the group of critical raw materials in the European Union. The enrichment factor for REEs is 5-10, for Zr 2-20, for Nb 12-16, compared to the upper crust. Usually, the rock bodies are LREE dominant, but the most enriched rock bodies could have significant HREE content in an increased ratio. The enriched rock bodies are Triassic metavolcanics and siliciclastic metasedimentary rocks from the SE and NE part of the Mts., next to major fault zones. The rocks were subject of low grade dynamothermal metamorphism during the Cretaceous.

In the Bükk Mts. the enrichment is carried by various minerals, such as REE-phosphates, - oxides, -carbonates, zircon, and Nb-bearing Ti-oxide minerals (probably rutile). These minerals are always small, maximum a few tens of μms, so they are detectable only with electron microprobe analyses. We have made backscattered electron (BSE) images, furthermore energy dispersive X-ray spectroscopy (EDX) analyses about the chemical composition of the individual mineral grains, although because of the small grain size the results are not necessarily accurate. The HFSE-bearing minerals usually occur in nests, veinlets, replace earlier grains or presents as disseminations. Most often they are associated with phengitic micas or potassic feldspars, sometimes with Fe-oxide minerals. The various HFSE-minerals often occur together (e.g., niobian Ti-oxide + zircon, monazite + zircon).

Although the minerals described above occur in similar textural position in each rock bodies, their relative abundancies vary from body to body. Furthermore, some chemical diversity is detectable with EDX, which is partly due to minerals with different origin (for example differences between the chemical composition of metasomatic and detrital monazite). The different abundances of the HFSE-minerals are probably due to the given protolith material, as well as the changing fluid composition. The existence of precursor minerals promotes the genesis of some new HFSE minerals, like apatite in case of REE-phosphates, or Ti-oxides in case of niobian rutile. During the alteration processes these precursor grains are decomposed and/or altered, causing depletion of P and Ti in the bulk composition of the host rock. In the case of these two minerals coupled dissolution – reprecipitation processes resulted new generation of fine-grained fluorapatite and submicrometric Ti-oxide minerals associated with zircon in anastomosing veinlets.

Based on the textural features described above, the HFSE-minerals are undoubtedly the products of metasomatic processes. The fluids migrated across carbonate rocks without any reaction until they reached the sampled rock bodies and caused enrichment. The range of this transport was at least some

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hundreds of meters. Although metasomatic HFSE-enrichments are usually connected to carbonatites and alkali magmatic bodies, in the Bükk Ms. no possible source body is known.

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AVL GAS PEMS GAS ANALYZER AS A METHOD OF MEASUREMENT IN AN UNDERGROUND MINE

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Keywords: Nitrogen Oxides, Mine Ventilation, Underground Mine

Today, the exploitation of minerals in underground mines is becoming harder. Underground mines face many natural hazards. One of the most dangerous hazards is the gas hazard. To ensure the safe work of underground personnel in gas-hazardous conditions, it is important to monitor and analyze the concentrations continuously. One of the most toxic gases is nitrogen oxides (NOx), which are produced in underground mines mainly due to mining technology. The article presents the measurement of nitric oxide and nitrogen dioxide concentrations using the AVL Gas PEMS gas analyzer. The measurements were carried out in one of Poland's ore mines. The results were analyzed according to the mine's technology cycle.

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THE MAIN REASONS FOR THE DECLINE IN PERFORMANCE AND CHARACTERISTICS OF PUMPING UNITS OF IRRIGATION PUMPING STATIONS

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Keywords: HPP, channel roughness, Reynolds number, relative roughness, hydraulic radius.

One of the ways to improve the efficiency of pumping stations (PS) is to improve the performance of pumping units used, which leads to a reduction in the cost of water supplied by them. Functional violations of the performance of pumps depend on objective and subjective factors. The operating experience of pumping stations has shown that many of them operate with a flow significantly lower than the design ones. The main reasons for this are the unsatisfactory hydraulic regime of the water supply machine channels and structures of the PS and the wear of the elements of the flow path of pumping units. The technical and economic consequences of pump wear as a result of cavitation-abrasive effects are manifested in a complex way. Firstly, the energy performance of the pump deteriorates and the associated power consumption increases, and secondly, it is necessary to periodically carry out repair work to eliminate the effects of wear. Thirdly, the productivity of agricultural crops is reduced due to a decrease in the water supply of pumps. The conducted studies have established that the excess consumption of electricity caused by a decrease in the efficiency of pumps can be estimated within 6-7% of the total amount of electricity consumed by pumping units. The problem of maintaining a high efficiency of pumping equipment is extremely relevant and important.

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IMPACT OF NATURAL HAZARDS ON THE OPERATION OF POWERED ROOF SUPPORT

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Keywords: coal mining, natural hazards, powered roof support, work safety

The powered roof support is mainly used in natural hazard conditions. Natural hazards in Polish mining include methane hazards, gas and rock ejections, coal dust explosions, climate hazards, water hazards, landslides, eruptions, hydrogen sulfide hazards, radioactive substances hazards and rock mass tremors. The latter has a significant impact on the operation of powered roof support. The work analyses rock mass tremor risks in the last ten years. The study showed an intense increase in this hazard, which significantly affects the work safety of people operating machines and devices in mining excavations. The paper takes into consideration surveys carried out among employees working in conditions of rock mass shock risk. The purpose of the study was to obtain information on the safe operation of powered roof supports. The data allowed us to draw conclusions regarding the possibility of increasing work safety regarding rock mass shock risk conditions.

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MEASUREMENT OF SIZE DISTRIBUTION OF BLASTED ROCK USING DIGITAL IMAGE PROCESSING AND UAV

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Keywords: blasting, MWD, grain-size distribution, machine vision

Well-designed blasting operations reduce the cost of the explosive, resource consumption, loading and crushing [Onederra, et. al., 2015]. Assessment of the grain-size distribution of rock material is an important parameter for assessing the quality of blasting works carried out [Czopek, 2005]. The standard assessment of the grain distribution is based on manual laboratory tests.

One of the quick methods of assessing the size of rock grains with the use of vision algorithms is presented. Measurements were made using a UAV with an installed camera. The algorithm is based on two sections. The first section is a neural network that detects the presence of rock grains in the images. The second section is the processing module responsible for separating the size of the rock grains. The effectiveness of the algorithm was tested in the field conditions of one of the granite mines. First, the image is thresholded - transformation to the black and white scale [Kittler, et. al., 1985]. The threshold is selected automatically based on the RGB scale of the image. In the next step, the image is repaired in order to clearly distinguish the boundaries and edges of the grains. The dilated and eroded function is used [Liang, et. al., 1989]. The image is masked to perform segmentation. The final step is calibration. Designated clusters (grains) receive actual dimensions based on an object with known geometry.

The obtained results were compared with the laboratory results. The vision algorithm turned out to be an effective and fast tool for the assessment of grain composition.

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MODELLING THE IMPACT OF FORMER MINING ACTIVITIES IN COMPLEX GEOLOGICAL CONDITIONS ON THE VEGETATION STATE: A CASE STUDY OF THE CLOSED LIGNITE BABINA MINE (POLAND)

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Keywords: NDVI index, spatial statistics, post-mining area, glacitectonic area, GWR model

The lignite mine "Friendship of Nations - Babina Shaft" ("Babina" in short) was closed in 1973 as a result of unfavourable geological and mining conditions. The area degraded during the exploitation of the raw material covered 479 ha. Despite the reclamation works carried out, the negative effects of the mineral extraction are still noticeable there (e.g. sinkholes, land subsidence and uplift, erosion of exposed dumps). In addition to the elements of the post-mining landscape, the area of the closed Babina mine is also characterized by a complicated glacitectonic structure, which is the result of successive glacial periods in the past. Both the former mining activities and the geological conditions of the area may have a significant influence on the vegetation state. The purpose of this study was to determine whether, and to what extent, the above-mentioned factors had an impact on the changes in the flora condition of the former mining field, identified in 1989-2019 period. The analysis of the relationship between former mining activities, complex glacitectonic structure and changes in the vegetation state was carried out using the multivariate spatial regression approach with the GWR method and the Normalized Difference Vegetation Index (NDVI). The dependent variable in the model, presenting the range of changes in the index value in 30 years, was determined using the cell spatial statistics. Archival geodetic and cartographic materials, as well as results of geological studies were utilised for the construction of 9 potential explanatory variables. The developed model confirmed that the former mining and complex geological structure had a significant impact on the identified changes in the NDVI index values in the period of 1989-2019. The value of the determination coefficient R^2 for the developed model was equal to 0.62. Moreover, the conducted analyses presented that the most strongly influencing factors on the flora state of the former mining field were: the difference in the absolute height of the area in the period before and after exploitation, the current terrain height, as well as the distance from the open-cast mining areas. Therefore, the obtained results indicate the need for cyclical monitoring of post-mining areas in order to identify places of vegetation degradation, as well as to reduce environment damage. In addition, the research is the basis for further studies, the subject of which should be the impact of the former mining activities and the geological structure of the area on the parameters of the flora, such as: water content, organic carbon concentration or the efficiency of light using in the photosynthesis process.

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THE NORTHERN CHINA M6.6 EARTHQUAKE SOURCE INVERSION FOR A FINITE RECTANGULAR FAULT PLANE FROM INSAR DATA

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Keywords: InSAR, seismic event, geophysical inversion, coseismic deformation

The study of the mechanism of a seismic phenomenon, both natural and induced, requires observation of cracks after their occurrence. Due to the fact that the process takes place at great depth, it is not possible to directly observe the process of rupturing the earth's crust - information about seismic phenomena comes from studies on the earth's surface or in the shallow subsurface layer. For this reason, to accurately model the source of the tremor and its impact on the surface, it is necessary to obtain additional data describing this process, such as SAR data.

The research used the inversion theory to infer about the parameters of the source of the seismic shock occurred on January 7, 2022 M6.6 in north-central China as a result of strike-slip faulting at shallow depth, based on the indirect measurements mentioned above. The earthquake occurred on either an east-west striking left-lateral fault, or a north-south striking right-lateral fault [U.S. Geological Survey, 2022] and was related to a slip in a finite size fault zone, not a point source. Both the magnitude of the slip fault and the size of the area are related to the size of the event and could be modeled using finite fault inversion, which is based on the recorded shock waveform used to reconstruct the slip history.

To determine surface displacements, Sentinel-1A synthetic aperture radar (SAR) data from two paths - ascending (128) (for January 5 and 17, 2022) and descending (33) (for December 29, 2021 and January 10, 2022) was obtained. Open source software GMTSAR [Sandwell et al., 2011] was used to generate differential interferograms using the Differential Interferometric Synthetic Aperture Radar (DInSAR) method. The earthquake has been characterized by timing (date, centroid time, assumed duration), location (depth, longitude, latitude) and mechanism (magnitude, scalar moment, moment tensor, fault plane – strike, dip, rake, assumed duration) information obtained from Global CMT (Centroid Moment Tensor) Catalog. After processing the data, determining the search parameters and iteration software Grond [Heimann et al., 2018] was used to estimated depth, north and east shift, width and length, strike, dip, rake, slip (slip plane parameters) visualized as Probability Density Functions (PDF).

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A METHODOLOGY FOR DETERMINING THE MAJOR ANIONS CONTENT OF THE GROUNDWATERS CLASSIFIED AS MINERALS

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Keywords: groundwater, medicinal water, anions, titration

This paper discusses the issues concerning groundwaters, which are classified as medicinal waters, and reviews selected titration methods to determine the range of concentrations of the main anions that occur in these waters. The described methods are used to develop internal procedures for the needs of the Laboratory of Earth Science and Mineral Engineering. The research has shown that selected methods are effective for both therapeutic waters with various mineralization as well as with diverse composition of dissolved dissociated components. The author conducted research on bottled waters of three Polish spa resorts and medicinal or potentially medicinal water samples collected from the Sudety mountains according to the standards of PN-EN ISO 5667-3. The author emphasizes the need to select proper research methods and precision in carrying out the research procedures

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TREATMENT EFFICIENCY IN FULL-SCALE WWTP OPERATED IN AEROBIC GRANULAR SLUDGE TECHNOLOGY

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Keywords: granular sludge, wastewater treatment, full-scale

The aim of the research was to evaluate the effect of seasonal temperature changes on the effectiveness of wastewater treatment in municipal wastewater treatment modernized to aerobic granular sludge technology. Wastewater and biomass samples were taken from two identically operated batch reactors with aerobic granules. It was observed that the efficiency of wastewater treatment increased with temperature - the lowest concentrations of organics, nitrogen compounds and phosphorus compounds in the outflow were recorded in the summer period. The concentration of biomass in both tested reactors changed during the year, and the lowest concentrations were recorded in the period of low temperatures (about 2600 mg MLSS/L). The best settling properties of aerobic granular sludge were observed in summer – sludge volumetric index was about 50 mL/g MLSS. To conclude, the seasonal temperature changes strongly affect biomass properties and effluent quality in aerobic granular sludge wastewater treatment plant.

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GRAIN SEGMENTATION IN SANDSTONE THIN-SECTION BASED ON COMPUTER ANALYSIS OF MICROSCOPIC IMAGES

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Keywords: image analysis; petrography; minerals; sandstone; mineral segmentation

Segmentation of minerals in sandstone thin-sections is an important part of microscopic quantification of mineral composition, commonly used in petrographic study. This process is often a hard task due to the difficulty in determining the exact boundaries between grains, mainly caused by secondary alteration in minerals, etching of grain edges by cement as well as the quality of the microscopic preparation. Structural features play a very important role in mineral identification and undoubtedly without their use mineral recognition in thin sections gives many misclassification results. Calculation of each grain area is an important part of the process that is very time-consuming if done by- hand. Presented method provides a precise solution while mixing automated and non-automated approach. Photos of a sandstone thin section were taken using a Nikon Eclipse LV100N POL polarizing microscope, at 200x magnification, in transmitted light, with crossed polarizers. Then, in order to determine the borders and therefore area of distinct grains, a sample image has been chosen. Initial contours have been created by-hand inside graphic application on tablet device, as the non-automated part of the presented method. Afterwards the layer with marked boundaries was analyzed by computer software. In the automated part of the method, marked contours were detected inside algorithm with areas calculated afterwards.

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ROTATION SPEED ASSESSMENT FOR IDLERS IN BELT CONVEYORS USING IMAGE ANALYSIS

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Keywords: image analysis; signal processing; belt conveyor; rotation speed; remote sensing

Monitoring and diagnostics of elements of a belt conveyor is a challenging task. One of the hardest aspects is dealing with objects such as rolling idlers that support the belt. They are distributed along the entire length of a conveyor, and their amount can easily reach thousands. In ideal case, every idler should undergo in-situ monitoring, however this is impractical. Hence, it is proposed to use remote sensing to acquire knowledge about some aspects of their condition. In particular, authors propose to measure the rotational speed of the idler based on short video recording. This data could be captured by mobile inspection robots, such as UAVs or UGVs, or even manually. Detecting the fact that idler rotates with improper speed (lower than nominal), could indicate developing fault of the internal bearing. An idler that rotates slower than it should, also creates additional friction between itself and the belt. This friction can increase the overall operational resistances, and even cause the fire due to increased temperature. In this paper authors present a simple method for establishing the rotational speed of the idler based on video data analysis.

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VERTICAL SOIL MOISTURE DATA EXTENSION FOR HUNGARIAN SOIL TYPES USING DIFFERENT INTERPOLATION METHODS

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Keywords: soil moisture, soil science, geostatistics, Sentek, scipy

An important step in today's modern precision crop production systems is the development of an irrigation system for arable lands. Most of these systems only examine the top, 10 cm layer of the soil [Dobos, 2020]. The problem is the root system of the crops also penetrates and grows into the deeper layers while absorbing water [Fan, 2016]. For this reason, there is a need for a cost-effective solution that tells how much water can be detected up to 1 meter. Our institute use Sentek EnviroSCAN sensors to measure soil moisture (SM) values of different soil types located in Hungary containing many soil mechanical and chemical attributes [Kibirige, 2021]. To be able to model water infiltration processes in a cost-effectively manner, SM values were only measured at certain depths. The missing depths are supplemented with estimated data done by interpolation. However, these estimations are not enough, as these sensors were located on different soil types, i.e. one kind of interpolation method may cannot be applied to all sensors without significant statistical error. Therefore, we collected the soil moisture data from several Sentek sensors. Each of them is placed on a specific soil type which is located in Hungary. The measured SM depth values were then used to produce estimated SM values lasting from 10 to 100 cm by using 8 types of interpolation methods. The interpolation was performed using a Python framework called Scipy [Pauli, 2020]. The final results of the research is the evaluation of the model performance of the soil moisture data estimated by 8 types of interpolation methods for different soil types in Hungary.

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A SMALL LEGGED ROBOT FOR INSPECTION PURPOSES

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Keywords: legged robot, inspection, mobile robotics

The paper deals with mobile robots with special emphasis on walking robots. A review of applications of particular types of mobile robots in various applications has been carried out. The validity of the use of walking robots in inspection tasks has been analysed. A list of commercially available solutions has been presented and their parameters compared. A concept of a miniature walking robot for inspection tasks requiring operation in a confined space has been proposed. The design of the prototype, the structural solutions used, the system diagram and the structure of the control algorithms are presented. Conclusions and observations on the design process are presented. A set of modifications and solutions enabling the application of the robot in real inspection conditions have been proposed. The validity of the presented concept has been analysed.

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DETECTION OF THE CENTER OF GRAVITY OF THE MILL LOAD USING COMPUTER VISION TECHNIQUES

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Keywords: Mill, Computer Vision, Mineral Processing

Various factors influence the power consumption of the mills. Some of the mill's operating parameters, such as rotational speed or shaft torque, can be read directly using simple sensors. However, other parameters have a great influence on the power consumption of the mill during operation, but their analysis causes many problems. One such parameter is the weight distribution inside the mill drum.

Researchers took the subject of insight into the interior of the mill during its operation using a transparent wall in the stands [Bian, et. al., 2017, Machado, et. al., 2017]. An analogous stand was constructed for our own research.

The mill filled with the colored slurry was recorded with a high-speed camera at 500 frames per second. Then, using the Computer Vision (OpenCV) library in the Python environment, an algorithm was developed to determine the center of gravity of the mill load.

The algorithm detects markers in the mill contour, thanks to which it can analyze the rotational speed of the mill. The image of the recording is converted to a binary black and white image without shades of gray with the cut-off level selected so that the entire mill load is represented by black color. Then the algorithm detects the edges of all objects that have been marked in black in the binary image. Then, from among all the resulting contours, after sorting, the algorithm selects the largest one - this represents the mill load. Knowing the position of the load, the algorithm can determine its center of gravity and the distance from the mill axis.

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GEOLOGY, COAL MINING, METHANE CONTENT AND EMISSION IN THE PGG SA ROW RYDUŁTOWY COAL MINE (POLAND)

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Keywords: methane emission, coal mining, atmosphere, natural hazards

The Rydułtowy hard coal deposit is located in the western part of the Upper Silesian Coal Basin, one of the largest in Europe, with an area of 7,250 km^2, including 5,650 km^2 in Poland, the rest is in the Czech Republic. The Rydułtowy 1 coal deposit is located in the Carpathian deep foreland, in the western part of the USCB in the upthrow of regional tectonic discontinuity – Michałkowice-Rybnik overthrust with throw size ~750-1500m. The Rydułtowy 1 coal deposit is represented by a fault-folded structure. This distribution of methane content in the Rydułtowy deposit corresponds to the so-called the northern pattern of methane distribution in the USCB, in which the several hundred meters thick degassed zone of natural desorption occurring in the upper part of the Carboniferous strata is characteristic (Fig.1).

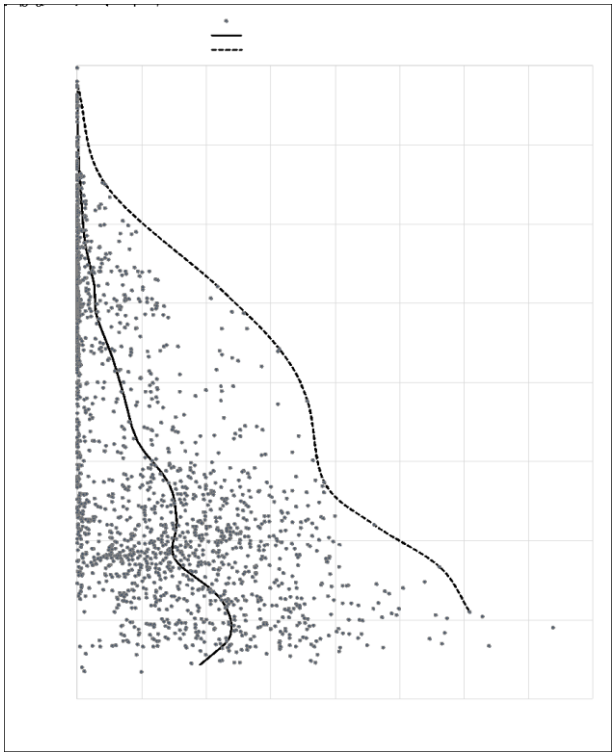

Fig.1 Methane content distribution in the PGG SA ROW Rydułtowy Coal Mine

The lack of secondary accumulation of methane at the Carboniferous roof in the deposit proves that the Miocene and Triassic overburden is not tight enough here for migrating gases. At first, coal was

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extracted in methane-free coal seams, therefore, no CH_4 emission was recorded. Methane emission was increasing rapidly from less than 3 million m^3 in 2000, to almost 35 million m^3 in 2003. Several years of coal production in comparatively harmless gaseous conditions resulted in decreased CH_4 emission (from ~26 million m^3 in 2004 to 11 million m^3 in 2007), but coal production decreased too (from 2.0 million t to just 0.90 million t). Methane that was released to goafs was systematically drained in the following years to provide safer conditions in adjacent coal workings. Mining in more methane-rich seams resulted in increasing amounts of released gas every year. The amount of released methane rose gradually from ~14 million m^3 in 2008 to 32 million m^3 in 2013. In the next years the methane emission was stabilised due to unwavering coal production ~1.5-2.0 million t/year.

The migration of methane can take place, through permeable sandstones, but also through faults. Discontinuous tectonic zones are considered to be pathways for gas migration, as rapid increases or decreases in methane content have been observed around them. Faults can also act as a sealing for gases or divide deposits into blocks of different gas capacity. Mining coal exclusively in Jaklovec layers resulted in constant methane emission to coal workings which was combined with greater amounts of extracted coal ~2 million t of coal and 32 million m3 of emitted CH_4 in 2013. Surrounding strata in Jaklovec layers consist of permeable sandstones (approx. 29% in the profile) which facilitate the migration of gases, such as methane to the exploited wall environment.

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REDUCING VIBRATION OF PUMPING UNITS OF RECLAMATION SYSTEMS

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Keywords: water intake, machine water lifting system, pumping station, vibration, impeller, reliability

The article presents the results of scientific research on the operation of pumping equipment at reclamation pumping stations. In pumping stations, more and more attention is being paid to measures to maintain the reliability and efficiency of pumping units, as well as to reduce the negative impact of factors of various origins. One of the most significant factors affecting the service life of the equipment is the increased vibration of the pumping unit. According to the results of the analysis of failures of pumping equipment at pumping stations in Uzbekistan for 2010-2021, more than 40% of pump stops occurred due to increased vibration. The most common cause of vibration of pumping equipment is waterjet and cavitation wear of the impeller, destruction of seals, wear and temperature rise of the bearing. The greatest vibration occurs when the equipment is operated in heavy and non-optimal modes. As a result of the generalization of the research results, active methods and means of reducing the vibration of pumping units were identified.

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COMPARISON OF EFFECTIVENESS OF TIME SERIES INSAR METHODS IN THE STUDY OF DISPLACEMENTS IN MINING AREAS

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Keywords: mining deformation, InSAR, Persistent Scatterers, Small Baselines, LOS decomposition

Extensive underground mining activity leads to changes on the surface in the form of ground subsidence. The multi-temporal Synthetic Aperture Radar Interferometry (InSAR) methods can be highly efficient in capturing the spatio-temporal patterns of ground surface displacements, owing to a high spatial resolution of SAR images and a short revisit time of the modern SAR missions. The objective of this study was to compare different approaches to processing multi-temporal InSAR data in their effectiveness of capturing surface displacements over mining areas, both in terms of accuracy and spatial coverage.

The study consisted of measuring ground surface displacements of a mining area in south west Poland, using two different approaches of multi-temporal InSAR processing. The Persistent Scatterer (PS) method (Hooper et al., 2012) and the Small Baseline approach (Sandwell et al., 2011) were used to process Sentinel-1A/B SAR data for the time period between May 20, 2016 and October 26, 2020. An inversion of Line-of-Sight (LOS) measurements was applied to obtain vertical and horizontal east-west displacements, following an approach described in (Wright et al., 2004). A statistical analysis of results was also conducted to compare their accuracy and effectiveness.

Two datasets of ground surface displacements were obtained from the two independent multi-temporal InSAR measurements. The PS method successfully detected measurement points over urbanized areas, but failed to do so over rural areas, as was expected following the principle of the method. The SB method proved to be more effective spatially, covering both urban and rural areas and capturing the extent of mining displacements more successfully. A qualitative assessment of the results proved that in urbanized areas with high interferometric coherence, both methods give comparable results in terms of measured displacement values. The most significant difference was noticed in areas of high, often non-linear, subsidence, in which case the PS method seems to underestimate the displacement value when compared to the SB method.

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GEOTHERMAL LITHIUM FOR EUROPE - REVIEW OF EXISTING RESOURCES AND OPERATING PROJECTS

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Keywords: groundwater, brines, BrineRIS, geothermal energy, critical raw materials, recovery

As one of the most desirable elements today, lithium is the subject of many scientific and research projects [Gromnicki, 2022]. More and more companies invest in technology to recover lithium from geothermal brines using brine heat. The rapidly growing battery industry motivates investors to search for new promising lithium sources in Europe and develop the most efficient technologies for its recovery. Such activities will contribute to building Europe's independence from lithium supplies coming mainly from South America or China [Zglinicki, 2021].

The BrineRIS project (Brines from RIS countries as a source of CRM and energy supply), co-financed by EIT Raw Materials, focuses on mapping geothermal brines enriched in lithium and other valuable elements in six selected countries – Poland, Czech Republic, Slovakia, Hungary Spain and Portugal - included in the Regional Innovation Scheme of the European Institute of Innovation and Technology (EIT RIS). Chosen sites will be evaluated in lithium recovery rate within three direct lithium extraction (DLE) methods: electrochemical membranes, solvent extraction, and adsorption. Moreover, the project will estimate these brines' electricity and heat production potential. This way, it will support the development of emissions-free lithium recovery technologies supplied by renewable geothermal energy. Such high-risk projects need brave investors. Therefore, BrineRIS intends to attract businesses to invest in RIS countries to decrease Europe's dependence on imported battery metals.

To give examples of the feasibility of such piloting installation and show the existing and already documented potential of Europe's brines, we analyzed and compared available and currently operating geothermal brine recovery projects and sites that are proven sources of valuable critical materials. In this context, five R&D projects related to the recovery of lithium from geothermal brines were characterized, including one of the most popular - CHPM2030, funded by the European Union [EU, 2022] or European Geothermal Lithium (EuGeLi), which is run by Eramet [Eramet, 2022]. The paper also analyzes seven locations for the prospective recovery of lithium from geothermal brines (France, UK, Germany, Italy, Portugal, Iceland, and Poland), including a piloting stage project of Vulcan Energy Company named "Zero Carbon Lithium™ Project" and located in the Upper Rhine Valley. These are locations where work is being done to recover critical raw materials from geothermal brines [Gromnicki, 2022].

Such analysis conducted at the early stage of the BrineRIS project gives the team an overview of the challenges and opportunities possible to meet during the project course.

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TECHNOLOGICAL REVIEW OF LITHIUM RECOVERY FROM BRINES - AN INTRODUCTION TO THE BRINERIS PROJECT

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Keywords: groundwater, direct lithium extraction, geothermal energy, critical raw materials, evaporative separation

BrineRIS (Brines of RIS countries as a source of CRM and energy supply) three-year project, co-financed by EIT Raw Materials, is focused on mapping the potential sources of geothermal brines in six selected countries included in the so-called European Institute of Innovation and Technology's Regional Innovation Scheme (EIT RIS). Furthermore, it aims to develop technology that would enable the recovery of critical raw materials (CRM) (including lithium) from geothermal brines in an emission-free and thus economical and environmentally friendly way. Limited access to CRM is a thoughtful obstacle in developing the battery and high technology sector. It caused hot, mineralized water to become an unconventional source of metals and the development of efficient technologies for dissolved elements recovery [Schultze, 1984].

Preparing for the project realization, we have analyzed and compared the available and currently implemented recovery technologies [Murodjon, 2020]. Starting from conventional evaporative separation, most common in the so-called "Lithium Triangle" in South America, through Direct Lithium Extraction (DLE) methods, we briefly described each technique's advantages and disadvantages, and limitations. Among DLE methods, we have analyzed precipitation, organic sorbents, inorganic sorbents, organic solvents, membranes, and electrochemical separation.

In this background, we characterized three technologies developing within the frame of BrineRIS and considered to be powered by geothermal energy [Stringfellow, 2021]. One of them is electrochemical Li extraction from brines [Diaz Nieto, 2020]. The first step will be the concentration of Li in solutions free of other cations, for which capacitive deionization (CDI) will be used to concentrate Li to a level of 500 ppm. Then, membrane electrolysis (ME) will be used for higher lithium concentrations. Finally, in the second step, solutions concentrated by the CDI process (500 ppm Li) will be treated with ME to recover Li as Li2CO3.

The second technology is the adsorption method which allows selective separation of lithium by adsorption in hydrochloric acid solution. The advantage of this technology is that lithium sorbents used in the direct extraction of lithium from brines can be used as cathode materials in lithium-ion batteries.

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And the last tested method in the BrinRIS project is solvent extraction. It is one of the most developed methods of separating metals from aqueous solutions. In this technology, metals extracted into the organic non-polar phase are usually recovered using an aqueous removal medium.

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IDENTIFICATION OF WATER BALANCE PROPERTIES OF URBAN ATLAS USING LANDSAT 8 DATA

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Keywords: Urban hydrology, Landsat 8, Sentinel 2, Urban Atlas, Runoff, Evapotranspiration, Infiltration

Water is a natural resource essential to the survival of populations and to the prosperity of their agricultural, industrial, and therefore economic activities. Despite the fact that the earth is the Blue Planet, it is water that is most lacking to Humanity [Grafton, 2011; Brun, 2012]. The growing population is converging on cities, where soil artificialization and various types of urban development are altering the local water cycle. In a watershed, urbanization can significantly change the natural water cycle. However, today's urban knowledge of the hydrological cycle is limited and there is still a lack of compatible data suitable for the generation of topical information about the urbanized water parameters and its changes at different scales. Furthermore, precise and small-scale urban water balance computations are not widely developed. In this context, the necessity for this research stems from the fact that efficient urban water management requires a comprehensive understanding of anthropogenic impacts on the urban hydrological cycle and the environment. Such effects vary widely in time and space, and must be assessed in relation to local climate, urban growth, cultural and environmental, as well as other socioeconomic aspects.

The research consists of three steps:

Maximum Likelihood Supervised Classification Landsat 8 satellite image to create a LULC map.

Water cycle parameter rates calculation (Runoff, Evapotranspiration and Infiltration).

Based on the prepared LULC map we calculated the hydrological parameters of an official land cover map from urban atlas

The ET, runoff, and I parameters have been added to the LULC of urban Atlas as attributes.

Urban Atlas was used to offer a precise computation of water cycle parameters (ET, R, and I).

Furthermore, Urban Atlas is widely used by researchers due to its open accessibility and high-resolution urban land use map, The Urban Atlas offers statistical and spatial data for 800 European Functional Urban Areas, including LULC categories, population, and area data for various land cover

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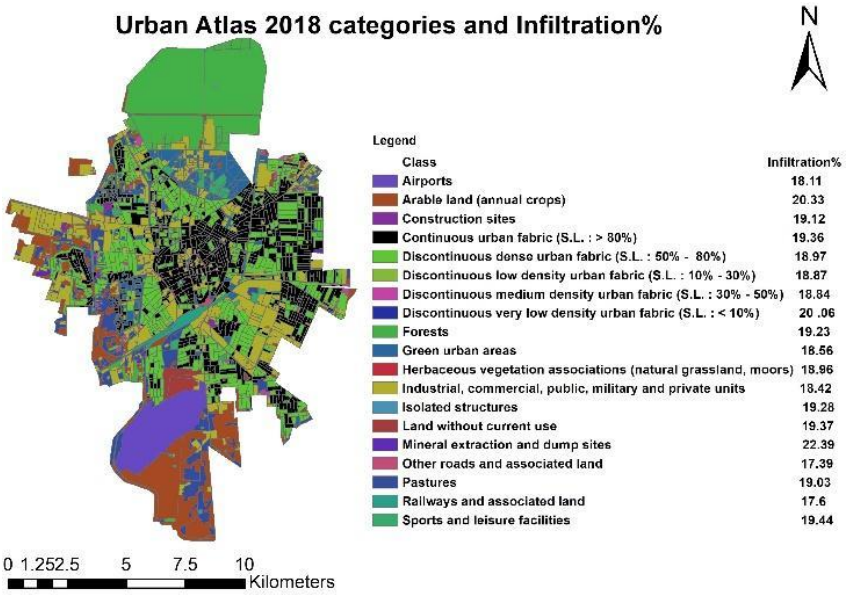

patches [Poleman, 2018]. However, it does not provide information or data on the hydrological parameters in an urban area.

The purpose of this study was to develop a spatial decision support system for water balance modeling that integrated geographic information systems (GIS) and remote sensing (RS), to learn about the connections between LULC and the water cycle's major hydrological components, generate a small-scale land use / land cover (LULC) map for more accurate water balance calculations, as well as to determine and integrate the most significant parameters to the land use and land cover classes, which including crop coefficient for computing crop ET and runoff coefficients for computing infiltration rate. This research provides an opportunity to attribute a new technique to address the lack of hydrological parameters in urban atlases and opens up new avenues for evaluating land cover changes over time as well as the impact of these changes on hydrological reactivity. The ET was estimated using meteorological data from 2016 to 2019. Debrecen, north-east Hungary is the study location. This study's method is suitable for usage in other urban areas.

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GROUNDWATER TEMPERATURE SPATIAL DISTRIBUTION IN WROCŁAW

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Keywords: groundwater temperature, subsurface urban heat island, Wroclaw

In Wrocław over the past 20 years, the recorded increase in the average ambient air temperature is approx. 0.5 °C [Polish Climate, 2020; Szymanowski, 2011]. In addition, urbanisation has created phenomenon called the Urban Heat Island (UHI) [Howard, 1818]. The combined effect of the UHI and climate change can influence groundwater temperature by penetrating underground [Previati, et. al., 2022]. The phenomenon of elevated groundwater temperatures in urban areas is called the Subsurface Urban Heat Island (SUHI) [Previati, et. al., 2022].

This study focuses on the spatial distribution of temperature in shallow aquifers in the city of Wroclaw. The spatial distribution was analysed based on groundwater temperature maps developed with various interpolation techniques. The results of measurements in a network of piezometers conducted in the 2004-2005 hydrological year have been used in this study. In total 67 locations were measured and the temperatures recorded show seasonal variation with the lowest recorded February (1.3 °C) and the highest in August (24.5 °C) with the annual average of 13.2 °C. The data has been processed with the Inverse Distance Weighted (IDW), Radial Basis Function (RBF) and kriging interpolation methods. Furthermore, the cokriging method based on multivariate linear regression models has been used to asses if variables such as groundwater table distance from the surface, distance from the city centre and the UHI distribution in Wroclaw improve the interpolation performance expressed as the lowest RMS value. It has been established that the kriging univariate regression model based interpolation method produced the best results (RMS equal to 1.33) and that the distance from the city centre have improved the accuracy of interpolation in case of cokrging.

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HYDROGEOCHEMICAL EVALUATION OF GROUNDWATER AND ITS SUITABILITY FOR DRINKING AND IRRIGATION USING WATER QUALITY INDEX, STATISTICAL AND GEOCHEMICAL MODELLING, NORTH EASTERN DESERT OF ALGERIA

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Keywords: Groundwater, Hydrogeochemistry, Water quality index, Geochemical modelling, Reverse ion exchange

Semi-arid countries such as Algeria are suffering from water shortage due to pollution risk of the groundwater [Khalil, 2018]. The study area is located in Souf valley in the northern east of Algerian desert (figure 1).

The water samples were collected from complex terminal which consist of semi-confined Mio-Pliocene and Lower Pontian aquifer [OSS, 2003]. The Depth of the wells range from 240 m to 500 m below sea level. The groundwater flows from southwest to northeast. Physicochemical parameters such as temperature, pH, Ec, TDS, major ions were measured in 2020 in the field and laboratory. The water samples from the complex terminal aquifer are not suitable for drinking where the value of the WQI higher than 100 [Brown, 1972] (figure2).

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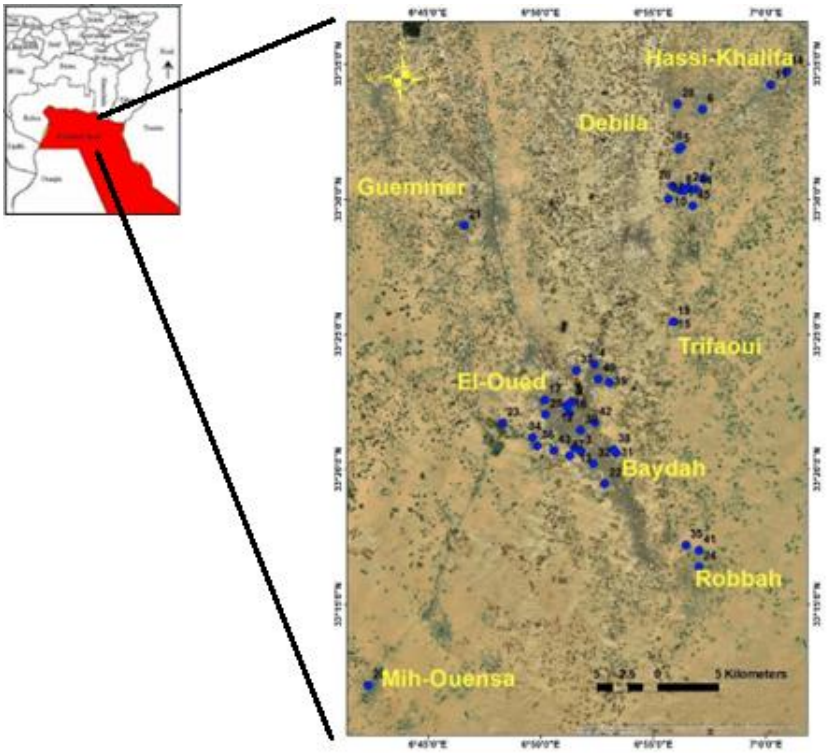

Figure 2. Location sampling map

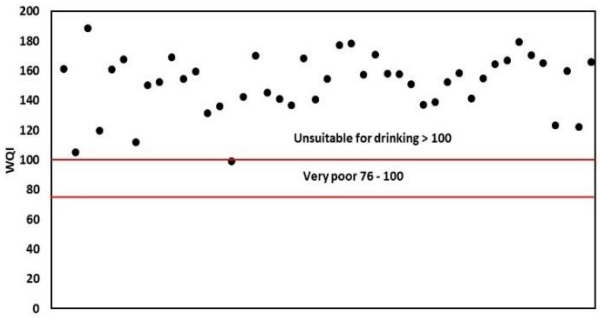

Figure 1. Water quality index.

The groundwater of CT in Souf valley is suitable for irrigation according to the resultsof SAR, Na%, MAR, PI and RSC [Richards, 1947] (figure 3).

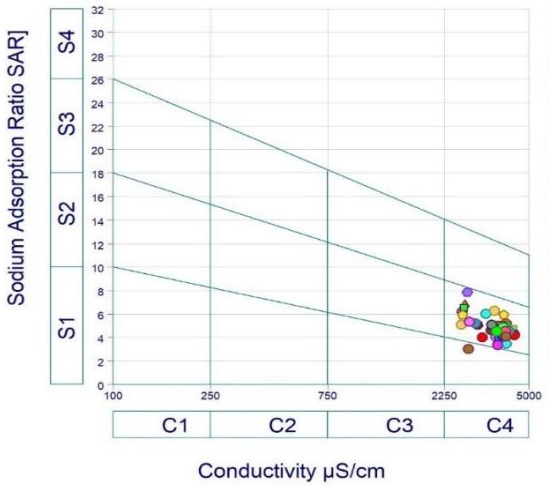

Figure 3. USSL diagram.

All the water samples showed very high salinity exceed the permissible limits for drinking and irrigation which can cause soil salinity and decreasing of plants and crops production in the future [WHO, 2011]. The semi-arid and hot climate has strong effect on the water quality through evaporation process. Piper diagram and Chadha diagram showed that the main hydrochemical facies of the groundwater are Ca-Mg-Cl/SO4 type and Na-Cl type [Piper, 1944; Chadha, 1999] (figure 4).

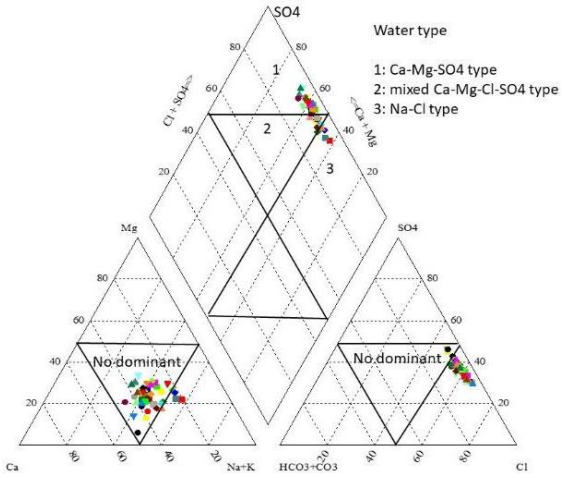

Figure 4. Piper diagram.

The statistical analysis such as binary plots, Gibbs plot and Durov diagram revealed that the main hydrochemical processes that control the water chemistry in the CT aquifer are evaporation/crystallization, gypsum dissolution and reverse ion exchange [Gibbs, 1970; Biswas, 2012; Fisher, 1997] (figure 5,6).

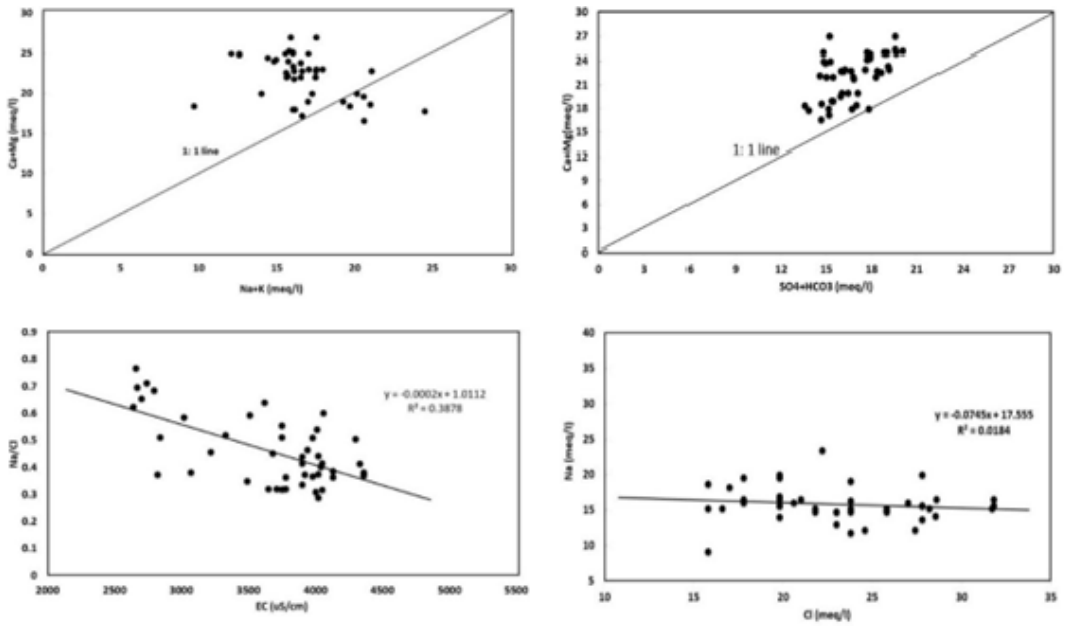

Figure 5. Statistical analysis.

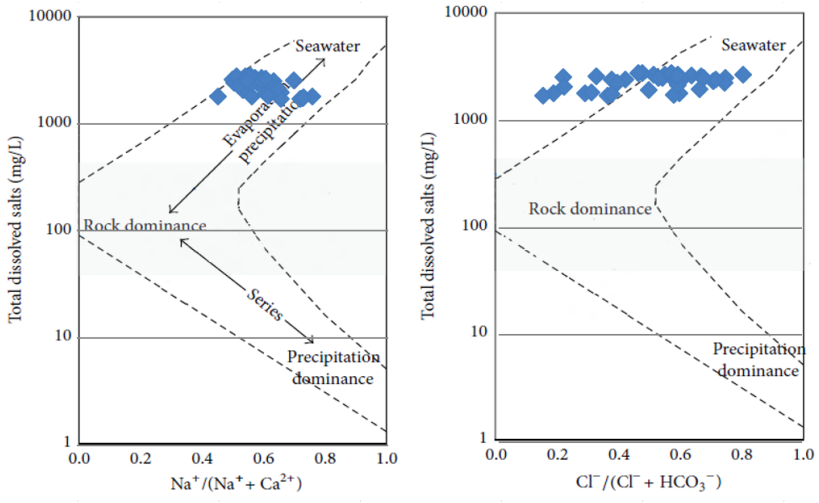

Figure 6. Gibbs plot.

The groundwater flows from the south west to the north east with rabid decreasing of the piezometric level in El-Oued, Baydah and Trifaoue region due to overexploitation for irrigation purposes. There is no need for using fertilizers contain calcium where the SAR has low to medium value and the soil will not be affected by sodification or infiltration capacity. All the water samples are undersaturated with respect to halite, anhydrite, gypsum while most of the samples are saturated to oversaturated by calcite, dolomite and aragonite. The saturation index of the samples refers to the groundwater will continue to dissolve more halite, gypsum and anhydrite and precipitate calcite and dolomite. The best management for using the groundwater in the study area for irrigation is selecting plants and crops that are resistant for high salinity of water.

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THE USE OF UAVS IN SUPPORTING THE PRESERVATION OF THE INDUSTRIAL AND MINING HERITAGE IN THE RUHR AREA

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Keywords: UAV, remote sensing, photogrammetry, transition, material sciences

Over the last decades, all hard coal mines (the last one in 2018) and most industrial plants (e.g. coking plants, steel mills) have been closed in the Ruhr region as part of an ongoing, long-term transition process. The centuries-old mining tradition is nevertheless very much embedded in the population. For this reason, the monuments of the industrial age are regarded as defining, identity-forming landmarks that must be preserved as original as possible in the future - not only in the Ruhr region, but also in many comparable regions in Germany (e.g. Saarland, Ibbenbüren or the Aachen area) and worldwide.

Extreme weather conditions caused by the fast progressing climate change are affecting these structures of disused steel mills or coking plants. Cracks, paint spalling and other material damage develop, making expensive refurbishment or, in the worst case, demolition necessary. Climate change also affects the subsoil and thus the stability of the facilities by negative environmental influences such as drought or moisture.

As part of a feasibility study, the Research Center of Post-Mining is developing an innovative method for non-destructively assessing the condition of monuments of industrial and mining heritage. UAVs equipped with optical, thermal and multispectral sensors are being used for the first time for this purpose. They collect high precision and high-resolution data, which is viewed and fused together,

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making it possible to model the complex buildings comprehensively in 3D (+time) and to examine them for possible damage.

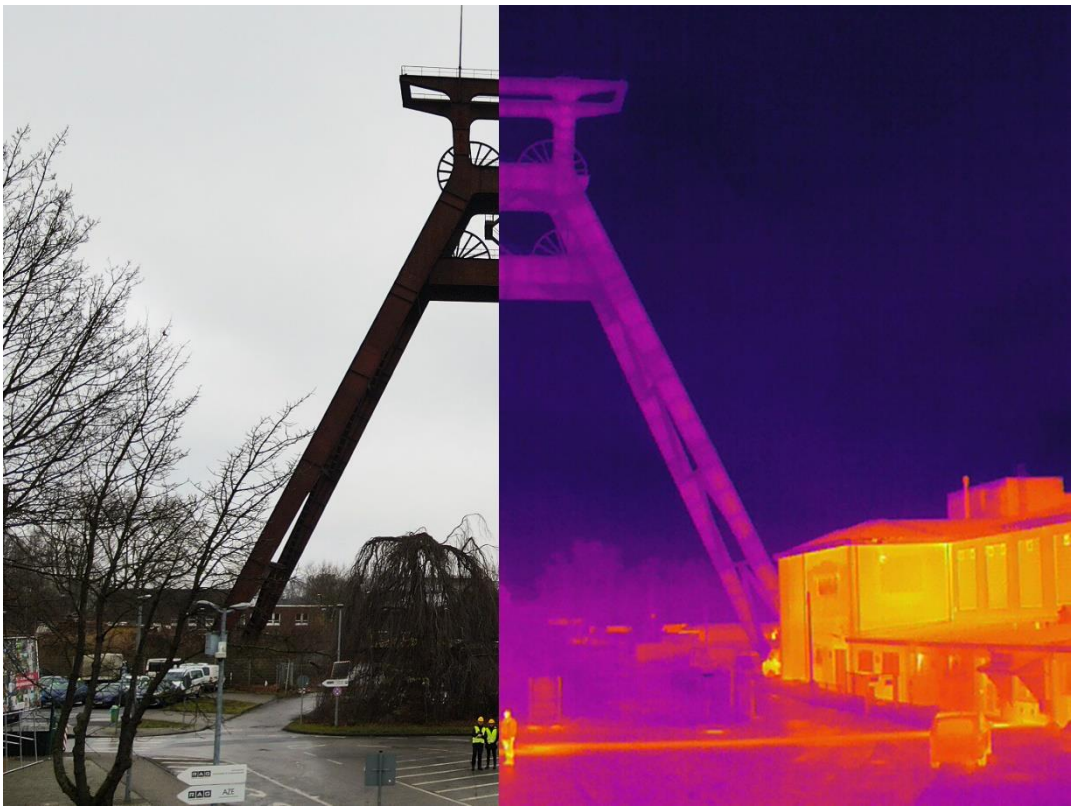

Figure 1. Comparison of parallel recorded and highly accurately georeferenced RGB and infrared thermal images from a DJI Mavic 2 Enterprise Advanced UAV at the pithead of the former Pluto coal mine in Herne, Germany.

In the long term, the highly accurate 3D-models with all their information will be integrated into the spatial data infrastructure of the Ruhr Regional Association (RVR) and thus made available to a broad public and experts from the fields of history, architecture or monument preservation.

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THE POSSIBILITY OF USING CYANOBACTERIA OF NOSTOC GENUS FOR THE PRODUCTION OF VARIOUS BIOSORBENT MATERIALS

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Keywords: Nostoc spp., polysaccharides, biosorbent materials, furcellaran, chitosan

Cyanobacteria belonging to the genus Nostoc occur all over the globe, both in aquatic and dry environments. They are gram negative, photosynthetic prokaryotes. They are characterized by a gelatinous structure due to the high content of polysaccharides. They show high resistance to changes in environmental conditions. In Asia and South America, cyanobacteria of the genus Nostoc have an important role in the diet of the inhabitants.

Polysaccharides secreted by plants and microorganisms have the ability to bind metal ions. Thanks to their natural origin, they are biodegradable and do not adversely affect the ecosystem. The large amount of polysaccharides secreted by Nostoc makes this cyanobacterium a potentially good source of these compounds that can be used as components of biosorbent materials.

Currently, new methods of removing certain metal ions from the environment are being investigated. The problem is both heavy metal ions, which pose a threat to the environment, and elements that are difficult to obtain from desposits and occur in small amounts. Biosorption materials could be used on a large scale as a new, innovative, ecological form of removing desire ions to clean the environment contaminated with heavy metals.

For the first time, an attempt was made to prepare carries based on furcellaran (polysaccharide extracted from sea algae) and chitosan with Nostoc polysaccharides extract as biosorbent materials.

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PREDICTION OF DILUTION IN SUBLEVEL STOPPING BY MAKING USE OF MACHINE LEARNING ALGORITHMS

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Keywords: Sublevel stoping, stope stability, dilution, machine learning

Open stope mining offers plenty of advantages compared to other underground mining methods but has some very important drawbacks, such as overbreak, wall instability and the presence of unplanned ore dilution during extraction (Urli, 2016)[1]. Unplanned dilution has a direct correlation to the inefficiency of the extraction rate for mining operations, which resulted in developing tools aimed to estimate the dilution on stopes. The tools currently being used can be divided mainly into empirical methods and numerical analysis.

The research looks to test the efficiency of using machine learning algorithms as an alternative to estimate the dilution in open stopes, some of the expected benefits are reduced time cost compared to numerical analysis and better results compared to empirical methods (Qi, 2018)[2]. The selected machine learning algorithms are random forest (RF), support vector machine (SVM) and K-nearest neighbors (KNN), all of these algorithms are mature, good at modeling nonlinear relationship between parameters and have seen an increment in use for rock mechanics (Qi, 2018)[3].

The key parameters for the analysis were selected based on the research performed by Clark (Clark, 1998)[4], Delentas (Delentas, 2021)[5] and Jang (Jang, 2016)[6], leading to the selection of 9 parameters from two categories: geological properties and stope design. The collected data samples came from different sources, consisting of 1152 cases from mines located in Chile, Argentina, Brazil and historical cases. Due to some sets missing the data for observed dilution, the research done by Papaioanou (Papaioanou, 2016)[7] that introduced a dilution-based stability graph (Figure 1) was utilized to estimate the dilution from the stability parameters.

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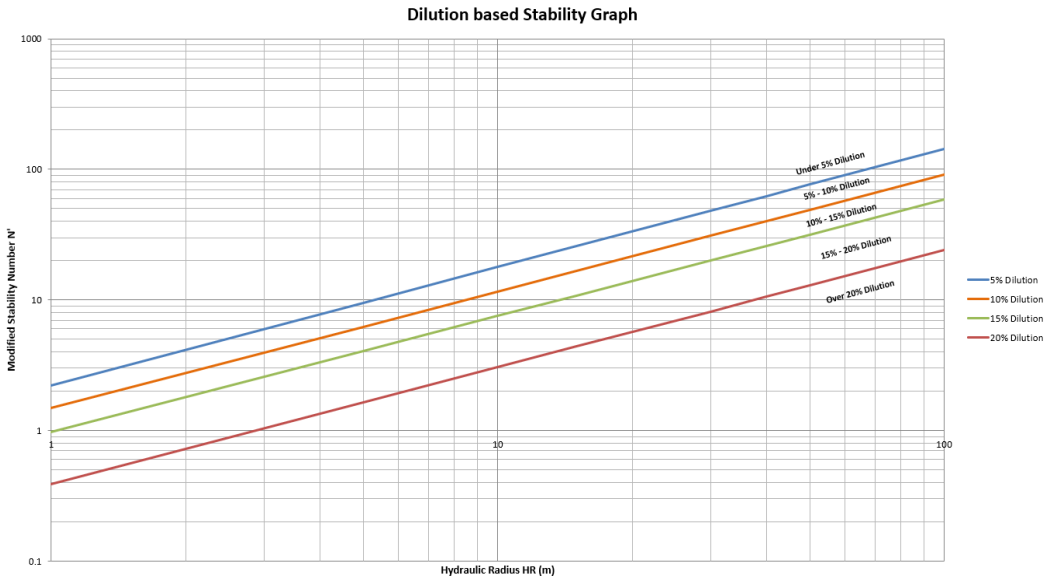
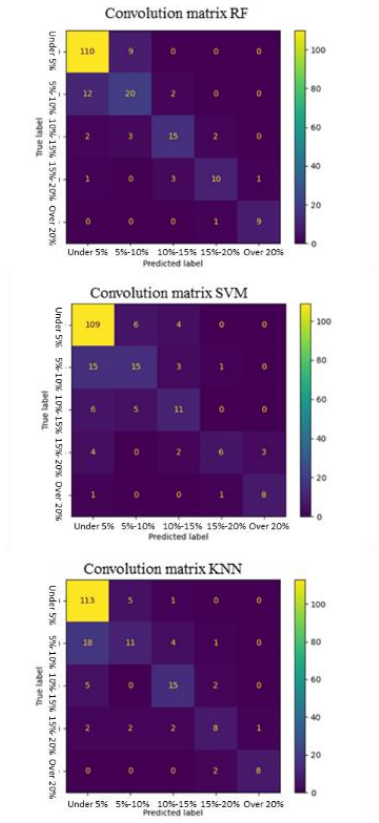


Figure 1: Dilution-based stability graph

The implementation of the machine learning algorithms followed the standard methodology: checking parameters correlation, separation of the database into training and testing set, hyper parameter tuning with the training set, and estimation of testing set data to obtain final results. The process was repeated 10 different times while shuffling the data sets in order to avoid any type of bias. After obtaining the optimal hyper parameters by the use of Bayesian optimization, the fitted algorithms were applied to the testing data in order to estimate the dilution. The performance indicators selected for comparison were accuracy, precision, AUC score and the convolution matrix (Figures 2-4).



Figures 2-4: Convolution matrix for testing data

For all three algorithms the AUC score was higher than 0.892 which can be considered as excellent results (Hosmer & Lemeshow, 2000)[8], the most impressive results were achieved by the random forest algorithm (Precision = 0.828, accuracy = 0.820, AUC = 0.951). When analyzing the convolution matrix, it is possible to see that most of the errors in estimation are under the diagonal, which denotes that the estimated dilution was lower than the observed dilution. The conclusion from analyzing the results is that the machine learning algorithms can be used as trustworthy tools for the estimation of dilution, but some adjustments are needed to increase the accuracy to specific mine sites.

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PROPERTIES OF CEMENT-SOIL MIXTURES CONTAINING COMBUSTION BY-PRODUCTS WITH REFERENCE TO CHANGES OVER TIME

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Keywords: soil-cement, xCT, combustion by-products

Jet grouting is a technique widely used in geotechnics. The technology is popular among contractors performing anti-filtration screens, reinforcing foundations and securing excavations. Structures created as a result of injection must have certain strength parameters and be able to impede water flow. The increasingly used trend of zero-waste leads researchers to introduce ingredients considered to be waste into modern materials. In his research work, the author focuses on the possibility of using bottom ash from a fluidized bed boiler as a mixture component in jet grouting. The paper will present the methodology of research conducted on cement-grounds. The conducted research distinguishes the application of mixtures on cohesive and non-cohesive soils. The basic physical-mechanical and chemical properties of cements, combustion by-products (UPS) and soils will be presented. Then the author will present the results of research in order to select the best composition of the mixture. The effect of changing mechanical properties in time is taken into account when considering cement and soil mixtures. An addition to the classical research will be the use of computed tomography to detect the mechanism of failure. The presentation will conclude with a study of the use of an in-situ testing stage operating during a CT scan. The combination of static load and tomographic scanning is possible in single institutes in the world and the analyses carried out bring modelling of failure mechanisms to a new level.

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TRANSPORTING CAPACITY OF THE AMU DARYA RIVER STREAM UNDER CONDITIONS OF GENERAL EROSION

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Keywords: Amu Darya river, general erosion, transporting capacity of the stream

The main causal factor of the general erosion is the clarification of the flow as a result of a change in the turbidity regime. The study of changes in the alluvial regime is an important component of the analysis tool when assessing the course of riverbed processes in the waterworks. The transporting capacity of the flow can be taken as the main quantitative characteristic. The purpose of the research was to analyze the nature of changes in the sediment regime in the nonregulated state and after regulation. The object of research was the lower reaches of the Takhiatash hydraulic engineering complex on the Amu Darya River. The study of the transporting capacity of the stream in conditions of general erosion was carried out on the field data of the Hydrometrological Service of the Republic of Uzbekistan for the Chatly and Samanbai gauging stations. The Samanbai gauging station is located 14 km below the Takhiatash hydro unit complex. Samanbai gauging station was organized in 1974 to replace Chatla gauging station, located 0.7 km below the hydrounit, and therefore found itself in the zone of its influence and consequently liquidated.

The analysis of the turbidity regime showed that during the initial operation of the Takhiatash hydrounit (1974-1981), the average turbidity decreased by 3-3.5 times compared to the nonregulated turbidity (1951-1959). The average turbidity for the period 1982-2017 is 30-35 times lower compared to the average turbidity of the household period and, accordingly, in 9-10 times lower compared to the average turbidity of the period 1974-1981. Thus, the degree of clarification was 0.70-0.75 for 1974-1982, and 0.95-0.98 for the period 1982-2017.

There are quite a huge number of formulas to determine the transporting capacity of a stream. All existing formulas can be conditionally divided into two groups: theoretical and empirical. For the conditions of the Amu Darya River, empirical dependencies have become the most widespread in hydrological studies. Based on the analysis and comparison of existing formulas, the type of structural dependence that best meets the field data was selected:

$$S_{aver} = k\frac{v^m}{gh^n w^a} \qquad (1)$$

where S_{aver} is the average turbidity of the flow corresponding to its transporting capacity;
v is the average flow velocity, m/s;
h is the average depth, m;
w is the average hydraulic size of sediment, m/s;

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k is the proportionality coefficient;
m,n,a are empirical indicators of the degree.

On the basis of field data and using statistical processing methods, empirical indicators were determined in the formulas for calculating the transporting capacity of the flow under conditions of general erosion on the Amu Darya River for the period of intensive erosion (1974-1981) (2) and the period of stabilization of the channel process (1982-2017) (3):

$$S_{aver} = 0{,}113\ (v^{1.50}/(ghw)^{0.50})\ . \qquad (2)$$

$$S_{aver} = 0{,}039\ (v\ /(ghw)^{0.33})\ . \qquad (3)$$

Thus, despite the existence of a large number of formulas for determining the transporting capacity of the flow and the flow rate of solid sediments, there is no universal formula suitable for any rivers. This is due to the fact that the movement of sediments is an extremely complex process, depending on a huge number of both natural and random factors. Each formula is valid for specific field or experimental conditions under which the research was conducted, which takes into account the proportionality coefficients present in the formulas of each group. The obtained dependences can be used to quantify the course of riverbed processes and calculate the total erosion on the Amu Darya River.

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COMBINED METHOD FOR CALCULATING THE TOTAL EROSION OF CHANNELS COMPOSED OF EASILY ERODIBLE GROUNDS

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Keywords: evolution of river bed, regulation of water course, general riverbed erosion, calculation method, riverbed erosion equation

Despite the large number of available methods for calculating the total erosion after river flow regulation, there is no universal, generally accepted methodology. This is due to the complexity of the riverbed process and its dependence on many factors that it is not possible to take into account. Especially difficult is the calculation of the total erosion of riverbeds composed of easily eroded grounds. All existing calculation methods can be separated:

1) hydrodynamic (theoretical) methods that are based on solving a system of equations of a suspended channel flow in a deformable channel.

2) hydromorphological (empirical) methods are based on the correlation of hydromorphological dependencies between the hydraulic characteristics of the flow, the morphometric characteristics of empirical channels.

According to the rigor of the theoretical justification and the reflection of the physical essence of the phenomena that determine the channel processes, the methods of the hydrodynamic direction are more preferable. But the solution of the system of basic equations presents serious, and in some cases insurmountable difficulties in view of the considerable complexity of the process of channel transformations and its dependence on a large number of factors.

The proposed method uses the basic equations of theoretical methods, which are supplemented by empirical dependencies.

1) The channel deformation equation has the form (the Saint-Venant equation):

$$\frac{\partial P}{\partial s} = \gamma \frac{\partial \omega}{\partial t} \ , \qquad (1)$$

where, $\partial\omega/\partial t$ is the change in the cross-section of the riverbed over time; P is the flow rate of sediment; γ is the specific gravity of sediment.

2) The equation of fluid motion (Bernoulli equation):

$$\frac{1}{g}\frac{\partial(\alpha_\omega v)}{\partial t} + \frac{\partial}{\partial s}\left[\frac{\alpha_0 v^2}{2g} + y\right] + \frac{\alpha_s v \rho_s q_s}{\rho_\omega g \omega} = -i_f \qquad (2)$$

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where, *y* is the mark of the free surface of the water; *v* is the flow rate; ω is the cross-sectional area; α_ω and α_s are flow adjustments that take into account the uneven distribution of local sediment concentrations and velocities over the living section; $\alpha_0=2\alpha_{0\omega} - \alpha_\omega^2$,$\alpha_{0\omega}$ — adjusting the amount of movement; ρ_s and ρ_ω are densities of sediment and water material, respectively; i_f is the friction slope.

3) Empirical morphometric dependence of the width of the riverbed on the average depth (the formula is of great importance for riverbed composed of easily eroded grounds):

$$B = \kappa h^{\alpha}; \qquad (3)$$

where B is the width of the riverbed along the edge; h is the average depth; k and α are empirical coefficients.

4) sediment flow equation:

$$\mu = K_1 \frac{v^m}{(ghw)^n} \qquad (4)$$

μ is the average turbidity of the flow corresponding to its transporting capacity; *v* is the average flow velocity, m/s; *h* is the average depth, m; *w* is the average median fall diameter, m/s; *k* is the proportionality coefficient; *m,n,a* are the degree indicators determined by according to empirical data;

The joint solution of equations (1)-(4) leads to an equation of the form:

$$\partial z/\partial s + F_1 \bullet \partial z/\partial t = -F_2 , \qquad (5)$$

where

$$F_1 = \frac{-(k^{m-1}(gw)^n h^{m\alpha-\alpha+m+n-2})\gamma(\alpha+1)}{K_1 Q^{m+1}(m\alpha+m+n)g}(gk^2h^{2\alpha+3} - (\alpha+1)Q^2)$$

$$F_2 = -\frac{(1+m)kqh}{Q(m\alpha+m+n)} + \frac{(1+m)kq(\alpha+1)Q}{(m\alpha+m+n)gk^2h^{2\alpha+2}} - \frac{Qkq}{gk^2h^{2\alpha+2}} + \frac{Q^2n^2}{k^2h^{2\alpha+2m_1+3}}$$

Equation (5) is solved by an auxiliary system of canonical equations of the form:

$$ds/1 = dt/F_1 = dz/-F_2 ,$$

$$\begin{cases} \Phi_1 = \int F_1 ds = t + C_1 \\ \Phi_2 = -\int F_1 / F_2 dz = t + C_2 \end{cases} \qquad (6)$$

where C_1 and C_2 are arbitrary functions of independent variables *s* and *t*. C_1 and C_2 are found by graphoanalytical method. Numerical integration using closed-type Newton-Cotes quadrature formulas was used to calculate the values of F_1 and F_2. Knowing the values of C_1 and F_1, which are determined for predefined marks of deformations *z*, it is possible to determine the value of the time interval for which this deformation will occur:

$$\begin{cases} t = \Phi_1 - C_1 \\ t = -\Phi_2 - C_2 \end{cases} \qquad (7)$$

By specifying the values of deformations, it is possible to use formulas (7) to find the time interval during which this deformation occurred and, based on them, to plot the change in the values of deformations in time z (t) and the change in the area of deformation in time $\omega(t)$.

To calculate the total washout, an algorithm and a calculation program in the language “Turbo Pascal 7.0" have been developed. Comparison of the calculation results with the actual data of the total erosion in the lower reaches of the Takhiatash hydrocomplex on the Amu Darya River showed good convergence. The discrepancies between the calculated and actual curve as a percentage for the entire period under review amounted to no more than 5% (the maximum deviations in some periods are 20-25%).

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RIVERBED PROCESSES IN CONDITIONS OF REGULATED FLOW (ON THE EXAMPLE OF THE AMU DARYA RIVER)

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Keywords: Amu Darya river, riverbed, riverbed process, regulated flow, riverbed regulation

The Amu Darya is the largest in terms of water content and the second longest river in Central Asia. The uniqueness of the river consists in the relatively large values of the slope of the longitudinal profile of the bed of the channel, significant (in turbidity ranks first in Central Asia and one of the first in the world) and the presence of easily eroded soils at the base of the riverbed. The Amu Darya belongs to wandering rivers. As a result of wandering, especially during a flood, the flow falls on both banks, causing erosion, flooding of the coastal zone. On the river, phenomena characteristic only for the Amu Darya often occur – "deigish".

The upper and middle reaches of the Amu Darya River on the prevailing length from Kelif to Tyuyamuyun has the same slope of the water surface – I = 0.0002 - 0.00025. The upper course of the Amu Darya River in geomorphological terms is the result of the embedding of the water flow into the Earth's surface. The predominant type of riverbed process is erosion. In the lower reaches of the Amu Darya, the average slopes are in the range of 0.00015-0.00005, i.e. almost 1.5-3 times less than in the upper reaches, respectively, the average speeds have lower speeds. Geomorphologically, the lower course of the river is alluvial deposits of sediments brought by the river from the upper sections of the river. The riverbed process occurs both in the form of degradation and sediment deposits. It was assumed that the construction of water support structures in the lower reaches of the Amu Darya River would reduce the intensity of riverbed processes. But the study of the riverbed process showed that the process of wandering of the stream and erosion of the indigenous shores continues.

The analysis of riverbed processes was carried out on the basis of a comprehensive analysis of both field data from expeditions of the Central Asian Research Institute of Irrigation (now the Research Institute of Water Problems and Irrigation) and hydrometric data of the Hydrometrological Service of the Republic of Uzbekistan on posts in the zone of influence of hydrounits. The analysis consisted in assessing the process of channel reforming based on a comparison of the materials of channel surveys carried out during various periods of operation of the hydrounit along fixed channels, by changing the average bottom mark, level regime, channel width along the cut and by the areas of deformation of the cross-section of the channel along the channels of hydrological posts.

The following measures are used on the Amu Darya River to regulate of river bed: construction of a system of traverse dams according to the plan-scheme of two-way regulation of the riverbed, the construction of separate channel-regulating dams, the use of short shore-protecting dams (spurs) and etc. In general, the measures taken to regulate water flow and regulate the riverbed have had a good effect on the use of water resources and the passage of flood waters along the Amu Darya River. The

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experience of regulating riverbeds with traverse dams was used in regulating the channel with the help of two-way dams on the Dunbatou-Gaocun section of the Yellow River in China.

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SPECTRAL ANALYSIS OF ORE HYPERSPECTRAL IMAGES AT DIFFERENT STAGES OF THE MINING VALUE CHAIN

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Keywords: Hyperspectral image processing, spectral unmixing, hyperspectral endmembers

Hyperspectral image processing is well-known in different scientific fields as aerial mapping, biomedical imaging, mined ore characterization and many others. Hyperspectral images contain the pixel data with reflected light values that count more than 200 wavelength values. Analysis of that data type can distinguish the "hidden" materials within the picture and establish preliminary information about it.

This study focuses on investigating the possibility of hyperspectral image processing to recognize the spectral signature and features of various ore samples taken during different stages of mine development. Due to the low resolution of the image, one pixel can cover a large surface containing several different materials. Spectral unmixing was performed to obtain a pure pixel spectrum of mineral in the ore and to estimate its corresponding abundances.

Hyperspectral images of presented ore were made on two cameras that record in sequential ranges: camera with visible and near-infrared wavelengths of 400-1100 nm and near-infrared (NIR) range of 900-1700 nm. After data calibration and correction, mean spectra of each ore material was calculated. Due to the uncertainty about the components of the samples, the endmembers that represent pure signature of a spectral element were computed statistically using NFINDR algorithm.

Hyperspectral image analysis efficiently characterizes materials and extract its spectral features whilst processing the ore of different complexity levels. Deriving those spectral characteristics contribute to fast recognition and further classification of given samples, as well as creation and expansion of data base for ore variations.

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ACCUMULATION OF CRUSHING PRODUCTS IN BALLAST LAYER UNDER CYCLIC LOADING

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Keywords: crushed stone, ballast layer, passed tonnage, ballast grain composition

Increasing of ballast layer bearing capacity is a widespread problem during the operation and maintenance of a railway track nowadays. It is known that with an increase of the passed tonnage, the ballast layer tends to become contaminated both by the products of its own crushing and by the external weeds which rapidly leads to the strength and operational characteristics degradation of the crushed stone ballast. In this study, an attempt was made to simulate the effect of cyclic load from rolling stock on the ballast layer and to determine the extent of wear of crushed stone ballast of category II in accordance with GOST 7392.

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Comparison of selected route search engines for vehicles in urban environment. The case study of Prague and Adelaide

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Keywords: route; search engine; GIS; vehicle; transport

Nowadays, many different search engines for optimal road routes are available including popular mobile applications and online services. Some of them also offer paid services with an extended performance. Finding the shortest or fastest route often utilizes standard algorithms with various unpublished SW-specific improvements. However, major differences are expected in exploited data sets which is a critical issue namely in big cities. Two cities, Prague and Adelaide, represent different urban and transport conditions. Performance, obtained route characteristics and recommended paths are compared for HERE Maps, Google Directions, TomTom, Open Source Routing Machine, and OpenTripPlanner. The route requests are generated for randomly selected Points of Interests from OpenStreetMap. Results confirm a major role of availability of current traffic data.

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PERFORMANCE OF GEOSYNTHETIC CLAY LINERS IN GEOENVIRONMENTAL ENGINEERING APPLICATIONS

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Keywords: geosynthetic clay liner, laboratory testing, geoenvironmental engineering, landfills, durability

Over the last decades the use of geosynthetic clay liners (GCLs) has continuously increased in geotechnical, hydrotechnical and environmental applications mainly for containment purposes. The type of construction, as well as the anticipated function, determine technical requirements that GCLs have to fulfil. A large number of laboratory test methods can be used for the characterization of GCLs as a composite final product or of their components (mineral and geosynthetic materials): physical, index, mechanical and hydraulic properties. Moreover, long-term performance of GCLs can be evaluated either by laboratory simulations, or by testing samples exhumed from test-pits or existing construction sites. This paper gives an overview on various factors affecting GCL performance such as: type of bentonite, initial water content and grain-size distribution of adjacent soils, geochemical interactions of bentonite and pore water or retained fluid (leachate), exposure to environmental conditions (freeze-thaw, wet-dry) etc.

In geoenvironmental engineering applications, GCLs can perform as a good hydraulic and gas barrier on a long-term basis if they are designed and constructed in compliance with recent research findings, proper regulations, and good construction practice. During the last several decades a number of standard procedures and methods for GCL testing have been developed and established. GCL manufacturers have responded to the needs of construction companies and have developed a large number of GCLs intended for different purposes. There have been a large number of successful applications, but there are also some problems and failures. Designing and assessment of long-term performance of GCLs requires the understanding of soil mechanics, geosynthetics and their mutual interactions. Some research findings obtained through laboratory testing of GCLs will be discussed in this paper, along with one case study.

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HOW TO MANAGE MINE CLOSURE? USING PPGIS TO INVOLVE THE COMMUNITY IN CREATING THE POST-MINING FUTURE

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Keywords: mining, decarbonization, mine closure, PPGIS

In the face of the planned energy transformation, focused on achieving the European Union's climate and energy goals, it becomes necessary to implement solutions supporting the management of decision-making processes in matters related to the liquidation of mines and the management of post-mining areas. The need to develop comprehensive liquidation plans that consider the public interest, emphasized in the literature [Bainton & Holcombe, 2018; Owen & Kemp, 2018; Gregory, 2021], becomes a contribution to proposing solutions ensuring public participation in planning of the post-mining future. This is crucial because, as emphasized by world leaders in the field of mining, i.e. International Council on Mining and Metals (ICMM), Anglo American and Department of Mines and Petroleum & Environmental Protection Authority (DMP & EPA, Western Australia), integrated activities involving the community in decision-making processes are responsible for the success of the transformation.

Managing complex processes, which can include decommissioning in the mining industry, in terms of cooperation with the community, requires the use of innovative solutions ensuring effective communication and appropriate response to received reactions, which is noted by Johnson et al. [2022]. Support in this respect may be a participatory approach to acquiring spatial information. The proposed methodology focuses primarily on the use of participatory GIS methods and tools (Public Participation Geographic Information System, PPGIS) and designing a geo-questionnaire, and then its implementation (online), collecting respondents' responses and processing the results.

A review of the literature on community involvement in decision-making processes with the use of PPGIS and the consequences of mine decommissioning was carried out. On this basis, a scheme for the functioning of PPGIS was developed and key issues to be included in the geo-questionnaire were proposed. Based on the answers received and the analyzes carried out, it is possible to comprehensively learn about the social vision of the post-mining future, as well as expectations, fears, and perceived opportunities. Further research in this area considers the implementation of the proposed solution in one of the post-mining areas struggling with revitalization and land development planning.

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LOAD BEARING CAPACITY TESTING OF ROCK BOLTING EXPANSION UNDER LABORATORY CONDITIONS AS PART OF WORK ON ROCK BOLTING SELECTION

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Keywords: rock bolting, expansion anchor bolts, rock bolting selection

The presentation outlined the work entitled "The 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" carried out by the author as an implementation doctoral programme. A brief description is given of all tests carried out for this purpose, including load-bearing capacity tests of expansion anchor bolt in underground conditions, strength tests of rock samples and numerical analysis of cooperation of bolts with rock mass. Special attention was paid to the presentation of results of laboratory tests of cooperation of anchor bolts with rock mass. The author compared results of load-bearing capacity tests and identified ways in which specific types of expansion anchor bolt can cooperate with various types of rock mass.

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THE INFLUENCE OF GEOLOGICAL PROPERTIES OF ANDESITE ON THE MECHANICAL PROPERTIES AND BREAKAGE CHARACTERISTICS

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Keywords: drop weight test, geological properties, mechanical properties, comminution

The single particle breakage characterization tests are commonly used methods in the field of mineral processing, with the aim to connect the breakage characteristics of materials with the breakage energy. The breakage characteristics are highly influenced by numerous factors, such as the petrological properties of the material, cracks and voids, the size and shape of the crushed particle, the stressing method (Napier-Munn et al. 1996, Petruk 2000). Single particle breakage characterization tests can be grouped in three main classes: single impact, double impact, and slow compression (Krogh 1980, Salman et al. 2007). In the case of double impact tests, the stressing is transmitted through impact between two surfaces. The classical drop-weight test (DWT) is a double impact type test, a single particle is subjected to breakage between two solid surfaces where the drop weight can be a steel ball or a plate. The impact energy is calculated with the following formula:

$$E_i = m_d\, g\, (h_i - h_f) \qquad (1)$$

where E_i is the impact breakage energy (m^2kg/sec^2), m_d mass of drop weight (kg), h_i initial height of the drop-weight above the anvil (m), final height of the drop-weight above the anvil (m). The specific comminution energy can be calculated as following:

$$E_{cs} = E_i / m_p \qquad (2)$$

where E_{cs} is the specific comminution energy (kWh/t), m_p mean particle mass (g).

Three different types of andesites, with different texture, structure and alteration degree from the Tállya Quarry (NE-Hungary) were examined. The quantitative mineralogical composition of the samples was determined using XRD. The chemical composition was determined using XRF, from the result chemical alteration indices were calculated. Textural properties were determined using polarized optical microscopical observations on thin sections. The mechanical properties, the resistance to wear (EN1097-1) and resistance to fragmentation (EN1097-2) was determined in the case of each type of andesites. Single particle drop weight tests were conducted on narrowly sized particles of andesites. The breakage energy was altered using different weights and drop heights, ranging from 148,7 J to 18,1 J. The particle size distribution of the broken fragments was determined using dry sieving, the t_n indices were determined.

The resistance to wear and resistance to fragmentation results showed a correlation with the texture and degree of alteration of the samples, the unaltered and slightly altered, vesicular andesites having better LA and M_{DE} values than the heavily altered sample, however the correlation between the calculated alteration indices and the resistance to wear and fragmentation was not linear, emphasizing

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the effect of texture on these values. The results of DWT showed that different type of andesites have different type of behavior during the breakage process. In the case of the slightly altered, vesicular andesites the degree of fragmentation compared to the altered samples was higher at lower energy levels. In the case of highly altered type of andesites the degree of fragmentation was higher at higher energy levels, leading to the assumption that the mineralogy and texture have a complex effect on the breakage process.

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222Rn ACTIVITY CONCENTRATION IN A PUBLIC FACILITY ON THE EXAMPLE OF KINDERGARTEN IN BOLESŁAWÓW

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Keywords: radon, 222Rn, indoor air, Bolesławów

Radon is a colorless and odorless noble gas with radioactive properties. Its longest-lived isotope is radon-222 (222Rn), which is formed by the decay of radium-226 (226Ra).

According to the radiation hormesis hypothesis, exposure to doses of ionizing radiation up to a certain level may have a positive effect on the human body, and above this level, it may cause harmful effects.

In Poland, according to the Atomic Law, the Ordinance was issued in areas where the average annual radioactive concentration of radon in the indoor air in a large number of buildings may exceed the reference level. One of the listed poviats is the Kłodzko poviat, in which the research object is located - a kindergarten in Bolesławów.

The kindergarten is located in an area with an average radon potential (the concentration of 222Rn activity in the soil air is 10-50 kBq/m3), on the Lądek-Śnieżnik crystalline rocks, highly metamorphized and morphologically diverse.

In one of the two rooms ("room 1") belonging to the kindergarten, renovation works were carried out before the measurements were taken, consisting of lining the floor with foil on which a screed was then made.

In the building, at the request of the Chief Sanitary Inspectorate (CSI), monthly measurements of the concentration of 222Rn activity were carried out with the use of CR-39 trace detectors. These results were converted with the use of appropriate factors into the average annual concentration (table 1).

The authors additionally carried out short-term measurements (figure 1), performed with the AlphaGUARD PQ 2000 PRO device.

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Table 1. Results of measurements of the concentration of 222Rn activity carried out in the period from October 16, 2020 to November 16, 2020, with the use of CR-39 trace detectors commissioned by CSI, including conversion to the average annual concentration

Room	^{222}Rn activity concentration (Bq/m^3)	^{222}Rn Activity concentration as a yearly average (Bq/m^3)
Room 1	400 ± 52	462 ± 52
Room 2	1200 ± 146	1386 ± 146

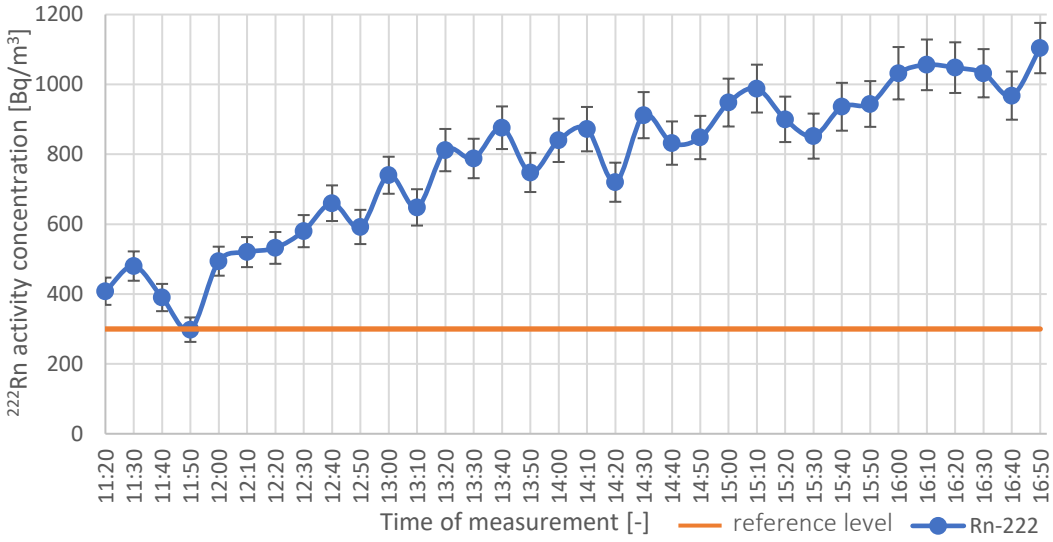

Figure 1. Results of short-term measurements of the activity concentration of 222Rn carried out in a room with a higher concentration on 04/09/2022.

Initially, the recorded lower values of the concentration of 222Rn activity were caused by the fact that the room was ventilated immediately before the start of the measurements.

Both long-term and short-term measurements showed that the reference level of 300 Bq/m3 was exceeded in both rooms.

The threefold different concentration of the activity of 222Rn in adjacent rooms may show that the penetration of 222Rn into one of them was significantly limited due to the sealing of the floor (foil, screed).

Short-term measurements showed that the initially recorded results were more than twice lower than those measured after two hours, and almost three times lower than those measured after more than five hours, from the restriction of internal and external air exchange. Thus, it can be concluded that it has a significant impact on the concentration of 222Rn activity in the indoor air.

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ENHANCING SIGNAL TO NOISE RATIO IN SEISMIC ATTRIBUTES USING THE INVERSION METHOD

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Keywords: Seismic attributes, IRLS-FS, Inversion, Hilbert Transform.

In applied geophysics, seismic attributes are used as important tools in geophysical interpretation. In most cases, results are very sensitive to the quality of imported data which mainly depends on the efficiency of the applied data processing algorithm. The transformation process from a time domain to a frequency domain is usually used in the step of geophysical data processing, due to the ability to improve the interpretation results in signal processing. The discrete Fourier transformation (DFT) is usually applied to analyze the frequency components for characterizing the complicated reservoirs. Most of the surveys contaminating noises that generate unwanted features can be incoherent or coherent. The reflection intensity attribute consider a post-stack attribute and it is useful to indicate the presence of a bright spot, gas accumulation, sequence boundaries, unconformities, and major changes in lithology. The new method is based on the development of the applied inversion-based Fourier transformation method in seismic data. It applied on the reflection intensity attribute and shows that the IRLS inversion-based Fourier transform has achieved resistance to outliers in noisy data. In a numerical test, the method was applied in a noisy synthetic seismic section loaded with different types of noises (Gaussian and Cauchy), and the results indicate the ability to reduce the noise using powerful computing systems. The procedure used multi-windows technical on the generated synthetic seismic traces and the result showed significant effects on outliers.

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QUANTITATIVE AND QUALITATIVE IDENTIFICATION OF ODOROUS GASES EMITTED FROM HIGH-TEMPERATURE PROCESSING OF CATEGORY 3 ANIMAL BY-PRODUCTS

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Keywords: high temperature animal fat production, odorous gases, biofiltration

Fetors out of industrial production is a long term problem of environmental enginery that gathers more and more society's attention. Epidemiological data shows that odors present in inhaled air cause not only disturbing discomfort but also can contribute to the development of respiratory, digestive and nervous system diseases. The value of odors emission has also became one of the key factors deciding of social and economic attractiveness of the area to choose for a place to live, invest money or local tourism development. One of industrial sectors characterized by high nuisance is high temperature processing of animal by-products category 3, including drying processes of bone-meat tissue.

Basic components of odorous waste gases generated during termical manufacturing animal material category 3 are ammonium, sulphur compounds and volatile organic compounds. Unfortunately, there is poor literature data of volatile organic compounds emission from high temperature processing of animal by-products category 3, including drying processes of bone-meat tissue. Scientists mainly focus on odors emission out of wastewater treatment plants, incineration plants, farms or chemical industry. That lack of knowledge significantly impedes the development of successful technological solutions of purifying waste process gases coming out of mentioned industrial area. Therefore, in this work, the attention has been focused on analyzing in quality and quantity of odors emission out of indicated previously industrial processes.

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DELINEATION OF GROUNDWATER POTENTIAL ZONES IN NORTHERN OMDURMAN AREA BY USING ELECTRICAL GEOPHYSICAL METHOD

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Keywords: Omdurman formation, Khartoum, Vertical electrical sounding, geophysical inversion, aquifer

The study is conducted in the north Omdurman area to delineate groundwater potential zones using geophysical method. Omdurman is the most ancient city known as the historical capital of Sudan. It is located in the western part of Khartoum state (Fig 1). The geoelectric method represented in vertical

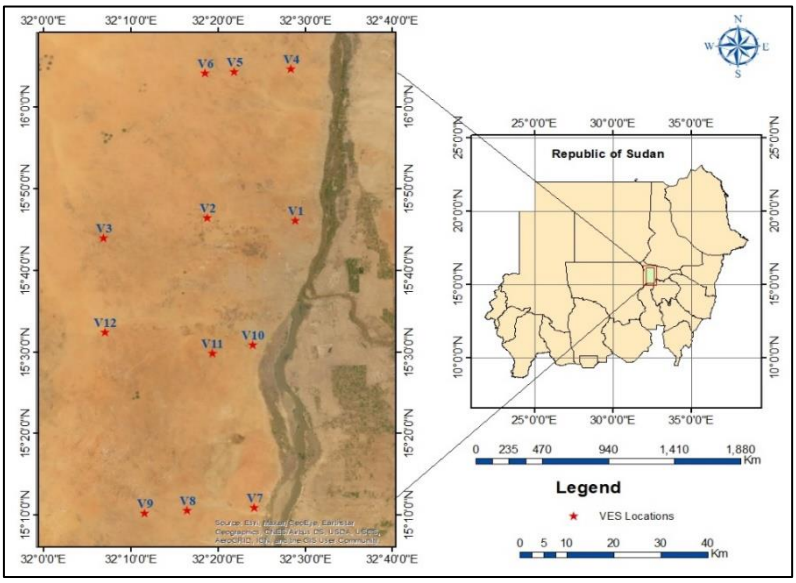

Figure 5. Geographic map showing the location of the study area in Sudan.

electrical sounding (VES) is applied to explore the availability of groundwater in the study area. The measurements were conducted using Schlumberger configuration. VES technique is well-suited for

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solving groundwater-related problems where no sufficient hydrogeological data is available. In this study, twelve VES points are measured along with four profiles (Fig. 2).

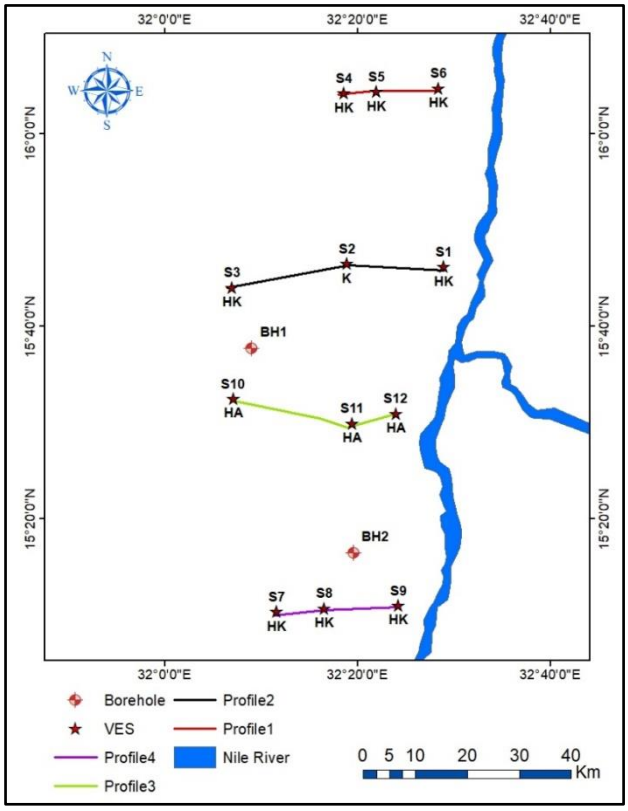

Figure 6. The type of the VES curves in each corresponding profile.

The obtained apparent resistivity is processed using IPI2WIN software. This software applies 1 dimensional geophysical inversion through which the observed data is compared to a synthetic model (Fig. 3). The acceptability of the resulted model is based on the fitness criteria between the observed and calculated curves [Bobachev, 2002].

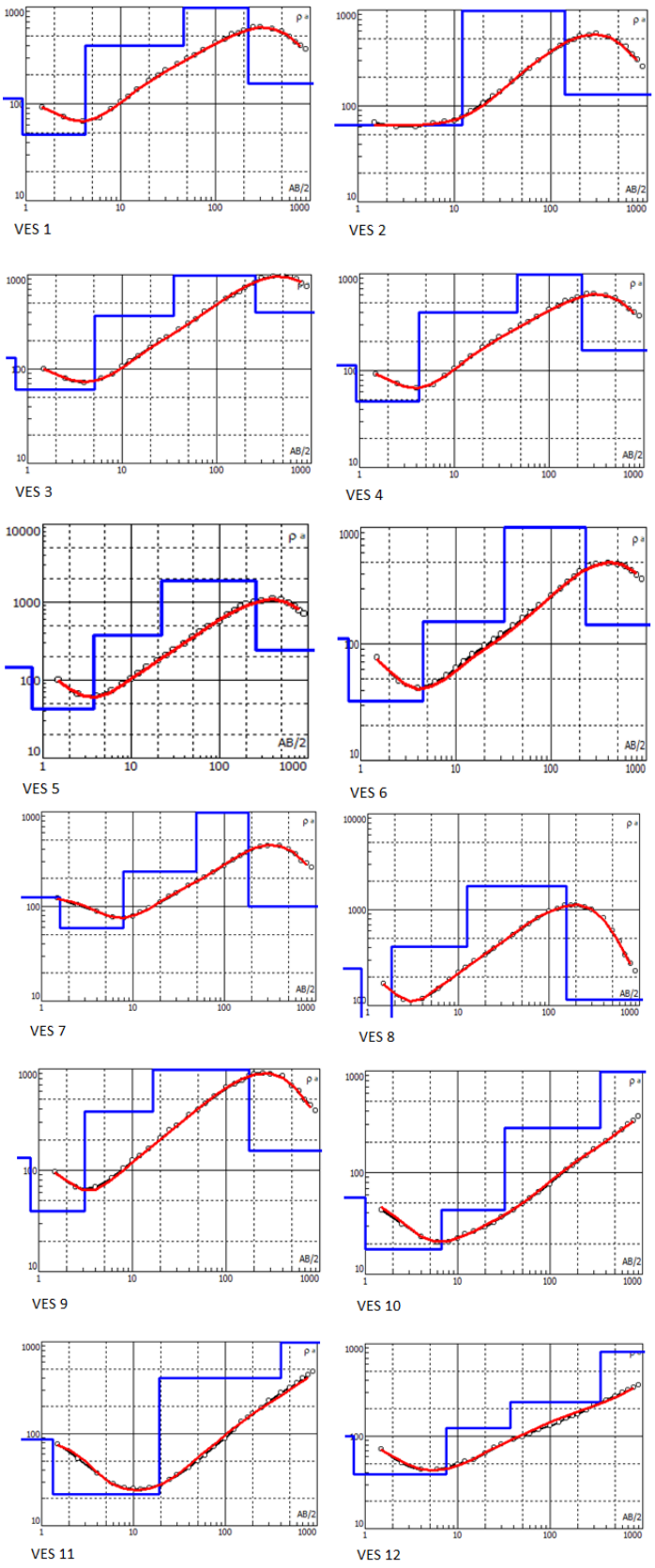

Figure 7. The inverted VES curves by comparing the observed and synthetic curves.

In a model-based inversion, the problem of ambiguity arises in which the same model can be referred to different geological and hydrogeological phenomena. To deal with this drawback a priori information needs to be added to the resulted model. The integration of electrical and geological data led to a reliable interpretation of the geophysical model. Firstly, the curves were qualitatively interpreted to gain a general concept about the distribution of electrical resistivity with depth [Soomro et al., 2019]. The shape of the VES curves gives insight into the thickness and number of layers that make up the model. Secondly, the quantitative interpretation of the VES data implies conversion of the resistivity cross sections to hydrogeological cross section. . The main task of the geophysical inversion is to measure the parameters that cannot be directly measured [Tabbagh et al., 2007]. The application of inversion is crucial to avoid deceptive interpretation of the VES curves [Alabi et al., 2010]. Earth materials have a wide range of resistivity, ranging from extremely low to very high. This broad range of variance is due to several variables, such as mineral composition, petrophysical parameters such as porosity and permeability, and fluid contents [Maillet, 1947]. The resistivity cross sections shown in

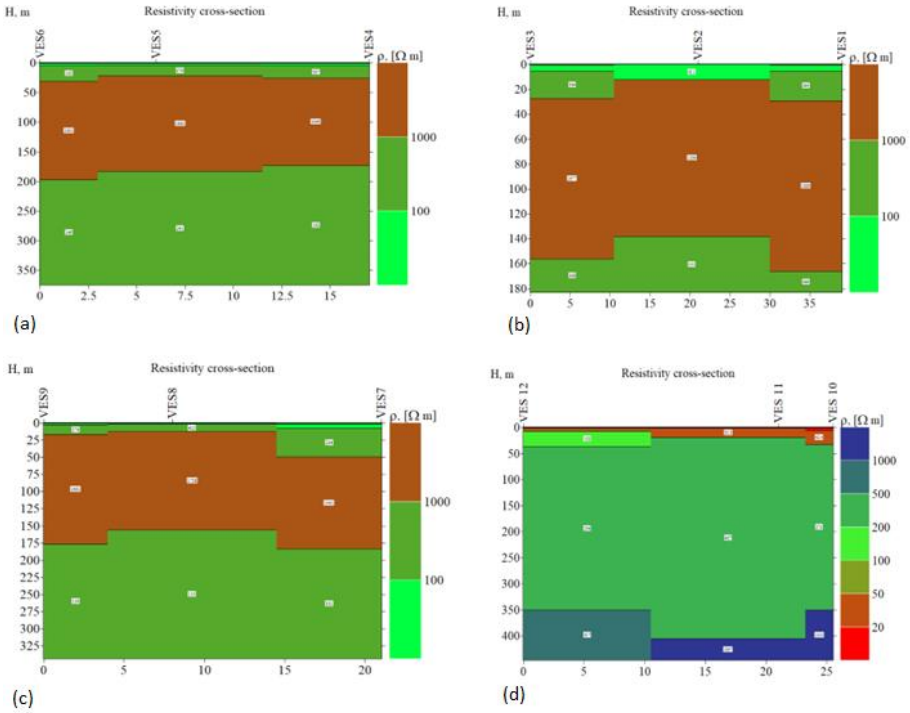

Figure 8. The resistivity cross sections for (a) profile 1 (b) profile 2 (c) profile 3 (d) profile 4.

Fig. 4 reveal the distribution of resistivity of the geological materials with depth. The obtained hydrogeological sections (Fig 5-8) revealed that the geological succession of the study area is mainly composed of five layers of recent deposits, clay, sandy clay, silicified and ferruginous sandstone, and sandstone. It can be concluded that the study area comprised of two aquifers.

Figure 5. Hydrogeological cross section interpreted from reistivity cross section of profile 1.

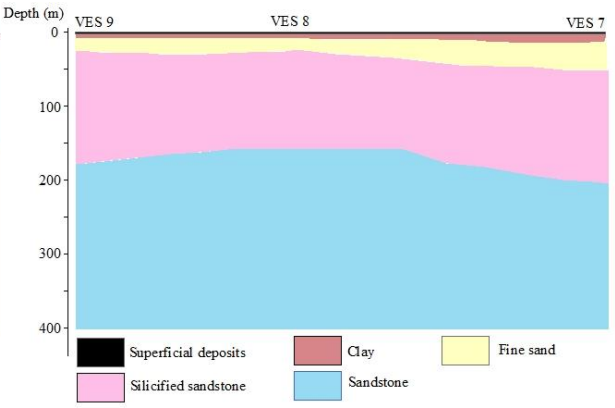

Figure 6. Hydrogeological cross section interpreted from reistivity cross section of profile 2.

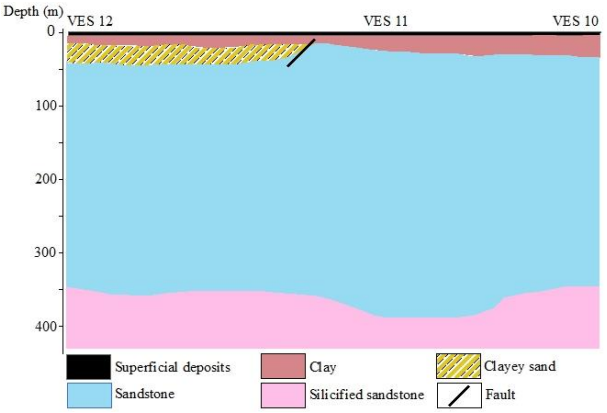

Figure 7. Hydrogeological cross section interpreted from reistivity cross section of profile 3.

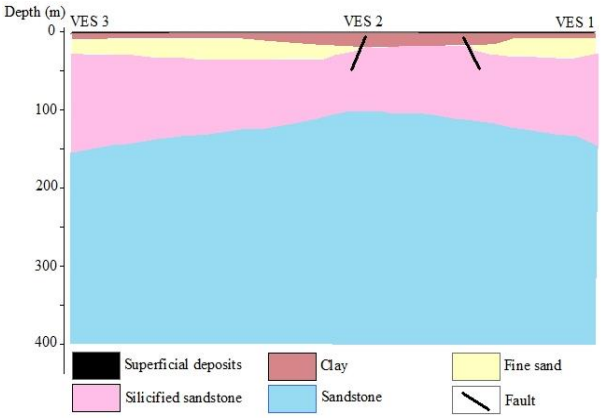

Figure 8. Hydrogeological cross section interpreted from reistivity cross section of profile 4.

The Upper aquifer with an average thickness of 30 m hosted by a fine sand layer and the lower aquifer with resistivity range from 100 to 500 ohm.m. The results indicated by [Mohammed & Hamadan, 2017] has proved that. The bottom layer in most profiles is considered saturated sandstone. This study showed high compatibility with the study conducted by [Köhnke et al., 2017] which revealed that the thickness of the lower sandstone layer in Omdurman ranges from 150 to 500 meters. This layer is considered to be the main water-bearing formation in the study area. The geoelectrical sounding methods successfully fulfilled the aims of the study. Nevertheless, detailed hydrogeological and geophysical investigations need to be carried out for a comprehensive characterization of the groundwater aquifer.

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NUMERICAL ANALYSIS OF DISCONTINUOUS BERM-SUPPORTED SHALLOW EXCAVATIONS FOR BUILDING CONSTRUCTION

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Keywords: slope stability, Mohr-Coulomb, berm, excavations

The use of berm-supported sub-vertical excavations continues to be a common strategy in shallow urban excavations when a uniform slope does not achieve sufficient safety and certain conditions are met. An image of the problem is presented in Fig. 1.

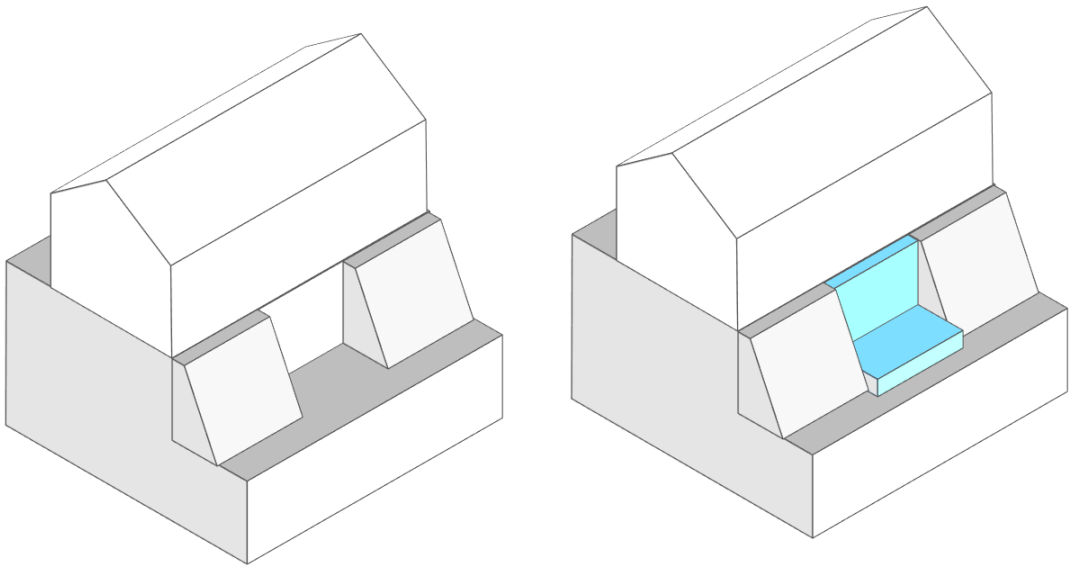

Fig 1. A schematic view or the berm-supported excavation used to facilitate a wall construction near an adjacent building

However, despite its frequent use, there is no extensive and contrasted reference available that allows its design and verification similarly as is done in the usual homogeneous slopes, either by charts such as those of Taylor or Hoek and Bray or two-dimensional numerical calculation with the Bishop method, finite elements or finite differences, among others. The difficulty associated with calculating the stability of slopes supported by berms lies in the fact that it is basically a three-dimensional problem, not admitting any of the simplifications that allow it to be reduced to a two-dimensional case and use one of the methods mentioned above. Only recently some research has deal with the problem [Cano, 2020].

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The present investigation is oriented to the modeling of an excavation supported by berms, considering its three-dimensional configuration and including as main variables the height of the slope, the width between berms, and the properties of the ground, represented with a Mohr-Coulomb failure criterion. From a large number of calculations, the necessary regressions will be obtained to allow pre-sizing and verification of the main cases that occur in practice.

A finite-element numerical model is developed using symmetry, as shown in Fig. 2, changing the height of the excavation *H* and the berm separation *B.*

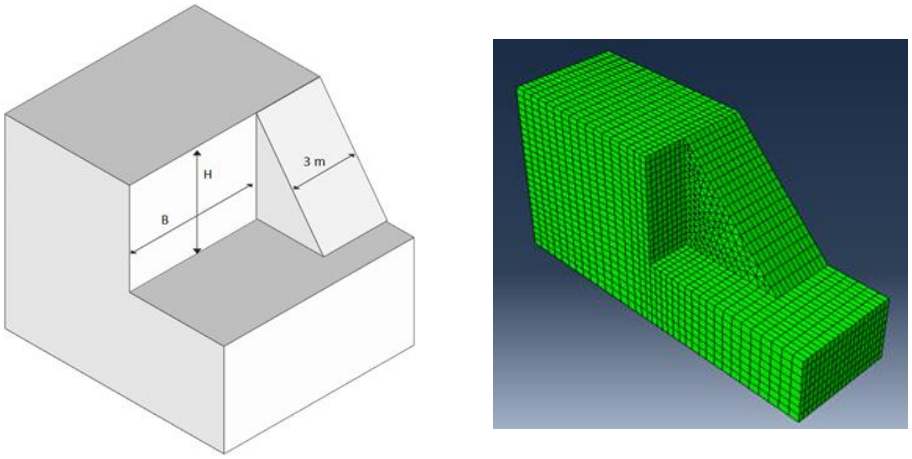

Fig 2. Symmetric representation of the problem and finite element model.

The communication presents the results obtained and details the advantages and disadvantages of the associated methodology. It is based on the Shear Strength Reduction Method (Duncan and Wright [Duncan, 2005]), using a strength reduction factor (*SRF*) that is applied simultaneously to the cohesion of soil *c'* and friction angle *φ'*, as follows:

$$c'_f = \frac{c'}{F} \qquad (1)$$

$$\varphi'_f = arctg(\frac{tg\varphi'}{F}) \qquad (2)$$

The value of the SRF for which the failure is reached corresponds to the safety factor of the slope.

The results are presented non-dimensionally using the stability number N_S

$$N_s = \frac{\gamma'.\ H}{c'_f} \qquad (2)$$

Where *H* is the excavation height, γ' is the unit weight of soil, and *c'* is the cohesion of soil.

Fig. 3 shows two different reference figures, that allow checking the bermed excavation safety.

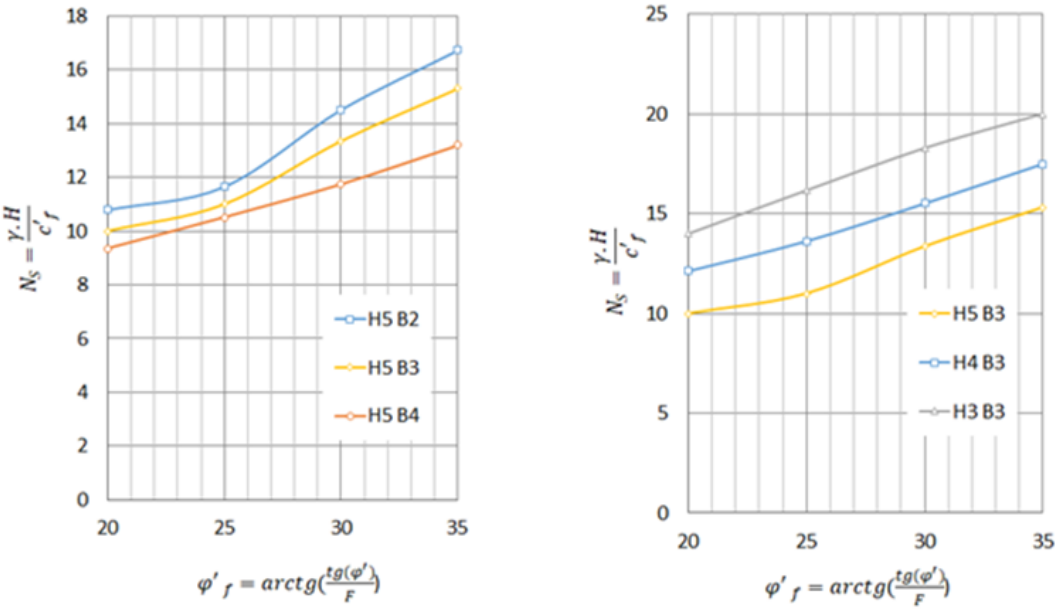

Fig 3. Two charts to check the bermed excavation safety. Left: Case with fixed height H=5 and different berm separations. Right: Case with fixed berm separation B=3, and different slope heights.

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MINERALOGICAL CHARACTERIZATION OF VEIN TYPE SULFIDE MINERALIZATION AT CINDAKKO PROSPECT, MAROS REGENCY, SOUTH SULAWESI, INDONESIA

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Keywords: Sulfide Mineralization, Ore Textures, Temperature Stability and Hydrothermal Alteration, Epithermal Type

There is sulfide mineralization vein type in Cindakko area, Maros Regency, South Sulawesi. Results of mineralogical studies on the prospects for the sulfide ore mineralization explained in the paper. Mineralization and alteration samples had been analyzed by petrographic, mineragraphic, and XRD methods. The results showed that the host rock mineralization is a basalt which is a member of the Baturappe-Cindakko Volcano in the Late Miocene age. Identified hydrothermal alteration mineral associations include quartz, chlorite, epidote, biotite, actinolite and pyrite, which are generally formed in propylitic alteration zones that are mainly characterized by chlorite. Mineralization types are crustiform-banding quartz veins, vuggy quartz and disseminated, which are contained hypogenic pyrite, chalcopyrite, sphalerite, bornite and tennantite ore and supergene ore minerals in the form of covellite. Ore textures recognized under a microscope are intergrowth, replacement, open-space filling and exsolution. Based on the interpretation of temperature stability of hydrothermal alteration minerals, it's concluded that it was formed in about 200°-320°C with the hydrothermal fluid pH almost neutral. Whole characteristics of hydrothermal alteration, ore mineral assemblage and texture, mineralization type, temperature range form and hydrothermal fluid pH indicated that the mineralization in the Cindakko Prospect is an epithermal type.

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MEASUREMENT OF NATURALLY OCCURRING RADIONUCLIDES AT THE ARCHEOLOGICAL SITE OF BAHIRI, EAST MIDNAPORE, WEST BENGAL, INDIA

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Keywords: Naturally occurring radionuclides, 238U, 232Th, 40K, Excavated sites

Naturally occurring radionuclides are primordial in nature and are present in various geological matrices. The major contributors of natural radiation are U-238 (4.47*109 a), Th-232 (1.40*1010 a), the daughter radioisotopes present in these decay series and omnipresent K-40 (1.25*109 a). Utilization of gamma-spectrometry to quantify the amount of NORM is uncommon in the field of archaeological exploration. This study explores the inventory of primitive radionuclides in an archaeological site of Bahiri (20.85° N and 87.79° E), East Medinipur district of West Bengal, India. The site is located within the sand dune ridges on the western most part of coastal Bengal, parallel to the sea, which are associated with mid-late Holocene marine transgressive phase. The material remains recovered during the excavation e.g., pot sherds, terracotta objects, beads and other artefacts, place the site within the Early Historic to Medieval period.

Soil and pottery samples, collected from the excavated trenches (Fig.1) were air-dried, pulverized and 60 g of samples were packed in air-tight petri-plates. After attaining secular equilibrium, samples were measured using High Purity Germanium (HPGe) detector having 80% relative efficiency and resolution of 1.65 keV at 1.33 MeV energy (make: CANBBERA). Respective U and Th standards were prepared from IAEA reference materials (RMs) RGU-1 (Uranium ore) and RGTh-1 (Thorium ore). 40K standards were prepared in-house by mixing weighted amount of KCl and silica.

Figure 1. Excavated Trench YB1 at Bahiri, WB; YB1 with embedded ancient potteries

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Result obtained for the soil samples showed the range of 238U activity from 22.6±1.3 to 38.8±1.7 Bq/kg. 232Th activity ranged from 59.7±4.4 to 95.2±6.9 Bq/kg, whereas 40K was in between 391.5±8.6 to 860.5±12.5 Bq/kg (Fig.2). Average 238U, 232Th and 40K activities in 11 soil samples were 30.9, 77.8, 613.0 Bq/kg, respectively. Activities of 232Th and 40K was higher than the global averages of 45 and 420 Bq/kg respectively, whereas 238U was within the limit of 35 Bq/kg.

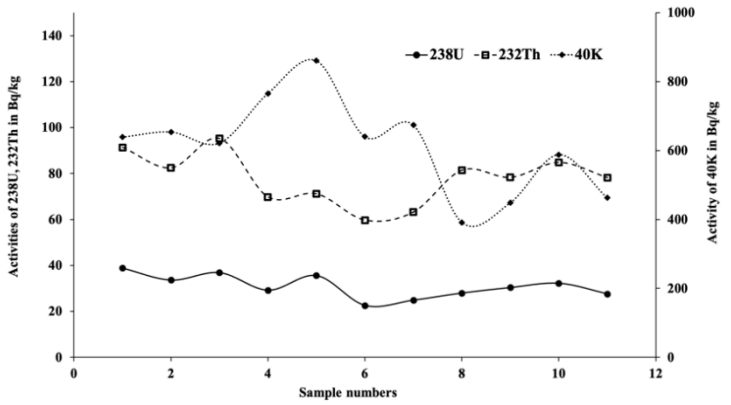

Figure 2. Activities of 238U, 232Th and 40K in soil samples

In case of the nine pottery samples collected from the same context of Trench YB1, 238U, 232Th and 40K activities ranged between 33.6±2.6 to 49.3±1.9, 66.0±5.6 to 82.4±4.7 and 666±13 to 972±13 Bq/kg, respectively.

This study is the first report on natural radiation from an archaeological site in WB, India. The obtained data reveals few important facts:

- the past geological environment has prevalence of 232Th, which may be because of its insoluble nature
- 40K activity decreased with the depth in Trench, indicating agricultural influence at the above digs
- availability of 238U and 232Th was uniform along the depth, supporting their geogenic origin.

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COMPUTER SUPPORTED SYSTEM AND GIS FOR MANAGEMENT IN THE FIELD OF ENVIRONMENTAL PROTECTION OF BASIN OF THE ARAL SEA

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Keywords: water quality, hydroecological monitoring, GIS, decision supporting system

The article is devoted to the urgent topic of creating a comprehensive geographic information system for hydroecological monitoring and decision support for the Aral Sea basin. The research results allow a more substantial assessment of the hydroecological situation. The fundamental features of the arid zone monitoring methodology are disclosed, which will help water and water organizations plan and predict the environmental status in the water sector. The results of a comprehensive analysis of the Aral Sea basin using GIS will help create a decision support system. The material also shines other aspects of GIS use on concrete examples. Uzbekistan's political and economic stability depends on adequate consumption of water resources and environmental policy. Over the past decade, we have been engaged in hydro-ecological monitoring, which resulted from GIS (Geographical Information System). The intense use of water resources within the Aral Sea basin for agricultural, industrial, and wastewater needs has resulted in the contamination of water resources by various hazardous chemicals from anthropogenic sources. Integrated planning and management of water policies are dependent on powerful tools to describe the present status and future development of the water resources sector in a country, region, or river catchments.

Most essential problems of hydro-ecology in the republic are: river pollution and return flow from the irrigation zone. In research work, information and communication technologies were used for a comprehensive analysis, according to the following plan:

1. Study of the distribution and levels of pollution in drainage and river systems adjacent to hydraulic structures of river systems, a study of the technical scheme of hydraulic and hydropower facilities (MONITORING).

2. Investigation of the peculiarities of pollution and analysis of pollutants dissolved in water to highlight the ecological situation in the adjacent territory, the peculiarities of technological schemes affecting the situation (MODELING).

3. Combining the methods used, taking into account all anthropogenic and physical-geographical factors and the influence of hydraulic and hydropower structures (SUPPORT FOR DECISION-MAKING)

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Outputs (expected results):

- The determined qualitative characterizations of contamination distribution in the ecosystem delta Amudarya and Syrdarya river.

- The hydro-ecological classification development, the modified concept of "Hydro-ecological monitoring" as a scientific base of regional hydro-ecological study processing, the evaluation criteria and applications of the concept to the environment protection.

- The contamination distribution regularities for the water of the delta Amudarya watershed, factors influencing the contamination distribution.

- Development of practical recommendations for solving different scientific and practical problems for environment protection aims; estimation of natural resources.

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ANODE MODIFICATION WITH REDUCED GRAPHENE OXIDE/FE2O3 IMPROVES ELECTRICITY GENERATION IN MICROBIAL FUEL CELL

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Keywords: MFC, anode modification, reduced graphene oxide, iron (III) oxide

In recent years, a lot of research has focused on energy recovery from biomass as an alternative to fossil fuels. Microbial fuel cells (MFCs), in which electricity is obtained by microbial decomposition of organic matter, are of great interest. The performance of the MFC depends on the electrode material and most often carbon materials with good electrical conductivity and durability are used. To increase the output power of the MFC anode material can be modified to reduce the internal resistance and increase the anode surface area. In this study, it was determined how the modification of the carbon felt anode with reduced graphene oxide (rGO) and the combination of rGO with iron (III) oxide (rGO-Fe) affected electricity generation in comparison with a control MFC. The voltages obtained in the MFC-rGO were significantly higher than in the other cells (average 0.107 ± 0.04V in the cycle). Based on the power density curves, it was found that the modification of the anode with rGO-Fe increased the power of the MFC to 4.5 mW/m2 – it was 9.3 and 3.9 times higher in comparison with the control and the MFC-rGO, respectively. As a result of anode modification, the internal resistance of the cell was reduced from 1029 Ω for the control MFC to 370 and 290 Ω for MFC-rGO and MFC-rGO-Fe, respectively. The study showed that the mixture of rGO with iron (III) oxide positively affected electricity production in MFC and can be successfully used for anode modification.

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ENVIRONMENTAL CHANGES CAUSED BY THE END OF COAL MINING

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Keywords: environment, environmental hazards, environmental monitoring, mining damage, post-mining area

The paper presents the environmental impact of the mining plant decommissioning process on the example of the recently closed ,,Katowice-Kleofas" mine in Katowice in the Upper Silesian Coal Basin (USCB). Various types of environmental impacts of the mining plant being closed were analyzed.

In addition, it has been shown that even after the cessation of mining activities, the following occurs: adverse impact on the aquatic environment, air pollution, as well as harmful physical impact on the environment.

Moreover, extraordinary threats to the environment that may occur after the mine has been closed were also presented. Furthermore, how the mining exploitation affects the transformations of the area was also analyzed.

Based on the analysis of the environmental impact assessment of the closed mining plant and the occurrence of further impacts of mining exploitation on various types of areas, a new method of straightening newly erected buildings in the areas of mining damage was proposed. As well as conclusions regarding the possibility of its use in engineering practice were formulated.

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NEURAL NETWORK AND STATISTICAL ANALYSIS IN DETECTING STEEL CORD DAMAGE IN CONVEYOR BELTS

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Keywords: conveyor belts, NDT method, belt damage, neural network, statistical analysis

The Diagbelt system is used for the automatic analysis and continuous diagnostic of the technical condition of steel core conveyor belts. One of the modules of this system is a magnetic module, which consists of a magnetizing device, a measuring device, a tachometer, and a controller. The device is designed to detect magnetic field changes resulting from an interruption in the continuity of the cord. The device precisely and automatically finds the locations of damage and connections in the belt loop.

The system supports decision-making regarding the repair and replacement of belts in mines and informs about the hazards related to the condition of the belt sections or their connections in the loop. By accurately determining the condition of the core of the belts and selecting the appropriate time for their replacement, more belts removed from the conveyor are successfully renewed and returned to work in the mine.

Laboratory tests carried out with the Diagbelt system allowed to obtain magnetic signals of model damage. Based on the obtained data, a statistical analysis was performed, which allowed to determine the correlation between the input data and the class to which they belong. An analysis was also carried out using artificial intelligence in the form of a multi-layer neural network (MLP). A set of the same data was used in the conducted analyses, which made it possible to compare both methods.

Statistical analysis was based on the determination of the mean value and the 95% confidence interval for each type of damage. The analysis of Pearson's linear correlation was also carried out, which allowed us to assess the dependence of the examined parameters on each other. The analysis using neural networks showed good effectiveness of failure qualification - over 98%.

It is worth noting cluster analysis and analysis using the neural networks have so far been rarely discussed and their results presented. The results of the analysis are very promising, so it may be a right direction for further research.

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INFLUENCE OF MINING AND GEOLOGICAL FACTORS ON TERRAIN DISPLACEMENT CAUSED BY INDUCED TREMORS USING THE RANDOM FOREST METHOD

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Keywords: mining tremors, Random Forest, displacements, Mean Decrease Accuracy

Induced seismicity is a global problem that is of interest to the scientific community and industry, in particular the aspect of preventing tremors and minimizing the negative effects of seismic events. One of the negative effects of mining tremors is displacement (deformation) of the terrain surface. The main goal of this study was to determine statistically significant mining and geological factors affecting the values of maximum LOS displacements caused by mining tremors using the machine learning method - Random Forest Regressor (RFR). The Rudna mining area was selected as the research area, which can be described as a "living laboratory of mining tremors", because several seismic events with energy above 10^6 J occur here each year. The stages of research concerned: detection of LOS displacements (dependent variable) using the DInSAR method (Differential Synthetic Aperture Radar Interferometry) and the SBAS method (Small Baseline Subset) after 11 mining tremors, preparation of data on mining and geological factors (independent variables) on the basis of materials from the Rudna mine, machine learning on a set of developed variables using the Random Forest Regressor method. The data set consisted of 89 observations and 28 independent variables. The execution of the above steps made it possible to determine the statistical significance of mining and geological factors using the Mean Decrease Accuracy method (MDA), which consists in the direct measurement of the influence of each independent variables on the model accuracy (determination coefficient R^2: value range from 0 - 1.0) obtained as part of machine learning. The model used for the MDA method was characterized by R^2 at the level of 0.93. As a result, the variable duration of mining operation (CTE) had the highest statistical significance, which decreased the accuracy of the model by 0.095. The following variables had half the impact on R^2: the area of exploitation field (PPE) 0.046, the method of liquidation of the excavation with roof deflection (SLWUS) 0.040 and the average distance between the epicenter and adjacent exploitation fields (SOESP) 0.038. The obtained research results can be a source of information for the management of hazards resulting from LOS displacements during seismic events caused in the area of anthropogenic activity.

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DETERMINING OPTIMAL NUMBER AND DISTRIBUTION OF GROUND CONTROL POINTS FOR MEASURING A LINEAR INFRASTRUCTURE WITH UAV PHOTOGRAMMETRY

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Keywords: UAV, photogrammetry, Structure from Motion, ground control points

Photogrammetry with UAVs is a very popular measurement technique. It is used in many fields, including the measurement of linear infrastructures like roads, bridges or railroad tracks. The difficulty in the case of this type of objects is the inability to make a traditional photogrammetric block consisting of many rows. Additionally, the approach related to the number and spatial distribution of ground control points developed on the basis of traditional blocks cannot be implemented in this case. Therefore, it is important to conduct independent research in this area for linear infrastructures. Ground control points are used for georeferencing which is one of the most important factors influencing the final accuracy of the alignment.

The aim of a research was to perform many photogrammetric adjustment with SfM and bundle adjustment approach by varying the number and distribution of ground control points to find the most optimal solution. The images for the tests were obtained using the DJI Phantom 4 Pro v2.0 UAV, ground control points and check points were measured using land surveying techniques. 18 variants of alignment were carried out, differing in the number and distribution of ground control points. Accuracy assessment was performed based on RMS error values and Shapiro-Wilk normality tests based on deviations for additional check points. The results show that not all variants of the distribution of ground control points allow to obtain the required spatial accuracy. A particularly important issue is the arrangement of ground control points on both sides of the measured object. Increasing the number of ground control points has a positive effect on the final results. However, to obtain an optimal workflow in terms of both accuracy and time needed for measurement, fewer number of ground control points can be used with the appropriate distribution approach.

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ANALYSIS OF CHANGES OF THE VEGETATION CONDITION ON THE AREA OF THE CLOSED PROSPER-HANIEL MINE IN 1984-2021 USING MULTISPECTRAL SATELLITE IMAGES

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Keywords: Geomonitoring, Vegetation analysis, Post-Mining

Mining processes have a significant impact on the surrounding environment even after the exploitation has ceased. Today it is important to continuously monitoring post-mining processes in the areas of water management, vegetation and air pollution. In the project "Digital Twin – Integrated Geomonitoring" funded by the RAG Stiftung (no.20-0013) and carried out in cooperation with the Geological Survey of North-Rhine Westphalia, scientists are investigating the possibilities of integrating and fusing data from multiple sources (mining and geological maps, in-situ measurements, drone flights and satellite missions). The goal is to understand the causes and phenomena occurring on the Earth's surface and thus to generate a process understanding. The key issue of this project is Geomonitoring of the environment in mining areas using vegetation indicators. This paper presents an analysis of the vegetation health of the cover for the period 1984-2021 using selected remote sensing indicators: NDVI, GNDVI, EVI, SAVI, MSAVI, NDWI and MNDWI. The studies indicate the possibility of long-term spatial-temporal observations of selected test areas in order to observe the impact of deterioration processes in the area of the closed Prosper-Haniel mine.

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ANALITICAL AND NUMERICAL ANALYSIS COMPARISON OF THE BEARING CAPACITY OF A PILE TIP ON A ROCK MASS

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Keywords: DLO method; bearing capacity; deep foundations; Hoek and Brown failure criterion; finite difference method.

This paper research the different approaches to calculating the ultimate bearing capacity of the tip of a pile embedded in a homogenous rock mass characterized by the modified Hoek and Brown failure criterion. The main objective is to analyze the performance of the novel Discontinuity Layout Optimization method (DLO) developed by Smith and Gilbert [Serrano, 2014], which directly calculates the limit load, instead of using a load convergence scheme. The DLO results are validated against the available analytical solution [Smith, 2007] and the Finite Difference Method results.

Perfect plasticity, plane strain conditions, associated flow rule, the modified Hoek and Brown failure criterion, and weightless rock media are considered in all models (reproducing the analytical conditions). Besides, the geometric characterization of the pile includes the width (B) and the pile length embedded in the rock stratum H_R. A non-resistant soil layer (height H_S and density γ_S) is assumed to be resting on the rock (due to its low resistance in relation to the underlying ground) and the corresponding pressure is exerted upon the rock surface, as explained in Figure 1.

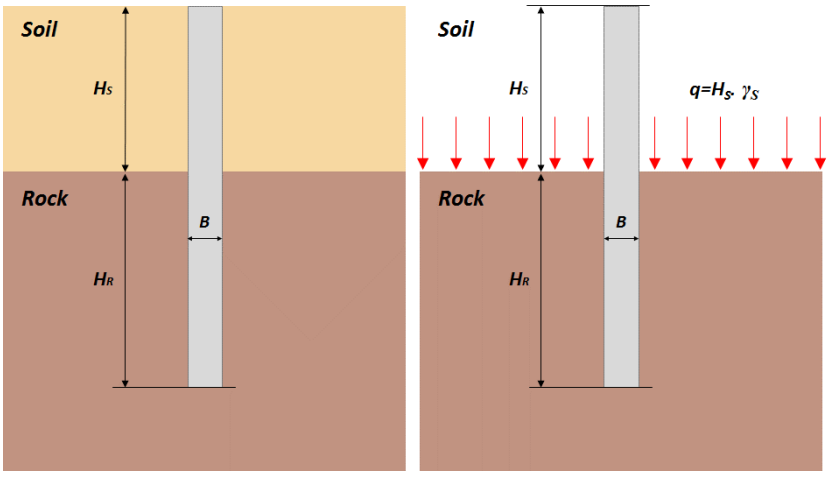

Fig. 1. Sketch of the problem and simplified model.

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The comparison between solutions is expressed by a percentage difference considering the analytical solution $P_{h,SO}$ or the numerical solution $P_{h,num}$ (in particular $P_{h,DLO}$ and $P_{h,FDM}$), as a reference:

$$\Delta P_{h,analit.} = \frac{P_{h,num} - P_{h,SO}}{P_{h,SO}} \quad (1)$$

$$\Delta P_{h,num.} = \frac{P_{h,FDM} - P_{h,DLO}}{P_{h,DLO}} \quad (2)$$

Results relative to DLO and FDM differences against the analytical solutions are shown in Fig. 2. Although most values fail between -10% and 10% error, there are some that even reach a 40% error. This behavior may be related to cases for which rock mass has small values of m_0 and high values of H_r, but they appear to depend on the different hypotheses and simplifications adopted to the analytical model.

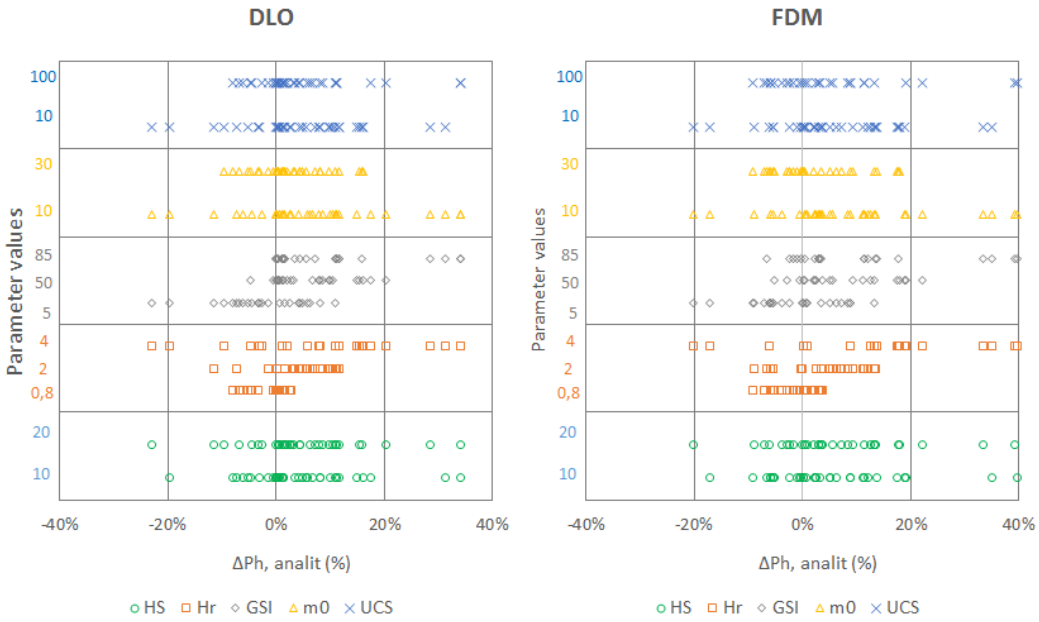

Fig. 2. Parameter dependence of $\Delta P_{h,analit}$ between the analytical solution and the DLO numerical results (left), and FDM numerical results (right), following equation (1)

This latter hypothesis seems to be supported by the strong coincidence between results using DLO and FDM, shown in Fig. 3.

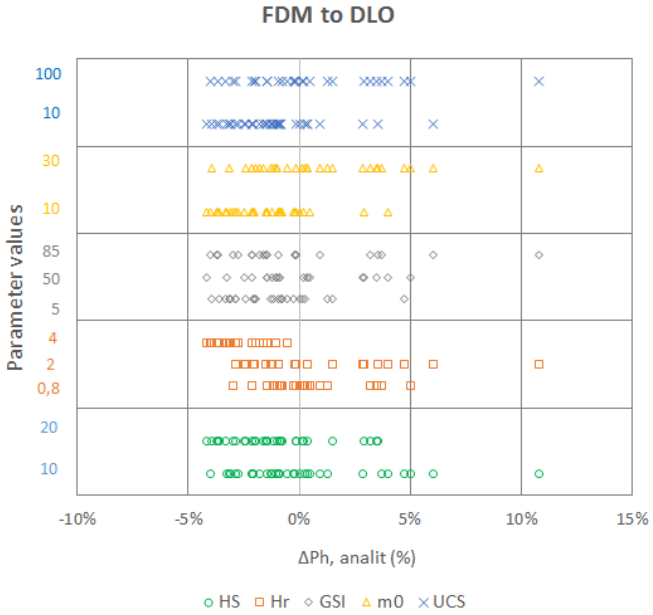

Fig. 3. Percentage difference $\Delta_{Ph,num}$ between the FDM and the DLO results following equation (2)

The above-mentioned differences point toward some limitations of the analytical solution that should be analyzed in detail.

The main issues related to the DLO method are also analyzed, focusing on the linearization of the Hoek and Brown failure criterion of the rock, and on its accuracy depending on the number of discretization nodes. From the analysis, DLO demonstrates to be a very efficient and accurate tool to address the tip-of-pile bearing capacity, presenting considerable advantages over other methods.

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DATA OPTIMIZATION FOR THE KNOWLEDGE BASES IN OIL AND GAS MONITORING-WHILE-DRILLING (MWD) SYSTEMS

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Keywords: data optimization, drilling simulation, database, machine learning, Monitoring-While-Drilling (MWD)

The current research is devoted to the analysis of the stages of data preparation for the application of case-based procedures to support the technological process in the field of drilling wells for oil and gas. This domain is characterized by a high level of uncertainty about the studied objects and a high cost of making the wrong decision. To overcome the existing limitations and reduce risks, many IT companies developed and the oil and gas industry applied the knowledge-oriented Monitoring-While-Drilling (MWD) systems. To learn such systems users and developers need data selection and organization. Optimisation and improvement of databases with normalization are important components of an effective data-driven drilling process control. Due to the complexity and variety of source data, these procedures involve steps of data correction and pre-processing, which are described in detail. Thus, the essence of formal-metric aspects of data processing in solving technological problems of the drilling process is defined. On this basis, all the described operations can be reduced to operations with values presented in the form of entities with imposed restrictions for the technological parameters.

When solving problems of intelligent automation, a lack of understanding leads to the need to simulate on a model the technological process of oil and gas wells drilling. The purpose of creating models is to manage risks at all levels of the hierarchy and all stages of the life cycle. Modelling involves determining the impact of changes in input parameters, describing their dependence and determining the compliance of output parameters to the expected state.

Problems of decision-making in the technological process of deep well drilling are that in case identification using machine learning, multidimensional vectors are fed to the input. As a platform for experimental research of new models, the most dependent parameters are considered a particular indicator of such sources as semantic dictionaries of the subject area, case databases in the form of knowledge bases, similarity metrics, adaptation and configuration containers. The analysis of the effectiveness of computer simulators for complex technological processes is given.

The presented concept allows concentrating expert experience in the subject area and satisfies the criteria of the knowledge sources required for the functioning of case-based reasoning (CBR). The main requirement and potential of artificial intelligence is the ability to build systems that can be learned. It is determined that CBR (precedent-based reasoning) is one of the effective methodologies for building knowledge-oriented MWD systems, where the central element is past expertise in the form of case studies (precedents). The more such cases, the higher the quality of machine reasoning, which is

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expected to solve the problem. The existing cases in the database serve to refine the design solution and allow adaptation of existing results as the sets of technological parameters to certain given initial conditions imposed as constraints. The decision is considered correct if it satisfies the imposed constraints.

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DEVELOPMENT OF HOLISTIC EXPLORATION SOLUTIONS ENABLING OBTAINING CHROMITES OF IMPROVED PHYSICOCHEMICAL PARAMETERS, USED FOR THE HIGH-ALLOY ADDITIVES PRODUCTION

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Keywords: chromites, podiform, exploration

Exploration for podiform chromite deposits has been a challenge because of the unpredictable nature of their occurrence [Mosier L.D., et al. 2012]. In most locations, the podiform chromite deposits appear to be randomly distributed in the ultramafic rocks, which makes exploration difficult. Although podiform chromite deposits are associated with dunite bodies, not all dunites contain podiform chromite deposits, and dunite bodies themselves appear to be randomly distributed in the peridotite [Wells et al., 1946]. Syngenetic nature of chromite deposits creates several issues for explorers. Chromite deposits don't create any alteration in the surrounding of mineralisation which could be an indicator for tracing and locating mineralisation occurrence. Mineralised bodies usually occur within dunite rocks but there are several cases that harzburgites play a significant role of hosting rocks. Moreover dunite bodies as well as chromite pods are randomly distributed within ophiolitic complex. Unpredictable nature of chromite mineralisation refers also to the size and grade of ore bodies. The exploitable deposits consist mainly of massive ore as lower grade deposits are usually undetectable by indirect surveys. All these issues make chromite exploration difficult and up to date there is no simple solution either pathway for effective and low cost exploration methodology.

PROXIS Sp. z o.o. from Poland executed a project "Development of holistic prospective solutions enabling obtaining chromites of improved physicochemical parameters, used for the high-alloy additives production". Project no. POIR.01.02.00-00-0166/16-00 co-financed within the Smart Growth Operational Programme 2014-2020, Measure 1.2. "Sectoral R&D programmes - INNOSTAL".

The scope of the project included geological mapping and sampling, laboratory mineralogical, petrographic, geochemical and physicomechanical analysis of collected samples, rock analysis with a portable XRF, geoinformatics (remote sensing) analysis with development of a chromite-bearing rocks detecting algorithm, application of structural analysis results, relevant selection of geophysical methods followed by geophysical surveys, drilling tests with analysis of obtained core samples verifying previous research, correction of geo-it algorithm and development of a comprehensive method for prospecting chromites during the stage of development works.

Gjakova and Ljuboten ultramafic ophiolitic massives in southern Kosovo were selected for testing exploration methods. The developed innovative method enables:

- prospecting fields with difficult access due to the complex topography of the area

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- significant acceleration of mapping due to hyperspectral diagnostics narrowing search area to about 40%
- more accurate prediction of location of geophysical profiles saving time and costs
- limiting invasiveness of prospecting project due to more accurate identification of drillings location at the stage of exploration reducing number of drillings by min. 20%

Developed method might be also used in exploration of other types of deposits, e.g. VMS, magmatic, exhalation - intrusive, hydrothermal and pneumatolytic using structural and lithological trends. These include deposits of zinc, lead, copper, tin, tungsten, tantalum, niobium, iron, nickel, cobalt, lithium, gold, silver, molybdenum and rare earth elements (REE).

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MINERALOGY, CHEMISTRY AND AGE OF CASSITERITE FROM BUGARURA – KULUTI DEPOSIT, KARAGWE – ANKOLE BELT, RWANDA

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Keywords: CASSITERITE, TIN, KARAGWE-ANKOLE BELT

Geological background

Bugarura – Kuluti area belongs to The Central African Mezoproterozoic Karagwe – Ankole Belt (KAB) which together with Kibara Belt (KIB) forms one of the world's largest Ta–Nb–Sn–W province [HULSBOSCH, 2019]. This metallogenic province stretches for over 1300 km from southern Uganda through north - western Tanzania, Rwanda, Burundi to the eastern part of Democratic Republic of Congo. The KAB consists mainly with siliciclastic pelite and arenite turbidite sequences which underwent a regional low-grade, greenschist to low-grade amphibolite (BAUDET *et al*. 1988). The sediments of the KAB were intruded by bimodal magmatism resulting emplacement of the older granites called G1-G3 (1375 Ma) [TACK *et al*., 2010] and the younger granites called G4 (986 ± 10 Ma) [TACK *et al*., 2010]. Granites "G4" are considered as the source of Sn, Ta-Nb and W mineralization and they have been described as F – poor, B – rich, non-deformed equigranular, peraluminous leucogranites (HULSBOSCH, 2019). The younger magmatic event was followed by emplacement of LCT pegmatites with Ta-Nb-Sn mineralization and hydrothermal quartz, quartz-muscovite veins with Sn and/or W mineralization [HULSBOSCH, 2019].

Results and discussion

The cassiterite from all of the type of deposits has common features like twinning, moderate to intense pleochroism, intense colorful anisotropy and mineral inclusions. However chemistry of cassiterite, quantities and chemistry of mineral inclusions varies in different style of deposits. Moreover, macroscopically, cassiterite shows variations in its size and distribution. The cassiterite from pegmatites is very fine-grained and occurs with Ta-Nb mineralization in kaolinized albite, muscovite and quartz zones. The size of crystals rarely exceeds 1mm. Single crystals contain numerous mineral inclusions of columbite group minerals. Chemically, cassiterite has elevated Zr, Ta, Nb and decreased Ti concentration compared to greisen and vein type. The cassiterite from greisen is chaotically distributed in the ore body and size of single crystals is around 1cm. Mineral inclusions are composed of columbite group minerals which locate in brighter zones of mineral. Cassiterite has also similar to pegmatite chemical composition with elevated Zr, Ta, Nb and decreased Ti concentration. Hydrothermal quartz veins are the richest in Sn mineralization. The cassiterite concentrates as discontinuous pockets in muscovite selvages and on the contact with quartz. Mineral inclusions are very rare compared to greisen and pegmatite type. They are composed of rutile, ilmenite and rare columbite group minerals. Contrary to greisen and pegmatite, the vein type cassiterite has elevated Ti and decreased Zr, Ta, Nb. Fe + Mn of all cassiterite minerals, show positive correlation with Nb + Ta which indicate magmatic evolutionary

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path. This confirms field observations and radial position of deposits around parental granite. The U-Pb dating on cassiterite revealed two distinct precipitation periods. First, a wide period stretching from 951±3Ma to 1016±4Ma, and second, from 833±20Ma to 854±22Ma. The older one covers late Mezoproterozoic and early Neoproterozoic G-4 magmatic event related to a post-compressional relaxation event related to Rodinia amalgamation [Tack et al., 2010]. The younger one might be related to final Rodinia amalgamation [Zhao et al., 2021] or within-plate and rift-related magmatism known in central and southern Africa [Hanson, 2003].

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APPLICATION OF ULTRASONIC SENSORS IN MEASUREMENTS IN MINING

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Keywords: ultrasonic sensors, NDT testing, conveyor belt, thickness measurement

As part of the LIDER X project (No. 0227 / L-10/2018) a system for continuous thickness measurement of conveyor belts in motion is being developed. The designed device in the measurement process uses the differential method - two measuring heads are placed on both sides of the tested object (above and below), and ultrasonic distance sensors installed on the heads measure the distance of the sensor from the top or bottom cover.

The main element of the measuring system is the ultrasonic distance sensor. The sensor measures the distance by emitting an ultrasonic wave (with a frequency above 20kHz), which propagates in the medium, reflects off the obstacle, and the reflected wave is received by the sensor. The time between sending the wave and its reception (measured internally by the sensor) allows to determine the distance between the sensor and the obstacle, thanks to the knowledge of the speed of propagation of the wave with the emitted frequency in the air. The sound wave is a mechanical wave, and therefore it propagates in the medium as its disturbance. The changing speed of particle vibrations also changes the speed of mechanical wave propagation in it. The measure of the average kinetic velocity of the medium's particles is temperature, therefore the speed with which the ultrasonic wave propagates in the medium depends on the temperature of the medium.

The problem with temperature is in most cases solved at the stage of production of the sensor itself - ultrasonic sensors internally measure the temperature and introduce appropriate temperature compensation, which, unfortunately, is one of the most important factors affecting the accuracy of the measurements. The second important parameter influencing the accuracy is the error in measuring the time between the wave transmission and reception. Despite maintaining a stable temperature and minimizing the error resulting from the measurement of time, distance measurement with ultrasonic sensors may remain distorted. The emitted wave propagates in the medium, reflects from the obstacle and returns to the sensor, but if the surface of the obstacle is not smooth, the wave reflects at a different angle than it would reflect from the flat surface and returns to the sensor after many other reflections or not at all and the value at the sensor output may be disturbed.

The impact of measurement errors can be minimized by using higher quality components, but the problem related to the distortion of the value measured by the sensor causes that some of the measurements obtained in industrial conditions must be rejected, and the missing values at the measurement grid nodes must be interpolated. The interpolation is not a problem due to the multitude of available methods, the challenge is the proper way of searching for nodes in which the value is distorted, and not caused by a significant loss.

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ASSESSMENT OF DAMAGE FROM SEISMIC RISK OF HIGH-MOUNTAIN BREAKOUT LAKES IN TASHKENT REGION

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Keywords: seismic risk, high-mountain breakout lake, damage, breakthrough wave, decision-making system

In mountainous regions throughout the globe there are many outburst-prone high-mountain lakes, which pose a great danger to the lower regions. The mountainous regions of the Tashkent region have about a dozen such dangerous high-mountain lakes. In the valleys of the Pskem and Koksu rivers, there are high-mountain lakes of the dam type of origin, formed as a result of the blocking of the riverbed by a large volume of rock mass.

The largest lakes include the high-mountain lakes Shavorkul, Bolshoy Ikhnach, Nizhniy Ikhnach and Koksu. The structure and composition of the rock mass that overlaps the beds of these rivers is unknown. When strong earthquakes occur in the studied objects, the stability of the rock mass may be disturbed and may lead to its destruction. As a result, a high-mountain lake can break through and a breakthrough wave can form. This wave, when the lakes break through, will spread downstream, causing great damage to the coastal areas of the rivers.

As the analysis of the available literary sources shows, at present there is no computerized seismic risk assessment system and an assessment of the possible damage emanating from the threats of a possible outburst of the high-altitude lakes Shavorkul, Ikhnach Bolshoy, Ikhnach Nizhny, and Koksu. The main purpose of the research is to develop a system for assessing hazard and risk zones in case of a possible outburst of high-mountain lakes in the Tashkent region under the influence of an earthquake. To achieve this goal, the following tasks were solved: Determining the parameters of the breakthrough wave formed as a result of the breakthrough of natural dams of these lakes; Determination of flood zones in the event of a breakthrough wave.

Theoretical and experimental research methods, topographic map digitization methods based on modern GIS technologies, methods of mathematical statistics and system analysis were used to fulfill the research tasks. To clarify the danger of the natural dams of these lakes, an expedition was organized and joint overflights and visual studies of their general technical condition were carried out with the services of Uzhydromet and the Ministry of Emergency Situations of the Republic of Uzbekistan. At the same time, at this stage of the research, the coordinates of the location of these high-mountain lakes were specified in order to plot these high-mountain lakes and digitize them on the ArcView 3.2.a platform. Modeling of the occurrence of emergencies on the high-mountain lakes of the Tashkent region in the event of complete or partial destruction of natural dams was carried out. On the basis of topographic material, cross-sections of the Pskem and Koksu river beds were compiled.

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To carry out calculations and determine the main hydraulic parameters of the breakthrough wave and determine the zones of flooding during the passage of this wave, primary material was collected, which was provided by Uzhydromet, the cartographic center "Uzgeodezkadastr":

1) Uzhydromet

• Schematic maps of bathymetric surveys of high mountain lakes Shavorkul, Ikhnach Bolshoy, Ikhnach Nizhny, Koksu;

• Maximum volumes of lakes;

• Lengths of the breakthrough wave from the above lakes to characteristic objects

2) Uzgeodezcadastre (cartographic center)

• Topographic maps in scale M 1:50000; M 1:25000.

To determine the main parameters of the breakthrough wave, which can be formed as a result of the breakthrough of natural dams of the high-mountain lakes of the Tashkent region Shavorkul, Bolshoy Ikhnach, Nizhniy Ikhnach and Koksu, design targets were marked on the rivers. On the Pskem River, which is fed from Lake Shavorkul, 12 calculation cross sections were planned. On the river Ikhnachsay, which is fed from the lakes Big Ikhnach and Nizhniy Ikhnach, 3 calculation cross sections were planned. On the Koksu River, which is fed from Lake Koksu, 5 calculation cross sections were planned.

According to the available method for calculating a breakthrough wave, its main parameters, wave height, propagation velocity of a breakthrough wave at certain distances, and the travel time of this wave to certain distances are determined.

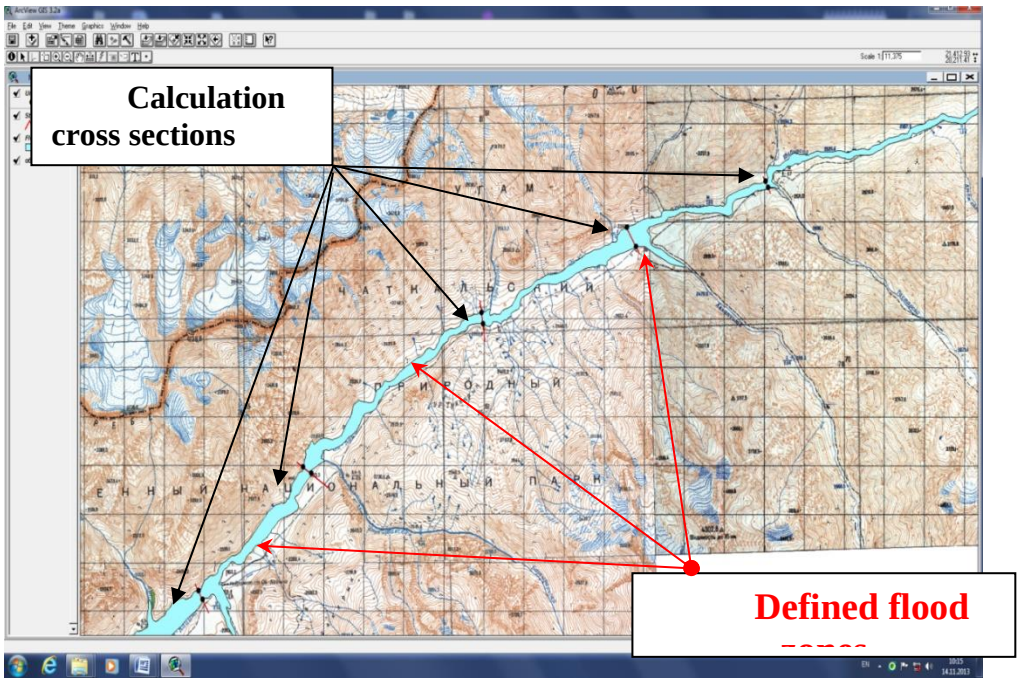

Figure 1. Computerized decision support system for the prevention and identification of hazardous flood zones along the Pskem and Koksu rivers.

On the basis of the calculation method, zones of possible flooding were calculated and plotted on a digital map in case of complete and partial destruction of the dams of high-mountain lakes.

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ROBUST SWITCHING KALMAN FILTER FOR DIAGNOSTICS USING LONG-TERM CONDITION MONITORING DATA IN THE PRESENCE OF NON-GAUSSIAN NOISE

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Keywords: Condition monitoring, long term data, switching kalman filter, non-Gaussian noise, robust method.

Diagnostic of vehicle health using condition monitoring data has been increasing with the growing usage of monitoring systems. Most methods used in systems work based on a pre-established fault detection threshold, while there are no specific limit values or thresholds in many cases, especially when the machine is unique. Also, in most actual applications due to the kind of process and harsh environment, the noise inherent in the observed process is non-Gaussian, making it a challenging task for conventional condition monitoring methods. This paper proposes a method according to robust switching Kalman filter for diagnostic by using long-term condition monitoring data. This framework is used multiple dynamic system models to explain different degradation stages, utilizing robust Bayesian estimation. Also, based on this fact, this approach works based on dynamic behavior; a threshold for fault detection is no longer needed. The proposed approach is applied to an actual condition monitoring dataset from bearings that prove the method's efficacy.

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ROBOT-BASED DAMAGE ASSESSMENT METHOD FOR IDENTIFICATION OF OVERHEATED IDLERS IN CONVEYOR SYSTEMS USING HISTOGRAM ANALYSIS TECHNIQUES

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Keywords: Belt conveyor, Idler inspection, Thermal imaging, Inspection robotics, Histogram analysis

Data-based robotic thermal imaging has been developed as a quality assessment tool for the precise fault detection and localization in conveyor systems. Manual investigation of thermal images can be a time-consuming and unreliable method. Therefore, in this paper, a procedure for automatic detection and analysis of overheated idlers in thermal images is proposed. Captured thermal images in real case scenarios at mining sites contain disturbances (e.g. sun reflections) which create difficulties in the segmentation of overheated idlers. For identification of hot spot areas in captured images, firstly, image processing techniques were used for contrast enhancement and brightness preservation of captured thermal images. Afterwards, we use histogram analysis methods for the identification of hot sports. A quantitative evaluation of the detection and analysis pipeline on real-world thermal images shows the reliability of our method.

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DEVELOPMENT OF MINING INDUCED FRACTURES DOCUMENTED WITH TERRESTRIAL LASER SCANNER – AN EXAMPLE FROM RUDNA COPPER MINE, POLAND

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Keywords: induced fractures, rock failure, terrestrial laser scanner, Rudna Copper Mine, KGHM.

Ollier (1978), when first describing the induced fractures he observed in granitic boulders in eastern Australia, concluded that such fractures were rather unlikely to develop in other types of rock. Years later, as the mechanism of their development was better understood, it became apparent that they are a relatively common phenomenon observed in nature and completely independent of lithology (cf. Wojewoda, 2012; Wojewoda & Ollier, 2013). Those fractures are also observed in artificially created mine workings, where the base of the rock face is loaded by the gravity induced force of the higher lying rock mass. The development of fractures is particularly well manifested in objects with clearly defined geometry. Their observation in the Rudna copper mine, which uses the room-and-pillar mining system, is therefore possible in various geological and mining situations.

Within the framework of the author's research work, one of the sites was located at the limits of the minrelized zone, where in the course of mining operations a barren zone was encountered and the building of excavations was stopped. In one of the corners of such an incomplete cross-cut of mine workings, a zone where induced fractures occured was documented and then observed with a laser scanner. The author has already demonstrated the great usefulness of this tool for documenting structural phenomena in various geological conditions (Sokalski et al., 2020). However, in this case, thanks to cyclic measurements and analyses of differential scans, it was possible to register the process of fracture development up to the point of failure of rock in a section of the mine workings.

The innovative use of the laser scanning method to document structural phenomena provides valuable support in the analysis of processes causing rock mass destruction, which may contribute to the improvement of mining safety.

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NON-OBVIOUS GEO-ENGINEERING - THE IMPORTANCE OF SCHOOL GARDENS FOR ENVIRONMENTAL PROTECTION

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Keywords: school gardens, environmental protection, education

As is well known, the world is struggling not only with the climate crisis, but also with the ecological one. This is due to decades of neglect and generational failure to think about the consequences of our actions as a community. Mankind has already destroyed or transformed at least 2/3 of ecosystems to its needs. Geoengineering raises a question about the legitimacy and ethics of innovative solutions stopping the inevitable effects of climate change. Perhaps it is worth considering the simplest solutions that may turn out to be the key to improving the state of the environment, which can be used by millions of people around the world.

One aspect that should not be forgotten is the impact that the deteriorating climate has on the economy. Preliminary results of research on climate change by Magdalena Mittermeier and Andrea Böhnisch show that the European climate is inevitably moving towards extreme droughts, that have become a permanent feature since 2015.

During the presentation, the results of next stage of own research on school gardens and their importance for restoring the balance in the environment will be presented. The vital aspect of environmental education and the role of architecture in this process will be discussed. The presentation will be a continuation of a series of papers on "non-obvious geoengineering". The methods adopted during the research are inductive and deductive. The research is primarily based on literature and subject studies, supplemented with a questionnaire and inventory research.

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[**] The research was carried out as part of the project "ClimEx-II - Climate Change and Extreme Events - Land Use Change & Droughts", research project manager: Prof. Dr. Ralf Ludwig, project implementation time: 09.2020-08.2023

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STUDY ON AN ELECTRIC ENERGY CONSUMPTION FOR BELT CONVEYOR TRANSPORTATION SYSTEM IN OPEN PIT MINE

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Keywords: belt conveyors, energy consumption, open pit mining

Belt conveyors are recognized as an effective kind of transportation in the mining industry. Among their advantages, the most mentioned are high efficiency, durability, and reliability. However, electric energy which is consumed during their operation is a significant within the mine site – even up to 50% of electric energy consumed in the whole mine. Following trends of energy efficiency policy, sustainable development, and corporate social responsibility; the problem of electric energy consumption by belt conveyors should be recognized including real conditions of their operation. That is why, performed research presents the analysis of an electric energy consumption by the belt conveyor transportation system in one of the Polish open pit mines in relation to transported amount of material, and comparison of energy performance of 6 conveyors in the system (transport the same amount of the material) considering their technical and organizational condition. As it appears the electric consumption of the system may be predicted with the use of power regression, and it indicates that the model explains 80% of the variability observed in the target variable. A comparative study shows that taking into consideration equipment, operation and technology indicators, multiparameter analysis of electric energy consumption by specific conveyors should be performed.

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Concept of loading tests of the receiving bin of retention bunker in O/ZG Rudna KGHM P.M. S.A.

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Keywords: retention bunker, receiving bin, copper mine

The use of MES-DEM numerical modeling methods allows to improve the process of designing machine systems such as ~~the~~ retention bunkers. Already at an early conceptual stage, it is possible to check many stress criteria for selected elements of the structure. Using the knowledge of the working conditions of elements and forces acting on them, advanced durability analyzes can be performed. The best parameters for simulation are those derived from measurements carried out on the structure, because they describe the real forces acting on the object. Depending on the complexity of the tested element, measurements may require a complex approach involving the selection of an appropriate measurement technique and its location.

Authors propose technical solutions which allow registration of parameters essential for validation of the receiving container model. Presented measurement techniques can be adapted to the underground in situ testing. The methodology aims to obtain data enabling the validation of the model for the full spectrum of occurring loads and to describe the load waveform of the receiver container as a bunker filling function. The result of this and future research can be used as a tool supporting the design and optimization of this type of object.

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POST-MINING GOES INTERNATIONAL: HURDLES TO CLIMATE NEUTRALITY USING THE EXAMPLE OF CHINA

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Keywords: post-mining; China; climate neutrality; structural change; sustainability

The topic of post-mining is becoming increasingly important globally in times of climate change and sustainability. This includes not only dealing with the post-mining heritage through adequate mine water management or environmental monitoring. Rather, it requires concepts for a successful transition in affected mining regions. China, as the world's largest mining country, offers an important point of reference here. In coal-intensive regions, economic viability is closely linked to the coal industry. Structural change requires additive policies and restructuring to create, on the one hand, innovative conversion opportunities such as the integration of renewable energies into existing mines. On the other hand, plant closures are followed by unemployment for former workers. Here, on the other hand, the creation of alternative employment and new incentives is needed to minimize the consequences for citizens and the environment. Nevertheless, it can be stated that it is essential to reuse abandoned mines in order to support several factors: Efficient use of existing resources, cost reduction, creation of alternative jobs, protection of industrial heritage, modernization of history, sustainability and green development. The driver behind this research is to actively contribute to a livable sustainable future, nationally and internationally. This area has many research gaps that need to be filled to promote internationalization and individual development. Therefore, the results are transferred from German experiences to an international level by taking China as a dominant coal player into account.

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ANALYSIS OF THE HANDLING AND PREPARATION OF SAMPLES IN THE RESONANT COLUMN AND CYCLIC TORSIONAL SHEAR EQUIPMENT

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Keywords: Resonant column, cyclic torsional shear, specimen preparation

In many geotechnical applications, the shear modulus G is the one that governs the dynamic behavior of the soil and many fields and laboratory methods are focused on calculating it. This is the case of the resonant column and cyclic torsional shear tests, which allow both the modulus G and the damping D to be obtained in different deformation ranges.

These laboratory tests are carried out in a triaxial cell and in both tests, torsion is applied to the upper part of the specimens, which has allowed new commercial devices to group both techniques in a piece of a single equipment. The combination of the two tests makes it possible to obtain the dynamic properties of the soil over a wide range of deformations, $10\text{-}4 \leq \gamma \leq 1\%$.

Due to the small deformations reached in these tests, less than 1%, the correct preparation of the specimens and their mounting in the triaxial cell are factors of vital importance for the reliability of the test results.

In undisturbed samples, the sample should be handled, and the specimen carved with special care, trying not to alter the structure of the original soil.

For remoulded clay specimens, static compaction in an external press and subsequent mounting on the triaxial cell pedestal are recommended. Saturation can present difficulties, as in these tests drainage and saturation can only be carried out from the bottom of the specimen. Consolidation times can be long.

Sand specimens should be made by placing a mould on the pedestal of the triaxial cell and applying a vacuum. The method of freezing the specimen is discarded due to the long assembly time.

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APPLICATION OF AN OPEN-SOURCE-BASED HANDHELD LIDAR SLAM SYSTEM FOR MAPPING A COLLAPSED ADIT

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Keywords: simultaneous localization and mapping, laser scanning, open source, robot operating system, adit

Mobile mapping systems are steadily growing in popularity for the 3D reconstruction of indoor spaces. They are becoming more and more available for end-users thanks to their simplicity in use and affordability, creating a cost- and time-effective alternative for traditional methods such as photogrammetry or terrestrial laser scanning where the resulting model accuracy would be sufficient. Handheld, backpack and robotic vision and LIDAR systems based on SLAM (Simultaneous Localization and Mapping) are becoming widely applied in industries such as construction and mining. The latter case is especially challenging since the algorithms employed for motion estimation of the sensor have to deal with disturbances such as low or uneven lighting, dust, high humidity, uneven surfaces and overall lack of distinct visual and geometric features. In our work we show the application of a handheld SLAM system, using only a rotating Velodyne VLP-16 LIDAR sensor and a Dynamixel actuator. The solution developed using open-source libraries and 3D printing rapid prototyping is capable of mapping unstructured mining environments, which is proved during the measurements of the tunnels of Gontowa collapsed adit located in Lower Silesia, Poland. Our approach integrates several components, such as generalized iterative closest points (GICP) lidar odometry, point cloud ego-motion compensation caused by the lidar and actuator rotating motions, as well as offline loop closure detection leveraging odometry-based scan merging for comparing point clouds with a GICP algorithm in a larger context. The system is integrated in a Robot Operating System environment, allowing further extension of the system or setting it up on a different machine in a simple manner. Because of the overall low costs and simplicity of creating such a mapping system, our approach could facilitate the popularization of applying 3D reconstruction and the use of 3D models in various industries, especially among small and medium companies.

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MACHINE LEARNING AUTOMATED DELINEATION OF GROUNDING LINES BASED ON SAR INTERFEROMETRY DATA

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Keywords: SAR; grounding line; machine learning; CNN; climate change

The importance of climate change observations has increased significantly in recent years. One of the key elements in which changes are occurring is the cryosphere. Paradoxically, polar regions consisting mostly of frozen water are also the fastest warming. It is therefore extremely important to conduct measurements of ice cover in these regions. One important indicator of these changes is the location of the grounding line. It is defined as the line where a glacier loses contact with the ground and becomes a freely drifting shelf glacier. One of the many possibilities to determine it is the usage of SAR (Synthetic-aperture radar) data [Rignot, et. al., 2011], since they cover a significant area and are nowadays acquired with high frequency. It is possible to detect grounding lines from above analyzing Differential Interferometry SAR (DInSAR) data where the flexure caused by tides is observable. Accuracy of this method is around 100 m which is fine compared to other methods like SAR Differential Offset Tracking (SAR DROT), Repeat-Track Laser Altimetry (RTLA) which accuracy is measured in kilometers [Friedl, et. al., 2020]. At the moment one of the biggest limitations of this measurement method is the time-consuming, manual analysis and delineation of features. A solution to this problem is attempting deep learning applications (methods/algorithms) for this purpose. That approach can significantly reduce the processing time retaining high accuracy and allowing to fully exploit the potential of obtaining source data frequently. Convolutional Neural Network usage can also produce higher quality results delineating grounding lines even in the regions where human interpreter would not [Mohajerani, et. al., 2021]. In this paper, we present one of such approaches.

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RECYCLING OF DISCARDED PHOTOVOLTAIC MODULES USING PHYSICAL-THERMAL METHODS

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Keywords: PV panel, crystalline silicon, recycling, waste, physical and thermal processes

Photovoltaic installations have experienced explosive growth worldwide since the early 2000s driven by growing industry and government interest in mitigating climate change, decarbonization, and increasing energy demand. From an estimated 1.3 gigawatts in 2000, global installed PV capacity reached 586 gigawatts (GW) in 2019, with a further increase to 4,500 GW projected by 2050. The most prevalent worry with photovoltaic (PV) solar panels, is that they age are limited and eventually must be decommissioned (which involves disassembly, recycling, and disposal). In fact, The expected average lifetime of a solar panel is 20-30 years, due to the deterioration of the encapsulated materials and wires, as confirmed by the Institute for Solar Energy Systems (ISE) in Freiburg, Germany. With the expansion of PV production capacity worldwide, a large amount of PV panel waste will be generated in the future. Global solar PV waste is estimated to reach 4–14 % (1.7 to 8 million tons) of total production capacity by 2030 and 80 -89% (approximately 60 to 78 million tons) 2050. In Europe, the estimated amount is about 10 million tons. Nonetheless, the long-term sustainability of photovoltaics will depend primarily on the success of processes to recycle the enormous amount of end-of-life panels that are expected to be generated soon, not only to avoid pollution but also to avoid depleting the planet's minerals. The IRENA (International Renewable Energy Agency) predicts that the total value of the raw materials that can theoretically be recovered from PV panels could be worth up to $450 million (in 2016 values) by 2030. Moreover, that is the amount of raw materials needed today to produce about 60 million solar panels or 18 GW of power generation capacity. By 2050, the recoverable value could be more than $15 billion, equivalent to 2 billion panels or 630 GW. Various recycling approaches have been proposed in the scientific literature, including physical, thermal, and chemical processes, which are most commonly used for recycling solar module waste. But the existing technologies and processes for PV panel recycling have not been improved to achieve the required quality of recovered raw materials and meet environmental requirements. However, the separation of the different PV panel layers or the delamination process step is the main challenge in the existing recycling process. The efficiency of this stage determines the efficiency of recovery of semiconductor materials and metals as well as the reduction of losses. Developing a sustainable, environmentally friendly recycling process and maximizing the recovery of components from PV panels at the end of their life is expected to solve the PV waste problem, which is the main objective of this work. In this study, three alternative processes for the recycling of silicon-based (mono/polycrystalline) PV panels were investigated, based on a combination of physical and thermal processes. The three alternative processes are hammer crusher followed by thermal treatment and sieve, shredder a knife followed by thermal treatment and sieve, and the thermal treatment followed by a slotted sieve. X-ray diffraction (XRD), and X-ray fluorescence (XRF) were performed to evaluate the properties of the obtained products. The novelty compared to the

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literature data is the , application of the process for the treatment of different types of panels: polycrystalline and monocrystalline, beneficiation of particle separation based on size and shape with a simple technology that meets the economic and environmental requirements. The results showed that thermal treatment followed by a slotted sieve proved to be the most effective method for direct glass recovery for all types of photovoltaic modules studied.

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POSSIBILITIES OF 3D LASER SCANNING DATA UTILIZATION FOR NUMERICAL ANALYSIS OF AIRFLOW IN MINING EXCAVATIONS

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Keywords: CFD, Mine Ventilation, Numerical Simulation, Laser Scanning

Underground mining of deposits is strongly dependent on several key processes enabling its safe operation. One of these processes is mine ventilation aimed at supplying an appropriate amount of air with a specific chemical composition, diluting harmful gases generated in technological processes and emitted from the rock mass, and ensuring appropriate climatic conditions at workplaces. For all that mine ventilation has strategic importance and is responsible for 30-40% of overall mine operation costs. A very important task is to conduct calculations and simulations to determine the airflow in ventilation networks, both existing and planned in the future, along with the progress of the mine operation. In the era of the development of modern technologies, new perspectives for changing the current approach to the design and optimization of ventilation networks are available. Their utilization may contribute to accuracy improvement, which can drive safety increases and process optimization. In this article, the authors evaluate the possibilities of using 3D laser scanning with LiDAR / Terrestrial Laser Scanner and Computational Fluid Dynamics to conduct numerical simulations of airflow in ventilation networks. The simulations are carried out on geometric models made based on point clouds collected during laser scanning in underground mining excavations.

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LARGE UNDERGROUND STRUCTURES GEOMETRY EVALUATION BASED ON POINT CLOUD DATA ANALYSIS

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Keywords: mining excavations, LiDAR, 3D model, statistical features, dimensionality reduction

As a result of underground exploitation performed by blasting technique or mechanical excavation large underground structures are created. Usually, due to the mining and geological conditions of the exploitation, obtained excavations geometry may be far from this assumed at the design stage. The geometry of the excavations is of key importance in several important stages of the technological process. Taking into account economic issues, deviations from the planned cross-section of the excavation generate additional, often considerable operating costs. If the cross-sectional area is greater than the assumed one, the ore may be impoverished, since the dimensions of mining faces are usually following the dimensions of the deposit zone. On the other hand, when the cross-sectional area is smaller than assumed, to maintain the proper operation of the mining plant, it is necessary to re-cut the excavation. It is particularly important from mine ventilation point of view, as it generates problems in supplying adequate amounts of air to work areas, as well as transport, causing significant problem for moving machines. Underground mine workings tends to change over time as a result of processes taking place in the rock mass aimed at establishing a new stress and strain state of rock mass after the excavation has been made. Considering the extent of underground mining structures, there is a need to develop a method that would allow the assessment of the geometry of workings, both newly created and existing ones, with the assumption of quick acquisition of measurement data, their processing, and analysis. Addressing those needs, in this paper, the authors are presenting a method based on a 3D point cloud of excavation geometry obtained thanks to measurements with the use of Terrestrial Laser Scanner/LiDAR, the procedure used to convert the point cloud into a spatial model of excavations, as well as data processing procedures used to extract informative parameters describing the geometry. Several statistical parameters are proposed for features analysis along the tunnel length.

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THE NEW GEOLOGY OF THE ANTHROPOCENE

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Keywords: Anthropocene, Holocene, global chemical cycles

Human civilization has grown around the stable shorelines and climate, and amid the diverse biosphere of, the last ten millennia or so of the Holocene Epoch: the latest of many interglacial phases of the Quaternary Ice Age, and the one that the created the world we live in.

The growth of human civilization has now put that stability into question. With the explosion in both human numbers and energy use since the Industrial Revolution has come sharp and large-scale changes to landscape, biosphere and climate. These rapid and large-scale changes have led to the suggestion that we are now living through the beginning of the Anthropocene Epoch - an interval of geological time dominated by human influence. The term was proposed just two decades ago by Paul Crutzen, the Nobel Prize-winning atmospheric chemist, and has since been widely used – and sharply debated.

Whether the Anthropocene will be formally accepted as a time term or not, it is, in reality, changing the geology of our planet, and therefore the working environment for the emerging generation of geologists. Within the evolving context for their work are the physical changes most strikingly represented by the spread of the 'urban stratum', the refashioning of sand, clay and limestone into our buildings, foundations and transport systems. Biological changes include the ongoing mass extinction event and the effect of invasive species (while human-made 'anthroturbation' is as extraordinary as anything in the fossil record). Chemical changes include the reshaping of the Earth's natural carbon, phosphorus and nitrogen cycles. The combined change is of a scale to leave a signal, in strata now forming, that will persist for many millions of years, but the effects of which need engaging with by human communities—including the geological community—today.

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USAGE OF MACHINE LEARNING WRAPPER METHODS FOR DRILL BIT ASSESSMENT STATE FOR UNDERGROUND DRILLING MACHINES

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Keywords: underground mining machine, machine learning wrapper, rapid model prototypes

Preparation for data science workflow considering dataset preprocessing, feature engineering, data validation, and model management consume enormous time before it can be delivered. Machine learning wrapper methods are often used to increase productivity and shorten the time to receive an insight generated by machine learning algorithms. The concept of the wrapper method relies on the evaluation of multiple machine learning algorithms and comparing them to optimize chosen metrics, which causes f.e reduction of an error for solving specific problems such as classification, regression, or time series forecasting.

Underground mining machines are a prominent data source from heavy-duty processes, where machinery park and asset management are significantly limited due to harsh working conditions. To empower the building of machine learning rapid prototypes, an open-source pycaret library can be used. This python-backed repository automates most of the data science project phase from wrapping dozens of machine learning libraries and frameworks to serving models with API using cloud computing. It becomes significant facilitation of project management using artificial intelligence.

In this paper, the process of machine learning model wrappers is presented using the dataset of the drill bit from an underground drilling machine for regression analysis. A phase of model creation, hyperparameters tuning, model ensembling, and analysis is shown. Moreover, the phase of model interpretation using the SHAP value is generated and the possibility of model deployment in the cloud services or in a local environment is described.

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FAULT DETECTION METHODS FOR IDLERS BASED ON IN-BELT IMU VIBRATION SIGNAL

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Keywords: Belt conveyor, Inertial Measurement Unit, Fault Detection, Wavelet, Hidden Markov Model.

Vibration signals measured on belt conveyor are widely used for condition monitoring and fault diagnosis of its rotating elements. Analyzing a signal using frequency or time-frequency analysis methods may provide precise diagnosis in narrow frequency band especially when the geometry of susceptible to damage elements such like bearings is known. However the measurement in real condition is contaminated with noise, an approach based on analyzing statistical features in wide frequency range is needed to be used. In recent years many different classification and anomaly detection methods have been discussed in literature. The measurement may be even more noisy if the Inertial Measurement Unit (IMU) is placed on the belt. Such a solution is nonetheless beneficial from the technical point of view. We are aiming to show that fault detection in idlers is possible to be conducted using a single IMU placed directly on the belt. Existing approaches and their results from the recent years are discussed in this paper. Different methods for the stage of feature selection and classification are presented.

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PROSPECTS OF IN-BELT IMU SENSORS APPLICATION FOR FAULT DETECTION IN MINING CONVEYORS

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Keywords: Belt conveyor, Inertial Measurement Unit (IMU), fault detection, idlers.

The belt conveyors of high power are the main transport in the industry, especially for mining enterprises. Since the total length of conveyors in the mines reaches several kilometres, the inspection of all idlers in harsh conditions is a challenge for maintenance personnel since the jamming of supporting idlers with damaged bearings causes belt overheating and subsequent fire. Conveyor belt breaking is also serious trouble.

The main methods in condition monitoring of conveyors are based on the following techniques: visual inspection; thermal imaging; contact thermocouple; sound recording; vibration measurement and magnetic sensors. Visual methods are implemented to detect damage to the belt surface while the deterioration of internal reinforcement cords and their coupling are monitored by the different magnetic sensors as well as in-belt RFID tags with appropriate external readers. Thermal imaging is efficient at the last stages of idler damage. Vibration and sound signals measured on the parts and near the belt conveyors are widely used for condition monitoring and fault diagnosis of its rotating elements but are contaminated with noise from surrounding parts and moving bulk material impacts. Although some companies propose "smart idlers" with embedded sensors, their replacement or installation of numerous additional sensors is not sufficient even in the case of wireless data transmission. Therefore, to avoid dangerous impacts on maintenance personnel during inspections in real working conditions of underground mines and to make inspections economically efficient, the special purpose robotic mobile platforms are under development.

The measurement may be even noisier if a vibration sensor is placed on or inside the belt. Such a solution is nonetheless beneficial from the technical point of view. Among advantages of such a "moving sensor", or the Inertial Measurement Unit (IMU) like the analogue of small drones, are the following: no need for additional tools for continuous motion along the full conveyor length (loop); short-time contact with every of upper and lower idlers in a certain row; economic solution for automatic data recording and wireless uploading to the one base station; a possibility to install several sensors over the belt width and near the belt coupling; different multi-axial sensors are available in one unit (accelerometers, gyroscopes, magnetometers). In parallel, some issues exist with IMU power supply, design of safe embedding into belt; dynamics interpretation of belt and idlers interaction; idlers identification; data uploading.

In this research, the authors based on preliminary measurements are aiming to show that fault detection in belt conveyor idlers is quite possible to be conducted using a single or multiply small-size

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IMU (or other type thin sensors) placed directly on the belt or inside it. The information available from the IMU sensor is discussed in this paper. Some methods for the transient signals processing when the sensor passes each idler and possible diagnostic features extraction are presented.

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ON SHADOWING EFFECTS IN THE FLOW AROUND THE GROUP OF CIRCULAR CYLINDERS IN THE GEOTECHNICAL APPLICATIONS

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Keywords: CFD, Flow around a Group of Cylinders, Navier-Stokes Equations, Numerical Simulation.

The purpose of the presented study is to investigate the influence of the distance between three infinite circular cylinders in a tandem group on their aerodynamic coefficients and the general flow pattern. The questions of the numerical simulation of viscous incompressible flow around a group of cylinders in the tandem arrangement are considered. The numerical study of the flow around the group of cylinders is based on unsteady Reynolds-averaged Navier-Stokes equations. The results are presented as a visualization of the instantaneous flow parameters and the dependencies of the averaged drag coefficients on the distance between the cylinders. Following the previous investigations, the flow parameters were chosen in a little-studied range, corresponding to the Reynolds number of 120 for a standalone cylinder. The distances between the centers of neighboring cylinders ranged from 1.1 to 6.0 cylinder diameters. Three characteristic flow patterns are distinguished depending on the distance between the cylinders. The first one is a steady-state flow similar to the flow around the standalone cylinder. This flow pattern is formed when the distance between the cylinders is less than three diameters. Increasing the distance between the centers up to four diameters produces the second flow pattern. The vortex street is formed behind the group while the flow between the cylinders remains steady. Further increasing the distance between the cylinders causes the formation of the third pattern when the flow between the cylinders becomes unsteady as well. The averaged drag coefficients for each cylinder in the group are obtained. The presented work helps better to understand the flow structure around the group of cylinders and can be used at the design stage in various engineering applications, including cooling towers, heat exchanger tubes, chimney stacks, marine platforms, and high-rise buildings.

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SUPER-RESOLUTION OF MULTISPECTRAL SATELLITE IMAGES USING SIMPLE CONVOLUTIONAL NEURAL NETWORK

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Satellite images are a powerful source of data used in many issues important to the environment of the planet Earth. One of the main missions which sourced this type of data is Sentinel-2 carried on by the European Space Agency (ESA). This data is widely used by its public and free access and high revisit time (approximately 5 days). Due to the specific design of the sensor, the data contains 13 spectral channels with different spatial resolution (10m, 20m, 60m per pixel). For many tasks this resolution is enough but for some applications the higher is needed. This work focused on the method to enhance spatial resolution of lower resolution bands of Sentinel-2 (20 m) to 10 m resolution. Compared to pan-sharpening methods used before (e.g. PCA, IHS), neural network methods prove better results in almost every performance metric. In this work method based on super-resolution convolutional neural network (SRCNN) is proposed. Deep learning models, which were created and trained on standard images (R, G, B) cannot directly translate well to multispectral images. The series of amendments was done to adapt the model for remote sensing purposes. Pairs of images were prepared: high resolution (HR) as a reference data (10 m R, G, B and Nir bands), and low resolution (LR) as (20 m R, G, B, Nir bands). Some different ways of data preparation were made for testing. Also modifications of the network architecture were implemented such as additional layers and residual connections. To assess the results two types of metrics were used: with and without references. Peak signal to noise ratio (PSNR) and structural similarity (SSIM) are metrics widely used in image processing to compare similarity of two images. Whereas more popular in remote sensing images metrics where used: Spectral Angle Mapper (SAM), Universal Image Quality Index (Q-index), *Erreur Relative Globale Adimensionnelle de Synthese* (ERGAS), Spatial Correlation Coefficient (SCC), and without reference Quality No-Reference (QNR). Moreover, a novel solution to assess the image quality based on deep network was introduced to satellite data - Learned Perceptual Image Patch Similarity (LPIPS). The obtained results were compared with traditional pan-sharpening methods and higher scores were gained for the proposed neural network method. Finally, attempts have been made to explore the potential of super-resolution for other remote sensing tasks such as land use and land cover classification or object detection.

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