



XXVI CPSYS

Conference of PhD Students and Young Scientists

Interdisciplinary topics in mining, geology and geomatics

Wrocław, October 22-23, 2026

BOOK OF ABSTRACTS

Editor in chief: Justyna Woźniak

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**KEYNOTE SPEAKER**

Mining Geomatics Body of Knowledge: A First Framework and the Emerging Role of GeoAI

Artur Krawczyk^{1*}¹AGH University of Krakow**Corresponding author: artkraw@agh.edu.pl*

Compiling a body of knowledge in the field of mining geomatics requires linking its conceptual foundations to the technologies used for organising, transforming and interpreting spatial data in mining operations. The proposed Mining Geomatics Body of Knowledge (BoK) structures the relationships between knowledge areas, processing methods and practical competencies. Its technological dimension is illustrated through complementary solutions showing how these principles translate into data exchange, geometric modelling and automated interpretation. As part of the mining geomatics concept, the PWEG application was developed to support both reading and writing mining datasets in GeoPackage format, establishing a link between application-level processing and data storage in a portable spatial database. Another solution enables the conversion of two-dimensional vector representations of longwall faces into three-dimensional models of mine workings. A further approach extracts vector representations from point cloud scans. Machine learning-based recognition of mine workings extends these capabilities to include automated interpretation and provides a transition to geospatial artificial intelligence (GeoAI). GeoAI is analysed as a means of combining spatial data processing with the identification, classification and interpretation of mining objects. Together, these developments provide technological examples for refining the Mining Geomatics BoK and identifying the competencies required to implement and integrate its methods. This publication was funded by the “Excellence Initiative – Research University” (IDUB) programme, Action 21, at AGH University of Krakow.





KEYNOTE SPEAKER**The on-going reshaping of the geospatial sector**Fabio Remondino^{1*}¹Fondazione Bruno Kessler, 3D Optical Metrology Research Unit**Corresponding author: remondino@fbk.eu*

The geospatial sector is undergoing a profound paradigm shift, evolving from a discipline traditionally focused on mono-sensor spatial data acquisition and offline processing into an integrated ecosystem of real-time large-scale high-resolution spatial intelligence. This transformation is driven by the rapid democratization of multi-source sensors and data (e.g. high-density mobile/aerial LiDAR, aerial/UAV photogrammetry, hyperspectral images, spaceborne Earth Observation, environmental sensing networks, etc.) paired with advanced information extraction methods, novel 3D representations and modeling solutions. These innovations mark an unprecedented convergence of remote sensing, photogrammetry, computer vision and computer graphics. By coupling this convergence with Geospatial AI (GeoAI) foundation models, the geospatial sector is changing its way of performing 3D modeling, monitoring, documentation, mapping, etc. The talk explores how this cross-disciplinary convergence is reshaping spatial data processing pipelines, enabling dynamic high-fidelity Digital Twins and redefining the skills required for the next generation of geospatial scientists and engineers.



KEYNOTE SPEAKER

Graduate Students as Drivers of Global Innovation in Geomatics: Lessons from the University of New Brunswick, Canada

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This talk will first introduce the past successes of the graduate students in the Department of Geodesy and Geomatics (GGE) at the University of New Brunswick (UNB), including the contributions to Google Maps. The talk will then introduce three recent graduate research results: (1) forest inset detection using space-based hyperspectral imagery and machine learning, (2) forest canopy height estimation using 2D satellite imagery and deep learning, and (3) spatial resolution improvement of satellite imagery using generative AI.

KEYNOTE SPEAKER

The Use of Earth Observation Technology in the Mining Industry

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Earth observation (EO) data have become an important source of information for the mining industry, offering consistent, repeatable and large-scale data throughout the entire mine life cycle. In exploration, multispectral and hyperspectral imagery supports the mapping of lithology and alteration zones, while its combination with digital elevation models or radar data enables the identification of structural features. This allows large prospective areas to be narrowed down, so that field investigations can be focused on the most promising targets.

During operation, very high-resolution optical stereo imagery processed using photogrammetric techniques is used to monitor open-pit development as well as stockpile and waste dump volumes, while Interferometric Synthetic Aperture Radar (InSAR) enables the detection of ground deformation, slope instability and subsidence, including at waste dumps and tailings storage facilities. EO technology also contributes to environmental monitoring, including the assessment of vegetation stress, water quality parameters such as turbidity and suspended sediment concentration, and the detection of acid mine drainage in rivers and pit lakes.

In the post-closure phase, regularly updated monitoring systems based on InSAR data enable the detection of surface deformation with millimetre-scale precision under favourable conditions. This capability is particularly valuable for monitoring subsidence above former underground mines and for assessing long-term ground stability. In addition, EO technology facilitates mine closure by documenting land restoration, vegetation recovery and infrastructure removal, helping mining companies to demonstrate regulatory compliance and optimise closure strategies.

Beyond these applications, the use of satellite data enhances transparency, for example through the detection of illegal mining, and supports sustainable mining development. Current limitations related to spatial and spectral resolution, atmospheric conditions, vegetation cover and the need for ground validation are discussed. Finally, future perspectives are outlined, including new satellite missions and multi-source data fusion, with particular emphasis on artificial intelligence as one of the key drivers shaping the future of Earth observation technology.

MINING ENGINEERING

Geothermal Energy Recovery From Abandoned Oil Wells In Syria

Elyas Haddad ^{1*}, Vadászi Marianna²¹Department of Petroleum Engineering, University of Miskolc, Hungary²Institute of Mining and Energy, University of Miskolc, Hungary**Corresponding author: eliasaddad94@yahoo.com***ORAL PRESENTATION****Keywords:** geothermal energy; abandoned oil wells; Syria; Euphrates Graben

Syria possesses approximately 2,500 million barrels of proven petroleum reserves, with over 400 documented oil and gas wells across the Deir ez-Zor Governorate, concentrated within the Euphrates Graben tectonic system. Following decades of conflict and economic disruption, a significant proportion of these wells are now inactive, abandoned, or near end-of-life. This study presents the first comprehensive geothermal feasibility assessment for converting abandoned petroleum wells in the Euphrates Graben into low-enthalpy geothermal energy systems for direct-use district heating.

We analyse subsurface thermal data from six representative wells (designated SY-G01 through SY-G06) using a closed-loop coaxial downhole heat exchanger (CDHEX) configuration. Our thermal modelling integrates bottom-hole temperature (BHT) measurements corrected using the Horner Plot method, geothermal gradient calculations ranging from 27.4 to 36.8 °C/km, and heat flow estimates of 51-72 mW/m². A validated 2D axisymmetric finite-difference numerical model was developed and applied to predict steady-state and long-term thermal extraction performance.

Results demonstrate that retrofitted wells at depths of 1,870-3,012 m can deliver 85-247 kW of thermal power per well under optimised operating conditions, achieving Coefficient of Performance (COP) values of 3.1-5.8. A 20-year thermal depletion forecast indicates output stabilises at 82-88% of initial capacity after Year 5. Levelized Cost of Heat (LCOH) analysis yields values of \$21.6-\$34.1/MWh – a 3 to 4-fold reduction compared to diesel-fuelled heating in rural Syrian communities (\$85-110/MWh). A portfolio of 50 wells could meet the annual heating demand of approximately 8,500 households, while the full 180-well inventory of the Deir ez-Zor field could contribute 26.2 MW of geothermal capacity.

Annual CO₂ savings of 73-212 tonnes per well provide significant climate co-benefits. This work provides a novel, data-driven framework for energy-sector reconstruction in post-conflict Syria, constituting the first integrated geothermal-petroleum well conversion study for the Eastern Mediterranean region, and offering actionable guidance for international development institutions and Syrian energy policymakers.





MINING ENGINEERING

Analysis of H₂S Concentration Dynamics in Response to Ventilation Pressure Changes in Deep Underground Mines

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POSTER

Keywords: hydrogen sulfide; underground mining; mine ventilation; gas hazards; time-series analysis; sensor response time; occupational safety

Deep underground mining operations face critical safety threats from hydrogen sulfide (H₂S) accumulation. Routine ventilation adjustments, such as throttling of the main fans, alter pressure conditions, motivating the need to understand transient gas dispersion. This study investigates the influence of ventilation pressure changes on the migration and spatial distribution of H₂S using continuous monitoring data from roof and floor elevations. Raw time-series data from a deep copper ore mine undergo moving average smoothing and statistical analysis to evaluate sensor response. Results confirm a clear relationship between changes in ventilation parameters and gas concentrations, characterized by a measurable time delay. The findings demonstrate that ventilation throttling can cause a temporary increase in H₂S concentration within the breathing zone, highlighting the necessity for continuous monitoring and predictive approaches in ventilation management to protect underground personnel.





MINING ENGINEERING

Physics-Informed Pseudo-Labeling Framework for Conveyor Idler Fault Diagnosis Using Dual-Stream Attention Networks

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POSTER

Keywords: Conveyor idler fault diagnosis acoustic signal analysis physics-informed pseudo-labeling Cyclostationary Spectral Coherence (CSC) dual-stream convolutional neural network cross-modal attention, predictive maintenance

Developing intelligent fault detection for mining conveyor idlers is constrained by the lack of accurately labeled acoustic datasets, limiting deep learning applications in idler fault detection. This paper proposes a physics-informed pseudo-labeling framework combined with a dual-stream cross-modal attention CNN for acoustic-based conveyor idler fault diagnosis. Raw acoustic signals are transformed into a time-frequency spectrogram and a bi-frequency Cyclostationary Spectral Coherence (CSC) map. The framework is physicsinformed since pseudo-labels derive from physical characteristics of fault-induced cyclostationary modulation rather than model prediction confidence. Each signal is represented by an Enhanced Envelope Spectrum (EES), and EESs of verified faulty sample is used to build a Reference EES (RefEES) representing the characteristic fault pattern. Similarity between each sample's EES and the RefEES is quantified via the Pearson correlation coefficient, termed the Fault Signature Correlation Index (FSCI), enabling automatic label assignment without manual annotation. Class imbalance is handled through targeted augmentation of the minority faulty class and inverse-frequency class weighting during training. The dual-stream CNN processes spectrogram and CSC inputs in parallel, while cross-modal attention adaptively learns the relative importance of both representations, emphasizing the most informative modality before fusion and classification. Results on real mining acoustic data show 97.53% test accuracy, 96.89% macro F1-score, 96.88% balanced accuracy, and 0.986 ROC-AUC, outperforming single-stream baselines. Sensitivity analysis of the FSCI threshold further demonstrates that the selected threshold influences the downstream diagnostic performance and should therefore be regarded as a dataset-specific operating point. The method offers an accurate, scalable solution while reducing reliance on manually labeled data.





MINING ENGINEERING

From Safety Scenario to VR Training Environment - Development of an Immersive OHS Training Scenario for Surface Mining

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POSTER

Keywords: virtual reality (VR); occupational safety; surface mining

Surface rock mining is characterised by a dynamic working environment in which employees operate in close proximity to heavy mobile machinery, haul roads and other temporary hazards. Effective occupational safety training should therefore develop not only theoretical knowledge, but also the ability to observe the environment, recognise hazards and make appropriate decisions in changing conditions. This work presents the development of an immersive Virtual Reality (VR) training scenario focused on safe pedestrian behaviour in areas used by technological vehicles in surface mines. The scenario was designed to reproduce a realistic occupational situation in which the participant must cross a haul road while responding to the movement of another vehicle. The training structure combines a realistic task, independent decision-making, behavioural measurement and feedback. During the scenario, selected parameters can be recorded, including the participant's position and trajectory, reaction time, minimum distance from the vehicle, entry into warning or critical zones, waiting time and final outcome. The proposed concept is intended to provide a controlled and repeatable environment for analysing safety-related behaviour. The next stage of the work will involve integrating the prepared scenario, 3D assets, interaction logic and data-recording functions into a functional VR demonstrator for later experimental evaluation of immersive OHS training effectiveness in surface rock mining.





MINING ENGINEERING

Floor Response to Partial Support in Deep Mine Tunnels in Weak Rock

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ORAL PRESENTATION

Keywords: weak rock; mine haulage tunnel; yielded zone; floor response; numerical modelling; support

Roof and rib reinforcement may improve local ground conditions without reducing deformation throughout an underground opening. This study examines four unsupported and four supported plane-strain RS2 models of a 6 m wide and 4 m high haulage tunnel in weak rock at depths of 600–1200 m. The rock mass is represented by the Generalised Hoek–Brown criterion, with intact compressive strength of 20 MPa and GSI of 45. Fully yielded zone extents are used as a numerical indicator of excavation damage. Depth-dependent support comprises bolts, cables, yielding steel arches and shotcrete, with no invert reinforcement. Roof and rib extents decrease in all four supported models. At 800 m, however, the floor extent increases from 10.893 to 14.879 m and maximum total displacement from 0.506 to 0.717 m. At 1000 and 1200 m, both quantities decrease. These results indicate that roof improvement alone is insufficient to assess the response of a tunnel with an unsupported invert. Load redistribution is a plausible explanation requiring further verification.





MINING ENGINEERING

Extraction and Processing of Rock Raw Materials in the Context of Occupational Exposure to Respirable Crystalline Silica

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POSTER

Keywords: open-pit mines; occupational exposure; respirable crystalline silica; RCS monitoring, measurement methods

The extraction and processing of mineral resources involve numerous risks to health and life. In terms of the work environment, many nuisance and harmful factors must be controlled. One of the most significant harmful factors requiring control is the presence and level/concentration of respirable crystalline silica (RCS) in the work environment. Exposure to RCS can occur at various stages of the technological process, particularly during drilling, mining, crushing, screening, transportation, and other work involving the mechanical comminution and processing of silica-containing material.

The aim of this study was to conduct a preliminary analysis of available literature data on occupational exposure to RCS among workers in the open-pit mining sector. Factors influencing exposure levels were identified. The analyses took into account the type of mine and the raw material being extracted, workstations, location, and the course of the technological process. The study also presented the methods used for sampling and determining RCS, including methods based on X-ray diffraction (XRD), infrared spectroscopy (IR), and analysis using portable FTIR spectrometers.

The information obtained indicates the need for further identification of factors influencing RCS exposure and for targeted, continuous monitoring in the workplace. This is particularly important for workstations where workers are at increased risk of exposure to this harmful agent. Clarifying the relationships between the stages of the technological process, the tasks performed, and potential sources of RCS emissions can serve as the basis for more effective monitoring of this harmful agent. This will enable the planning and implementation of more effective measures to reduce worker exposure.





MINING ENGINEERING

Hazards associated with underground mining operations – the need to standardise the concept and directions for changes to legal regulations

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ORAL PRESENTATION

Keywords: natural hazards; mining; combined hazards; legal issues; health and safety at work

The current regulations governing the criteria for assessing hazards and the methods for controlling them do not include the term associated hazard. The relevant literature refers to this definition but does not set out the assessment criteria or control methods. In view of this, we can define combined hazards as identified hazards occurring in a given working of a deep mine, where two or more such hazards are present. These may cause mutual adverse effects. Combined hazards may pose a threat to the mining environment, as combating one may exacerbate the other. This publication describes a proposal to adopt criteria for the assessment of combined hazards, together with their definition and purpose, based on an actual incident. The authors of the publication propose criteria for the assessment of combined hazards and their incorporation into the regulations currently in force.



MINING ENGINEERING

Harmonization of Legal Provisions Regarding Natural Hazards in the Mining Industry

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ORAL PRESENTATION

Keywords: natural hazards; mining; combined hazards; legal issues; health and safety at work

This publication is a preliminary commentary on the harmonisation of legal provisions relating to natural hazards in the mining industry. The current regulations are divided into two aspects concerning natural hazards. The Regulation of the Minister for the Environment of 19 May 2014 defines ten of these. By contrast, the Regulation of the Minister of Energy of 23 November 2016 on detailed requirements for the operation of underground mining works describes six natural hazards occurring in the operation of mining works, together with methods for mitigating them. In the assessment of a criminal case pending before the court, in which the main cause of a fatal accident was the impact of natural hazards, the concluding recommendations highlighted the need to consolidate these provisions into a single Ministerial Regulation on natural hazards in mining operations, together with criteria for their assessment, identification and mitigation.



MINING ENGINEERING

Literature review on model-based studies of dynamic loads on machine structures

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ORAL PRESENTATION

Keywords: dynamical model; dynamical loading; longwall supports; hydraulic cylinder

Modeling the behavior of powered longwall supports under diverse conditions requires a comprehensive investigation of appropriate methodologies and simulation tools. During this systematic literature review, several key aspects of powered longwall support modeling under different environments and conditions were investigated, highlighting their potential implementations. These include the impact of mechanical vibrations on hydraulic pressure pulsation, dynamic response models, the dynamic control of hydraulic roof supports within underground longwall mining complexes, the unevenness of hydraulic cylinder extension, and inner wave propagation. The analytical results presented in this paper serve as a foundation for future improvements and provide a better understanding of potential modeling approaches and their practical applications in mining engineering.





MINING ENGINEERING

Powered Longwall Supports: Current State Of The Art And New Challenges

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ORAL PRESENTATION

Keywords: powered longwall supports; hydraulic shields; longwall mining; operational performance; industry standards

Powered longwall supports are a critical component of modern underground coal and mineral extraction complexes, playing a pivotal role in ensuring roof stability, worker safety, and the continuous operation of longwall faces. This article provides a comprehensive overview and comparative analysis of powered longwall supports, evaluating their primary design characteristics and mechanical performance, as represented through detailed performance plots. Operating conditions, environmental norms, and exploitation standards are reviewed to assess support behavior across diverse mining regimes. Furthermore, the study evaluates various support models in accordance with specific operational tasks and technical requirements, discussing their key specifications, structural configurations, and functional specializations. International design standards and safety norms are also reviewed as an integral part of the engineering, selection, and deployment process.





MINING ENGINEERING

Nuhilgram – Student's t degrees of freedom for informative frequency band selection in non-Gaussian noise

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POSTER

Keywords: rolling element bearing; signal processing; informative frequency band selection; non-Gaussian noise; Student's t distribution; degrees of freedom; envelope spectrum

The poster presents a new criterion for selecting the informative frequency band (IFB) in vibration-based diagnostics of rotating machinery, aimed in particular at rolling element bearings operating under heavy-tailed, non-Gaussian disturbances, which are common in mining machines. Like the kurtogram, the approach decomposes the signal with a 1/3-binary filterbank, scores each candidate band with a single statistic and passes the best band on to envelope-spectrum analysis. The difference is the statistic itself. Kurtosis, entropy measures and the α -stable stability index are replaced with the degrees-of-freedom parameter ν of the Student's t location-scale distribution, estimated by maximum likelihood. A low ν indicates heavy tails and therefore impulsive content. Two variants are considered: the nugram, which estimates ν from the band-limited signal, and the nuhilgram, which estimates it from the Hilbert envelope. For the nuhilgram, we show that the fast-kurtogram filterbank does not produce circular subband signals, which biases ν even for Gaussian noise. We therefore introduce a simple variance-rescaling correction that removes this bias without attenuating fault-related impulses. The methods are tested on simulated signals with Gaussian and α -stable noise, in Monte Carlo experiments, and on semi-synthetic signals in which a fault signature is superimposed on real copper ore crusher vibrations. They are compared with the kurtogram, the infogram and its variants, and the alphagram. The ν -based criterion is most advantageous when non-cyclic impulsive disturbances mask the cyclic fault component. The nuhilgram gives the most stable results. It matches or outperforms the alphagram while being about eight times faster, which makes it suitable for online and large-scale monitoring.





MINING ENGINEERING

A robust machine health index extraction method for signals with non-Gaussian highly impulsive noise via time-domain windowed feature smoothing

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POSTER

Keywords: non-Gaussian noise; local damage detection; health indicators; statistical analysis

Simple statistical measures are widely used in condition monitoring systems as well as in advanced diagnostic procedures proposed by various researchers. Unfortunately, in the case of non-Gaussian disturbances, these measures respond much more strongly to random, high-amplitude impulses than to the cyclic impulses associated with a fault.

To enable the practical application of these popular and physically interpretable parameters, we propose a simple signal processing procedure employing the aforementioned measures. This procedure involves signal segmentation, the calculation of partial values for a given statistic, and the determination of their median. Consequently, local fluctuations in the measure's value are smoothed out, and the final value of the diagnostic feature remains robust against such disturbances.

This simple yet highly effective approach offers several significant advantages: it leverages well-known features that are often already implemented in condition monitoring systems, it is straightforward to execute, and, following the proposed modification, it retains variables with a strong physical basis. To validate the proposed approach, we conducted a simulation study and analyzed real-world data from a run-to-failure test (XJTU).



MINING ENGINEERING

Drone based inspection of belt deviation in belt conveyor at the clay mining site in Jaroszów

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POSTER

Keywords: belt conveyor; belt misalignment; UAV inspection; computer vision; condition monitoring; clay mining

Belt conveyors are essential for continuous material transport in clay mining, and belt deviation is one of the most common operational problems. It is caused by uneven loading, idler misalignment or changing operating conditions, and it leads to material spillage, accelerated component wear and unplanned downtime. This study investigates the use of an unmanned aerial vehicle (UAV) for non-contact inspection of belt deviation at the Jaro clay mine in Jaroszów, Poland. Video and still images were acquired with a DJI Mini 3 drone (3840×2160 at 30 fps for video, 4000×3000 for stills) during multiple passes over the conveyor route. The proposed image-processing approach estimates belt deviation as the offset between the centreline of the idler pair and the centreline defined by both belt edges. Two key tasks are addressed: detecting the idlers, including idlers hidden beneath a displaced belt, and determining the belt width in pixels. Pixel measurements can be converted to physical dimensions using the drone's current altitude. The method distinguished three representative states: proper belt positioning, partial misalignment and full deviation (critical stage). Aerial inspection provides a viewpoint that ground-based robotic inspection cannot reach. The resulting data can support detection of critical belt–idler contact points, documentation of conveyor condition and maintenance planning. It can also be fused with measurements from other mobile platforms to identify the root cause of failures. Future work will focus on detecting damage indicators related to the belt surface and edges.

MINING ENGINEERING

Structural Analysis and Typology of SMEs in the European Mining Sector: Implications for ESG Assessment

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ORAL PRESENTATION

Keywords: mining SMEs; structural analysis; ESG assessment; European Mining Sector; sustainability assessment; ESG indicators; VSME; ownership structures; mining technologies; ESG benchmarking

The European mining sector comprises enterprises operating under diverse technological, organisational and economic conditions. Small and medium-sized enterprises (SMEs) play an important role in mineral extraction and the associated value chains, yet their structural diversity is not always adequately reflected in approaches to environmental, social and governance (ESG) assessment. Differences in company size, ownership, extracted raw materials, mining technologies and positions within the value chain may substantially influence both sustainability impacts and the capacity to collect, manage and report ESG-related data.

This study aims to develop a conceptual framework for the structural analysis and typological classification of SMEs operating in the European mining sector, with particular attention to the implications for sector-specific ESG assessment. The proposed approach combines a preliminary analysis of the European mining sector with a multidimensional classification of enterprises. The dimensions of comparison include company size, ownership and control structures, type of mineral resource, extraction technology, and position within the mining value chain. The framework distinguishes between direct extraction companies, mining service providers and exploration-oriented enterprises, while also considering differences between independent businesses and enterprises affiliated with larger corporate groups.

The study outlines how these structural characteristics may shape companies' operational profiles, sustainability impacts, reporting capabilities and exposure to ESG-related risks. Rather than treating mining-related SMEs as a homogeneous category, the proposed typology provides a basis for identifying relevant differences between enterprise groups and determining which sustainability aspects require specific assessment.

The research constitutes the initial stage of a broader research programme aimed at developing a sector-specific ESG benchmarking framework for European mining SMEs. Its expected contribution is to establish a structured basis for proposing sector-specific ESG indices, improving the comparability of assessments and supporting the development of proportionate sustainability assessment methods tailored to the diversity of the mining sector.

MINING ENGINEERING

Assessment of quarries safety status and OSH culture maturity in Poland

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Quarrying operations are characterized by a specific, dynamic working environment where ensuring safety requires continuous monitoring of machinery condition, geological factors, and the human element. The objective of this paper is to evaluate occupational safety levels in Polish open-pit mines by comparing the results of a 25-year analysis of severe and fatal accidents recorded by the State Mining Authority (WUG) with inspection findings from the National Labour Inspectorate (PIP) conducted in 2023-2025. An analysis of 86 accident events between 2001 and 2025 demonstrates a dominant share of technical and technological hazards (47.7% of cases, primarily centered around improper operation of power-driven machinery and moving parts) as well as human hazards (37.2% of cases, dominated by falls from height and drownings). This comparison exhibits close consistency with the results of 90 PIP inspections across 88 entities in 2023-2025, which revealed technical deficiencies in belt conveyors in 53% of plants (and up to 69% in previous years) and in screening and crushing machinery in 36% of entities, along with working time record non-compliances and flawed occupational risk assessments. Comparing hard historical data with the regulatory authority's assessment proves that the primary source of recurring accidents is occupational routine, insufficient supervision, and habituation to working under conditions that violate OSH principles (e.g., operating machinery failing to meet safety standards). The paper indicates that overcoming organizational barriers requires moving away from a bureaucratic approach, focused solely on formal compliance and paper-based procedures, toward actively shaping a mature OSH culture. Methodological research triangulation is proposed, combining quantitative safety climate assessments (NOSACQ-50), qualitative behavioral audits (BBS), and operational metrics. This framework serves as an effective tool for identifying informal unsafe habits and transitioning organizational maturity toward a proactive safety culture.



MINING ENGINEERING

Drilling Smarter, Shifting the Footprint: Benchmarking Conventional MINOTAUR Against Conventional Diamond Drilling

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POSTER

Keywords: robotic drilling; MINOTAUR; maturity conditioning; conventional diamond core drilling; indicators

Robotic exploratory drilling is presented as an alternative option to lower environmental burden, but the claim has not been tested against a measured baseline, and the technology has not entered service. This study develops a technology readiness conditioned, multiple functional unit benchmarking framework for a priori sustainability assessment, and applies it to conventional diamond core drilling against the MINOTAUR robotic exploration system. Four qualitative commitments from MINOTAUR Deliverable D1.2 were operationalized into twenty-four environmental, safety, operational and economic indicators, normalized against three functional units: one meter advanced, one campaign of specified geological confidence, and one sampled meter delivered. The baseline is a measured program, the sixteen hole, 1,211.5 meter BTW infill campaign drilled in 2016 at the Driftwood Creek magnesite deposit, British Columbia. The hybrid configuration was derived rather than assumed, by dominating set solution over surveyed collar coordinates at the specified branch reach. Nine indicators were quantified; twelve could not be closed, all on the robotic side, itself a finding about disclosure at Technology Readiness Level 3 to 5. At 100-meter reach, eleven of sixteen collars are eliminated. That 68.8 per cent reduction transfers without erosion to surface disturbance but yields only 0.8 per cent less total metreage once 671.2 meters of branching are counted, an outcome the neutrality condition $r = d / (d + b)$ explains. Excavated volume rises 187.5 per cent and cuttings mass 428.0 per cent, while core requiring off site custody falls 56.2 per cent, face exposure 53.7 per cent and information yield rises 4.0 per cent. Composite scores range from 0.9213 to 2.5717 across four weighting schemes without any change in performance. The published thirty per cent cost projection reduces to a single condition, that robotic advance, cost no more than 47.2 per cent of conventional drilling per meter. The technology trades rather than reduces. Its case rests on land take, core custody and exposure, not on rock removed, and the outcome is governed by the benchmark as much as by the technology. MINOTAUR is classified at GMG Level 3, automated with human fallback, rather than as autonomous.





MINING ENGINEERING

Shift-Invariant Convolutional Detection of Local Bearing Damage on CSC Maps: a Controlled Study of Cross-Machine Transfer

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POSTER

Keywords: cyclic spectral coherence; rolling element bearing, shift invariance; cross-machine transfer; condition monitoring

Convolutional neural networks are increasingly used to read cyclic spectral coherence (CSC) maps in bearing diagnostics, but the fault frequency, and hence the position of the damage signature on the map, differs between machines. This study tests whether a single architectural choice decides cross-machine transfer. Four networks with identical convolutional layers and classifier, differing only in the final aggregation (global max pooling vs. flatten) and in shift augmentation, were trained on the IMS data set and evaluated zero-shot on XJTU-SY and on a controlled simulated benchmark. The shift-invariant networks transferred perfectly (AUC 1.000). The position-sensitive networks dropped to 0.31–0.96 depending on map placement, below a simple global map statistic (0.961). Shift augmentation did not close this gap. The resulting detector requires no tachometer, no bearing geometry and no prior knowledge of the fault frequency.

This work is supported by the National Science Centre, Poland, under OPUS 29 project No. 2025/57/B/ST7/03507 "Fusion of an inspection robot-based, non-contact measurements for sound driven condition monitoring of rolling element bearings under varying speed, harsh noise and uncertain experimental conditions".



MINING ENGINEERING

Szarik – SpecialiZed Autonomous Robot for Inspection tasKs

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POSTER

Keywords: mobile inspection robot; belt conveyor; rolling element bearings; acoustic diagnostics; multi-sensor data fusion

Continuous condition monitoring of belt conveyors is essential in mining, but installing fixed sensors along kilometers of conveyor line is costly and often impractical. Within the FUSION project, an alternative is being developed: a mobile inspection robot that collects contactless measurements along the conveyor. This contribution presents Szarik (SpecialiZed Autonomous Robot for Inspection tasKs), the first prototype, built on a Unitree Go2 quadruped. The robot carries an RGB-D camera, a LiDAR scanner and an RGB camera, while a custom mounting frame holds a directional microphone array with a dedicated acquisition system for synchronous audio recording. An on-board NVIDIA Jetson Orin NX handles acquisition, processing, and communication, so no additional compute resources are required. A first walkthrough test in the faculty's belt conveyor laboratory confirmed that the robot remains stable at full payload and moves reliably among conveyor infrastructure. Future work includes acoustic, infrared and RGB measurements, localization of individual idlers, and tests with simulated bearing faults under time-varying load/speed conditions, as well as autonomous inspection of suspect idlers, with the ultimate goal of fusing all these data sources into a single diagnostic assessment.

This work is supported by the National Science Centre, Poland, under OPUS 29 project No. 2025/57/B/ST7/03507 "Fusion of an inspection robot-based, non-contact measurements for sound driven condition monitoring of rolling element bearings under varying speed, harsh noise and uncertain experimental conditions".

MINING ENGINEERING

Fossil-fuel and carbon price transmission to Polish day-ahead electricity prices: implications for energy intensive mining

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POSTER

Keywords: electricity prices; fuel and carbon prices; EU Emissions Trading System (ETS); conditional value at risk; energy-intensive mining

Electricity-price volatility has become a significant challenges for energy-intensive industries, particularly mining operations. This study examines the relationship between fossil-fuel, carbon prices and Polish day-ahead electricity prices. The data used in this study cover the period from January 2018 to September 2026. Daily local projections, monthly pass-through regressions, and three forecasting models are implemented to evaluate the price dynamics and predictive performance. The results shows that a 10% increase in EU carbon allowance prices is associated with a 3.3–5.1% increase in electricity prices seven days later, while the pass-through effect of natural gas cost is approximately twice as high during expensive hours as during average hours. For a mining case scenario, a 100 MW operation is considered which shows if EUR 20/MWh electricity-price increase could generate approximately EUR 17.5 million in additional annual wholesale electricity costs. The findings highlight the importance of fossil-fuel and carbon-price information for understanding electricity-price exposure and managing procurement risks in energy-intensive mining operations.



GEOINFORMATION

UAV Remote Sensing and Geospatial Inventory of German Coal Heaps for Fire Risk Assessment within the FRAM Project

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ORAL PRESENTATION

Keywords: coal heaps; UAV; geomonitoring

Coal mining spoil heaps are prominent, long-lasting features of post-mining landscapes across Europe. A critical challenge in their long-term management and safety is the risk of endogenous fires (spontaneous combustion), triggered by the oxidation of residual coal and carbonaceous materials within the heap body. To address this environmental and geotechnical hazard, the FRAM project (Fire Risk Assessment and Management of European Coal Heaps) establishes a systematic framework for the identification, assessment, and mitigation of self-heating phenomena, funded by the European Union's Research Fund for Coal and Steel (RFCs, Grant No. 101216667). A core milestone of the project is the development of a comprehensive geospatial inventory of coal heaps in Germany. Covering major districts like the Ruhr and Saar regions, alongside smaller post-mining areas in Saxony, Lower Saxony, and Bavaria, the inventory highlights significant regional variability in heap morphology, volume, and preservation status-ranging from large-scale engineered landforms integrated into urban recreational spaces to smaller features undergoing natural ecological succession. To achieve precise hazard monitoring, the FRAM project focuses on the extensive capabilities of unmanned aerial vehicle (UAV) thermography. Utilizing advanced drone platforms equipped with high-resolution radiometric thermal sensors, this approach allows for non-invasive, rapid, and high-precision mapping of large and often inaccessible post-mining sites. UAV-based thermal imaging enables the early detection of localized surface temperature anomalies, pinpointing potential subsurface self-heating zones long before visible smoke or open venting occurs. Furthermore, these thermal datasets facilitate the evaluation of past reclamation effectiveness, such as the integrity of sealing layers and compaction measures. The synergy of satellite observations, UAV-based thermal surveys, and localized groundtruthing provides a scalable, efficient framework for early hotspot detection and risk management, safeguarding post-mining communities at both regional and European scales.





GEOINFORMATION

Integrated Geomonitoring of Post-Mining Waste Heaps Using UAV, Satellite Remote Sensing and Mobile GIS Technologies

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ORAL PRESENTATION

Keywords: post-mining; UAV; remote sensing; mobile GIS; heap

Post-mining areas pose significant environmental and societal challenges due to the occurrence of degradation processes such as soil erosion, geotechnical instability, spontaneous combustion of waste materials, and contamination of soil and groundwater. Effective monitoring of these areas requires advanced methods for acquiring and integrating spatial data to assess current environmental conditions and predict future changes. Therefore, the MITIGATE project aims to develop an innovative methodology for the geomonitoring of mine waste dumps by integrating data acquired from unmanned aerial vehicles (UAVs) equipped with multispectral and thermal sensors, satellite imagery, and field measurements collected using mobile GIS technologies. The proposed approach combines high-resolution remote sensing data with precise GNSS positioning and in-situ observations, including soil moisture and temperature measurements, to provide a comprehensive assessment of post-mining environments.

The collected data are processed and analyzed using GIS-based spatial analytics, geostatistical methods, and machine learning techniques. This integrated framework enables the identification of areas most vulnerable to adverse mining-related impacts and supports the development of predictive models for assessing future environmental changes. The results contribute to risk assessment, environmental protection, land reclamation planning, and sustainable management of post-mining landscapes.

Preliminary tasks and results focus on the Hoheward waste heap in Herten, Germany. Initial UAV campaigns equipped with multispectral and thermal sensors have been conducted to investigate surface temperature patterns and vegetation condition. Satellite remote sensing data and mobile GIS-based field observations have been integrated into a common geospatial database. First analyses demonstrating the potential of the proposed monitoring framework for the assessment of post-mining landscape dynamics.

The project is carried out through collaboration between Technische Hochschule Georg Agricola Bochum (Germany) and Wrocław University of Science and Technology (Poland). Beyond its scientific objectives, the project promotes the development of young researchers and strengthens international cooperation in the field of environmental geomonitoring and post-mining area management.

Funding: This research is conducted within the MITIGATE project and is funded by the German Federal Ministry for Research, Technology and Space (BMFTR) under the German-Polish Academic Exchange Programme 2025, administered by the German Academic Exchange Service (DAAD). The Polish partner's participation is funded by the Polish National Agency for Academic Exchange (NAWA) within the framework of the Polish-German Academic Exchange Programme.





GEOINFORMATION

Analysis of the accuracy of RTN GNSS measurements using receivers equipped with an Inertial Measurement Unit (IMU) at different tilt angles: a case study of selected models

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ORAL PRESENTATION

Keywords: Inertial Measurement Unit (IMU); tilt compensation; Global Navigation Satellite System (GNSS); Real-Time Network (RTN)

Modern surveying technologies increasingly integrate satellite-based positioning systems with inertial technologies, improving the efficiency and scope of field surveying. An example of such a solution is GNSS (Global Navigation Satellite System) receivers operating in RTN (Real-Time Network) mode and equipped with IMU (Inertial Measurement Unit) modules. Solutions of this type have been available on the market since approximately 2012. The use of an IMU enables pole tilt compensation, eliminating the need to keep the surveying pole in a vertical position during measurements. This allows for faster data acquisition and facilitates measurements in difficult-to-access locations, such as building corners. An IMU module, incorporating accelerometers and gyroscopes, enables the determination of changes in the spatial orientation of the surveying pole and the receiver mounted on it.

The aim of this study was to compare the accuracy of RTN GNSS measurements performed using IMU-equipped receivers. The analysis was conducted for two receivers: the AlphaGeo L2 IMU and the Leica GS18 T. Measurements were performed at previously established survey control points with the surveying pole tilted at different angles, ranging from 0° to 80°. The obtained results were subjected to statistical analysis to assess the effect of pole tilt angle on the accuracy of point position determination.

The results showed that the mean errors in point position determination for both receivers did not exceed 0.05 m. A nearly linear increase in measurement errors was observed with increasing pole tilt angle. Despite the decrease in accuracy at greater tilt angles, the results obtained for both receivers remained within the accuracy requirements applicable to planimetric and height surveying in Poland. At the same time, differences in the performance characteristics of the two receivers were observed, with the Leica GS18 T demonstrating greater stability.



GEOINFORMATION

Evaluation Of Stationary Methane Sensors For Underground Storage Facilities Monitoring

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ORAL PRESENTATION

Keywords: methane monitoring; underground storage; stationary sensor technology; low-cost sensor systems; MOx; NDIR; MEMS; MPS; LoRaWAN; Methane Regulation; LDAR

Methane monitoring at underground gas storage facilities is challenging because potential emission sources are spatially distributed, emission patterns vary over time, and measured concentrations are strongly influenced by meteorological conditions and sensor placement. In addition, the European Methane Regulation (EU) 2024/1787 increases the need for traceable and reliable monitoring approaches. This study evaluates the application-specific suitability of five stationary methane sensors and sensor nodes—MQ-4, TGS2611-E00, MIPEX-04 ppm CH₄, Honeywell Versatilis Signal Scout and MethaneTrack LoRa—for use at underground storage sites. A structured review of scientific literature, regulatory documents and technical product information was conducted. The systems were assessed according to measurement principle, concentration range, methane selectivity, environmental dependence, calibration requirements, system integration, communication capability, outdoor suitability and level of independent evidence. The results show that none of the evaluated systems provides a universal solution across atmospheric background, local event and source-near hotspot concentrations. The MQ-4 is unsuitable as a primary sensor for low-concentration monitoring, whereas the TGS2611-E00 may support trend and event detection when combined with individual calibration, environmental correction and continuous quality assurance. The MIPEX-04 is technically more appropriate for significantly elevated concentrations close to potential sources. The integrated Honeywell and MethaneTrack nodes are particularly relevant for industrial hotspot and event monitoring, while their LoRaWAN connectivity offers advantages at geographically distributed sites with limited mobile coverage. The findings support a multi-tier monitoring architecture combining calibrated sensors for background and trend observation, robust industrial nodes at emission hotspots, meteorological measurements and periodic reference validation. Stationary sensor networks should therefore be regarded as tools for continuous surveillance, event prioritisation and operational decision support rather than as stand-alone methods for emission quantification or regulatory compliance.

GEOINFORMATION

A QGIS Plug-in for Air Change Rate Simulation at Urban-Scale: Application to Residential Buildings in Turin

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ORAL PRESENTATION

Keywords: air change rate; ventilation; urban building energy modelling; QGIS; plugin

Urban Building Energy Models (UBEMs) commonly represent air infiltration using fixed air change rates, despite its dependence on building geometry, envelope characteristics, urban morphology, and hourly weather conditions. This study presents an enhanced QGIS-based plug-in that automatically prepares building-level air change rate (ACR) simulations for urban-scale applications. The proposed workflow is designed to prepare atomically inputs starting from building geometries, the plug-in derives footprints, volumes, façade and roof areas, orientation, simplified thermal zones, street-canyon dimensions, and the position of airflow paths. Other parameters including envelop airtightness and leakage distribution are assigned using archetypes. The prepared building database is combined with hourly outdoor and indoor temperature, wind speed, and wind direction data. Urban morphology and aerodynamic roughness are used to correct the reference wind conditions at façade level. The plug-in then creates a three-zone building model, runs the user-selected airflow simulation engine, either the Three-zone Lumped Parameter Model (3ZLPM) or CONTAM, and returns hourly, building air change rates at urban scale in a format suitable for integration into UBEMs. The plug-in was applied to residential buildings in Turin, an Italian city, as a case study. The ACR results were integrated into a physics-based UBEM and evaluated with measured heating consumption data. Compared with the fixed-ACR, dynamic infiltration improved the accuracy of UBEMs. The results demonstrate the potential of the proposed plug-in to reduce model preparation effort while enhancing the reliability and scalability of UBEM applications.



GEOINFORMATION

Automated 2D Cross-Section Extraction and Geometric Parametrization from 3D LiDAR Point Clouds

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ORAL PRESENTATION

Keywords: LiDAR point clouds; automated cross-section extraction; B-spline centerline; geotechnical modeling; spatial data processing

Converting large 3D LiDAR point clouds into 2D cross-sections for numerical modeling, such as finite element analysis, is typically a slow and manual task. In most commercial software, manually slicing tunnels or caves is relatively easy, but the process is time-consuming, and it is difficult to maintain the perpendicularity of the cut to the cave axis. In geomechanics, a cut that is not strictly perpendicular to the tunnel axis can lead to distorted geometries and inaccurate stress calculations.

To solve this, this paper presents an automated Python pipeline that extracts orthogonal 2D profiles directly from raw point clouds. The workflow first simplifies the cloud using a 3D voxel grid, picking the first point in each cell to reduce data size while keeping the true shape. The general tunnel direction is determined using Principal Component Analysis (PCA), and geometric centroids are calculated along the passage. These points are fitted with a 3D cubic B-spline curve to create a smooth central axis. Section planes are calculated analytically from the curve's tangent vectors, guaranteeing that every cross-section is strictly perpendicular to the local cave trajectory. The script slices points using a defined thickness and a search radius. The cross-sections prepared in these way can be later used in determination of cave shapes characteristics and as an input in FEM based modelling. The method was tested on real lidar datasets, including lava tube caves in Lava Beds National Monument, California.



GEOINFORMATION

HGIS geoportal - map of World War II memorial sites

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POSTER

Keywords: WWII; HGIS; GIS; spatial analysis; history

The poster presents research that integrates history, geodesy, cartography, geoinformation, and education. Its aim is to develop and launch an interactive, publicly accessible geoportal mapping sites of atrocities, repression, and violence against civilians and prisoners of war between 1939 and 1945 within Poland's pre-war borders, as well as to promote the use of HGIS (Historical Geographic Information Systems) methods in historical research and education. The geoportal is intended to serve as a platform for knowledge and reflection—integrating historical, spatial, and source data—and as a tool for modern, fact-based communication regarding World War II. The methodology relies on combining critical source analysis with GIS tools adapted to the specific nature of historical data. The team conducts research and evaluates existing resources; the gathered information undergoes historical scrutiny and is processed in accordance with digital humanities principles. Each location (sites of executions, pacification operations, camps, forced labor, deportations, and other forms of violence against Poles, Jews, Roma, prisoners of war, and other victim groups) is assigned a concise, accessible description accompanied by source citations. The system enables the mapping of locations and spatial relationships between crime sites, while accounting for uncertainties regarding location, dating, and other attributes. Users can conduct historical-geographic inquiries by displaying features against the backdrop of both modern and historical maps. Plans include a mobile version with field navigation capabilities, as well as mechanisms for reporting new sites and corrections, allowing local knowledge to enrich the dataset. The authors also plan dissemination activities, including a conference, workshops for school and university students, and a publication aimed at the general public (featuring lesson plans). The project is being carried out by a team of researchers combining expertise in the history of World War II, spatial data, and digital tools for public engagement with science.

Research demonstrates that HGIS enables the combination of scholarly rigor with an accessible digital format and a social mission. Interactive mapping, open access, and educational initiatives foster reflection on the memory of victims and strengthen the bond between academia and society. This project addresses the needs of contemporary humanities and digital audiences by integrating scholarship, technology, and civic education, while serving as an example of the responsible dissemination of historical knowledge—one that not only conveys facts but also inspires reflection on the past.

This research was funded by the Excellence Initiative—Research University (IDUB) program and the scientific research subsidy no. 16.16.150.545 of AGH University of Krakow.

GEOINFORMATION

Spatial Modelling of Sinkhole Morphology and Driving Factors in a Brown Coal Post-Mining Area, Western Poland

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POSTER

Keywords: sinkhole morphology; post-mining area; spatial modelling; geographically weighted regression; XGBoost

Sinkhole development in post-mining areas reflects the combined influence of former underground workings, hydrogeological conditions, geological structure and near-surface processes. Quantifying these relationships is challenging because their strength may vary spatially and different sinkhole characteristics may respond to different controlling factors. This study investigates the spatial controls on sinkhole morphology in the Babina brown coal post-mining area in western Poland.

A point-based database of 238 sinkholes was developed from a high-resolution digital elevation model and field verification. Sinkhole depth, diameter and volume were analysed in relation to topographic, geological, mining, hydrogeological, geophysical and environmental variables. Because mining and geophysical datasets had different spatial coverage, two partially overlapping analytical groups were considered: Group A included 137 sinkholes with geophysical information, whereas Group B comprised 171 sinkholes with mining data. Relationships were evaluated using ordinary least squares regression (OLS), geographically weighted regression (GWR) and XGBoost.

Global OLS models showed limited explanatory power, with adjusted R^2 values of 0.10–0.31. Allowing regression relationships to vary spatially substantially improved explanatory performance, with GWR adjusted R^2 values ranging from 0.39 to 0.57. The highest GWR value was obtained for sinkhole depth in Group A (0.57), followed by volume in the same group (0.55). XGBoost models achieved high training performance ($R^2 = 0.97$ – 0.99), but substantially lower validation performance ($R^2 = 0.13$ – 0.45), indicating limited generalisation for some model configurations. The highest validation R^2 was obtained for volume in Group B (0.45), while depth reached 0.42 in both groups.

The results show that sinkhole morphology cannot be attributed to a single dominant control. Instead, recurrent predictors related to elevation, groundwater conditions, gravity anomaly, overburden thickness and proximity to mining and hydrological features indicate interacting mining, hydrogeological, geophysical and surface controls. The improved performance of GWR further demonstrates the importance of spatially varying relationships when analysing post-mining sinkhole morphology.



GEOINFORMATION

InSAR-Derived Landslide Motion and Potential Climatic and Seismic Influences in the Hunza Valley, Northern Pakistan

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POSTER

Keywords: InSAR; landslides; displacement monitoring; time series analysis

Slow-moving landslides threaten settlements and transport routes in high-mountain regions and may precede catastrophic failure. In the Hunza Valley of the Karakoram, northern Pakistan, deformation has mostly been reported along the radar line of sight alone, and climatic and seismic controls assessed only qualitatively. In this study, Sentinel-1 imagery from ascending and descending tracks (January 2023 - January 2026, ASF HyP3) was processed by SBAS-InSAR in MintPy, and line-of-sight velocities from the two geometries were decomposed into vertical and east-west components under the assumption of negligible north-south motion. The resulting time series for three active landslides -Hopper, Nagar Khas 1 and Nagar Khas 2 - were compared with weather-station rainfall, NASA POWER precipitation and temperature, MODIS snow cover and the USGS earthquake catalogue. All three landslides subside at -101 to -160 mm/yr, and Hopper additionally moves eastward at up to +175 mm/yr. Descending line-of-sight displacement shows an apparent same-month association with station rainfall at two sites, but its absence in the ascending track indicates a probable atmospheric rather than hydrological origin, and no association with temperature, snow cover or seismicity was observed. The results demonstrate sustained, measurable slope motion in the Hunza Valley whose drivers remain to be resolved.



GEOINFORMATION

How do local climate conditions and level of development of buildings influence urban energy modeling?

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ORAL PRESENTATION

Keywords: urban building energy modelling; process-driven; local climate; urban weather generator; level of development of buildings; space-heating consumption; solar analysis

Urban building energy models can help cities estimate building energy demand, identify opportunities for efficiency improvements, and plan energy strategies. Producing reliable predictions at large scale remains challenging because buildings are often represented with limited detail, while local climate and the surrounding urban environment vary from one site to another. Increasing model detail may improve predictions, but it also requires more input data and computational effort. This study investigates that trade-off through a component-level comparison of two process-driven approaches, CitySim and a detailed building model developed in Honeybee/EnergyPlus.

The analysis considers buildings with different construction periods, geometries, urban morphologies, and surrounding building densities. To assess how climate inputs affect building energy modeling, each approach is evaluated using both weather station data and locally adjusted conditions generated with the Urban Weather Generator (UWG). The assessment examines thermal zoning, air temperature, solar radiation, shading from neighboring buildings, wind exposure, and air exchange. Building geometry and envelope characteristics are used to represent solar gains, while urban form and building exposure are considered when assessing the effects of wind on infiltration.

The comparison includes both final energy predictions and intermediate outputs that show how each model represents the underlying physical processes. Heat flows, surface temperatures, indoor air temperatures, and solar irradiance are examined where equivalent outputs are available. Predicted space-heating and space-cooling demands are compared between modeling approaches, while space-heating demand is additionally evaluated against measured consumption at hourly, monthly, and annual scales. Assessing differences from different component outputs to final heating and cooling demand will help identify which representations of building physics and local climate meaningfully improve accuracy. The findings will inform the development of process-driven urban building energy models that remain reliable without requiring unnecessary detail or computational effort.

GEOINFORMATION

From Coal to New Functions: Spatial Transformation of Former Mining Sites in the Ruhr Region

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POSTER

Keywords: Ruhr Region; post-mining transformation; land use; geographic information systems; industrial heritage

Coal mining played a central role in the economic and spatial development of the Ruhr region in western Germany. Following the decline of hard coal mining and the closure of the last mines in 2018, former mining and industrial areas underwent long-term spatial transformation. The study aimed to identify the dominant present-day land use surrounding historical coal mining sites and describe the spatial patterns of post-mining transformation.

The analysis focused on the Ruhr region, utilizing spatial data on historical mining sites obtained from the Regionalverband Ruhr and the Copernicus Urban Atlas 2021. A total of 80 historical mining sites were included in the analysis. A 500 m buffer was created around the sites and intersected with the Urban Atlas land use layer. Detailed land use classes were grouped into higher categories and the area and share of each category within the analysed buffer area were calculated.

The results, presented in maps and charts, showed that industrial, commercial, public, military, private and transport units represented the largest land use category (34.42%), followed by urban fabric (32.50%). Together, these categories accounted for 66.91% of the analysed area. Artificial non-agricultural vegetated areas accounted for 17.19%, while mining, dump and construction sites represented only 1.67%.

The results indicate that historical mining sites are currently embedded mainly within urban and economic land uses, accompanied by a substantial share of green and recreational functions. The study demonstrates a simple GIS-based approach for analysing the spatial transformation of former mining areas and provides a broader regional view of their contemporary land use.



GEOINFORMATION

Temporal Stability and Redundancy of Spectral Vegetation Indices in Forest Areas: A PCA-Based Analysis of Sentinel-2 Data

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POSTER

Keywords: spectral vegetation indices; principal component analysis; Sentinel-2; forest monitoring

Spectral vegetation indices are widely used in forest monitoring; however, many indices are strongly correlated and may provide redundant information. This study aimed to assess the temporal stability of relationships among spectral indices, identify groups showing similar variability, and evaluate changes in their redundancy throughout the growing season. Sentinel-2 imagery acquired between May and September 2023 was analysed for 30 fixed forest polygons. Approximately 80 spectral indices were initially calculated. Correlation analysis was used to select a diverse subset of 10 commonly applied indices. For each polygon and acquisition date, 500 valid pixels were randomly sampled. The data were standardized and analysed using principal component analysis (PCA), both globally for the entire growing season and separately for individual months.

Monthly PCA revealed clear seasonal differences in dimensionality. June showed the highest concentration of variance in the first component and required only three principal components to exceed 95% cumulative variance, whereas September required five components, indicating greater differentiation among indices. May, July, and August required four components. Relationships with the global PCA axes also differed among indices: several indices, such as NDVI, NDMI, and OSAVI, maintained consistently strong associations with PC1, whereas NREIFG was strongly and stably associated with PC2, and TCARI with PC3. The results demonstrate that redundancy among spectral vegetation indices varies seasonally and that a reduced, diversified index set can preserve distinct dimensions of forest spectral variability.





GEOINFORMATION

Use of GNSS systems in climate change research

Kamil Maciuk^{1*}¹AGH University of Krakow, Krakow, Poland**Corresponding author: maciuk@agh.edu.pl***POSTER****Keywords:** GNSS; GPS; Galileo; Beidou; GLONASS; climate change; climate

Global Navigation Satellite Systems (GNSSs) are playing an increasingly important role in monitoring climate change, providing precise and continuous data on processes occurring in the atmosphere, hydrosphere, cryosphere, biosphere, and lithosphere. Initially, GNSSs were used primarily for navigation and geodetic purposes, but the development of satellite signal-processing methods has significantly expanded their applications. This poster presents an overview of climate research with particular emphasis on GNSS-RO, PPP, CORS, GNSS-R, and GNSS-IR techniques. This poster discusses the possibilities for monitoring atmospheric water vapor content, sea-level changes, snow cover, glaciers, soil moisture, vegetation status, and crustal deformation associated with redistribution of the Earth's mass induced by climate change. The analysis indicates that GNSS observations are currently an important data source for climate and environmental research, as well as in weather forecasting systems, environmental monitoring, and geodynamic analyses. Integration of GNSS data with other remote sensing techniques supports a more comprehensive assessment of changes occurring in the Earth's climate system as well as supporting the development of methods for adaptation to ongoing climate change.

This research was funded by the Excellence Initiative—Research University (IDUB) program and the scientific research subsidy no. 16.16.150.545 of AGH University of Krakow.





GEOINFORMATION

'Pechkohle' Heaps in Penzberg and Peißenberg, Bavaria: Six Decades of Post-Mining Landscape Evolution

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POSTER

Keywords: heap; reclamation; post-mining; Bavaria

This study examines the six-decade-long post-mining landscape evolution of "Pechkohle" spoil heaps in the Upper Bavarian towns of Penzberg and Peißenberg. Pechkohle is a regional brown coal variant whose properties approach those of hard coal due to intense pressure and elevated temperatures from Alpine mountain building. In Penzberg, coal mining began in 1796 and lasted for nearly 170 years until the mine closed on September 30, 1966. By 1974, its former spoil heaps were transformed into a green recreational area, which today includes the "Berghalde" recreation area, walking paths, sports facilities, a dog park, and the "Barbarakapelle". In Peißenberg, systematic extraction at the Tiefstollen began in 1837, and the mine eventually closed on March 31, 1971, due to declining coal demand and oil competition. Over six decades, both sites have demonstrated a successful and sustainable transformation of heavy industrial scars into vibrant public spaces, recreational areas, parks, and cultural landmarks that integrate industrial heritage into modern environments.

This is part of the scientific project titled "Fire Risk Assessment and Management of European Coal Heaps" (FRAM), which is funded by the European Union's Research Fund for Coal and Steel (RFCS) under Grant Agreement No. 101216667.



GEOINFORMATION

Spatiotemporal Assessment of Post-Mining Land Reclamation Using Sentinel-2 Data - Results from the REECOL Project

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ORAL PRESENTATION

Keywords: post-mining land reclamation; long-term monitoring; remote sensing; Sentinel-2; spatiotemporal analysis; REECOL

Long-term monitoring of post-mining landscapes is an important component of evaluating reclamation processes and supporting sustainable land management. Building upon the integrated monitoring approach previously presented within the REECOL project, this study focused on the application and results of satellite-based observations of reclamation processes in the Konin Lignite Basin (central Poland). The investigation covered the internal dumping ground of the former Józwin II B lignite opencast, where biological reclamation activities contribute to ongoing landscape transformation. The monitoring approach was based on multitemporal Sentinel-2 satellite imagery processed using Google Earth Engine. Selected spectral indices, including the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) were used to characterize vegetation cover, surface conditions, and their changes over time. The analysis combined spatial and temporal comparisons to investigate the variability of reclamation processes across different parts of the monitored area. Particular attention was given to the interpretation of vegetation dynamics, the spatial differentiation of reclamation progress, and the challenges associated with distinguishing long-term changes from seasonal variability. The study also considered the potential of automated satellite data processing for identifying areas with different patterns of vegetation development and supporting the evaluation of post-mining land recovery. The presented work contributes to the development of geoinformation-based monitoring methods within the REECOL project and explores their applicability to long-term environmental assessment of reclaimed mining areas. The approach highlights the potential of Earth observation data as a complementary tool for evaluating reclamation processes and supporting future land management decisions.



GEOINFORMATION

Changes in Vegetation Cover in the Post-Mining Areas of the “Pokój” Coal Mine (Ruda Śląska) as an Element of Urban Climate Change Adaptation Policy – A Multi-Temporal Analysis of the NDVI

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POSTER

Keywords: NDVI; post-mining areas; adaptation to climate change; KWK „Pokój”; green infrastructure

Post-mining areas pose a significant challenge for urban climate policy, yet there is no approach that links the monitoring of their natural recovery with the objectives of Urban Adaptation Plans (UAPs). The aim of this study was to assess changes in vegetation cover at the site of the former “Pokój” coal mine in Ruda Śląska in the context of the city’s adaptation to climate change. The analysis was based on Sentinel-2 imagery from 2017–2025 (growing season) and annual medians of the NDVI. The results indicate a marked change in the structure of vegetation cover: the share of bare ground increased from 11.7% to 22.9% of the area, while the share of dense, healthy vegetation decreased from 69.2% to 63.3%. Mean NDVI rose from 0.39 in 2017 to 0.46 in 2023, then dropped sharply to 0.36 in 2024. The declines are concentrated in the central and south-eastern parts of the area and may be related to changes in its land use. The results show that multi-temporal NDVI monitoring can support UAPs in assessing the potential of post-mining areas as urban green infrastructure.





GEOINFORMATION

A low-cost 2-DoF scanning head for single-beam bathymetry: simulated coverage gains and prototype verification

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POSTER

Keywords: single-beam bathymetry; flooded post-mining pits; scanning head; survey coverage

Flooded post-mining pits have steep walls and poorly surveyed bathymetry. They are usually mapped with an unmanned surface vehicle (USV) and a downward-looking single-beam echosounder (SBES), so soundings follow the vessel track: dense along each line, tens of metres apart between lines and sparse on steep walls, while denser coverage costs proportionally more sailing time. We propose to move the sensor instead of the boat: a low-cost two-axis servo head orients a ranging sensor and the USV performs spherical scans from a few stations. Both strategies were compared in Isaac Sim on a photogrammetric pit model with an ideal (zero-width) ray across 200 scenarios (5 station layouts, 2 angular steps, 20 reservoir scales from 50 to 1000 m), with coverage defined as the share of the bottom surface with a sounding within 5 m. In a representative 61 min scenario the spherical scan reaches 92 % coverage and the lawnmower survey 25 %; at budgets of an hour and more the gain grows with reservoir size. The simulation assumes that the head points where commanded, that points taken in motion are timed correctly and that a scan takes the modelled time. All three were verified on a prototype (Dynamixel XM540 servos, 50 Hz control loop) with a laser rangefinder as the zero-width ray: backlash of 0.50°/0.20°, timing error within 10 ms, repeatability with median 5.3 mm and scan times within 2 % of the model. Next steps are a terrestrial laser scanner reference for the room reconstruction and echosounder tests in water against a lawnmower benchmark.



GEOINFORMATION

Measuring urban heat: a review of heat island types, methods and gaps

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POSTER

Keywords: urban heat island; surface urban heat island; canopy-layer urban heat island; land surface temperature; review

The urban heat island (UHI) is a well-documented effect of urbanisation, but the term is used for several different phenomena. This study reviews the main UHI subtypes, including the surface UHI (SUHI), the canopy-layer UHI and the boundary-layer UHI, and summarises how each is measured.

Distinguishing between these subtypes is essential, as they are driven by different physical processes and show distinct spatial and temporal patterns. The SUHI is usually strongest during the day, whereas the canopy-layer UHI, which most directly affects human thermal comfort and health, is mainly a night-time phenomenon. Land surface temperature therefore cannot be used as a direct substitute for air temperature, and results based on different subtypes or reference areas are not directly comparable. Mixing them up can lead to wrong conclusions about heat exposure and the effects of mitigation.

The review highlights a strong reliance on satellite-derived land surface temperature, while air temperature and other atmospheric layers are studied less, and the two are rarely analysed together. Urban and rural reference areas and intra-urban hot spots are defined inconsistently across studies. Research is also concentrated on large cities, and small and medium-sized towns remain underrepresented.

GEOINFORMATION

Evidence Base for Urban Heat Adaptation Measures Interventions, outcomes and study designs: an evidence gap map and a method audit

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POSTER

Keywords: urban heat island; heat adaptation; evidence gap map; land surface temperature; heat health action plans

Urban heat adaptation measures such as greening, cool roofs, water and shading are usually justified by the cooling they deliver. It is less clear whether they protect people. We combined an evidence gap map with a method audit. We read 128 files in full text; after removing 11 off-topic documents, 117 documents (2001 - 2026) remained, including 41 reviews. From 16 review tables and papers we coded 109 evidence items, 95 on cooling the city and 14 on protecting people, by intervention, outcome and study design. They cover 55 cities in 26 countries and territories. None comes from Africa or South America.

Of the 95 cooling items, 86 end at temperature or thermal comfort, and half of those are simulations. Health appears only as a modelled benefit (5 items), and no cooling item observes a health outcome. Conversely, all 13 heat health action plan evaluations observe mortality, but none measures temperature or exposure. Reported cooling for the same intervention varies with metric, model and time of day. Our descriptive medians are 2.74 ° C for surfaces (n = 29) and 1.31 ° C for air (n = 52), but these heterogeneous samples do not isolate a metric effect.

Studies that cool the city and studies that protect people rarely meet. We recommend reporting air temperature or comfort alongside surface temperature, linking greening and cool roof projects to health records with control areas, recording exposure in action plan evaluations, and testing measures in Africa and South America.



GEOINFORMATION

Detecting urban expansion with spectral indices - a comparison with Urban Atlas in the Wrocław Functional Urban Area

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POSTER

Keywords: urban sprawl; Landsat; spectral indices; Urban Atlas; Google Earth Engine; Functional Urban Area

Urban sprawl in Polish cities increasingly occurs beyond administrative boundaries, in the suburban zones of Functional Urban Areas (FUA-s). Long-term monitoring of this process requires consistent, openly available data such as the Landsat archive. However, spectral built-up indices are known to confuse impervious surfaces with bare agricultural soil, which is widespread on the urban fringe.

This study assesses how reliably spectral indices identify built-up areas and urban expansion in the Wrocław FUA. Harmonised Landsat May–June composites for 2006 and 2021 were processed in Google Earth Engine to derive vegetation, built-up, bare-soil and water indices. Two change rules were compared: a simple rule combining vegetation loss with an increase in built-up signal, and an extended rule that additionally excludes bare soil.

Urban Atlas 2006 and 2021 served as the reference. Accuracy was assessed on a stratified sample of stable and newly built-up areas, arable land, other vegetation and construction sites, and on a 1 km grid. The comparison focuses on whether adding bare-soil information reduces the overestimation of urban expansion on arable land, and how well newly built-up areas are detected in low-density residential zones, where sprawl is most pronounced. The study is an attempt to develop an open-data methodology for multitemporal monitoring of urban sprawl in cities and their functional areas.





GEOINFORMATION

Comparison of vegetation spectral characteristics in a flooded post-mining environment - case study of Olkusz-Pomorzany, Poland

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POSTER

Keywords: remote sensing; vegetation condition; spectral reflectance; NDVI; surface water extent; sub-canopy water delineation

Following the shutdown of dewatering pumps at the Olkusz-Pomorzany underground zinc and lead mine in southern Poland, groundwater levels began to rebound, leading to the formation of lakes that inundated densely forested areas. The dense vegetation canopy obscures most of the shoreline, limiting the accuracy of surface water delineation using spectral remote sensing methods. This study investigates whether information on vegetation condition can be used to estimate surface water extent. Spectral reflectance (SR) and the Normalized Difference Vegetation Index (NDVI) were derived from Sentinel-2 imagery and compared for selected pixels representing flooded and non-flooded vegetation, as well as flooded vegetation located in the lake center and near the shoreline. The results showed that SR and NDVI values differed in flooded and non-flooded vegetation, indicating differences in vegetation condition. The largest difference of mean SR values was noted in the NIR band (0.12), while the difference in mean NDVI was 0.29. However, the NIR band showed a lower distribution overlap coefficient (OVL = 21%) than NDVI (OVL = 34%), indicating that SR in the NIR band may better distinguish between flooded and non-flooded vegetation than NDVI. Variations in spectral index and NIR reflectance were also observed between flooded vegetation in the lake center and near the shoreline, suggesting limitations in estimating surface water extent based on similarities in vegetation condition. Future research should consider the duration of vegetation inundation, and canopy density within individual pixels to account for spectral mixing at the 10-m spatial resolution of Sentinel-2 data.

The work was supported by the project Minigrants for doctoral students of the Wrocław University of Science and Technology.





GEOINFORMATION

Machine-learning models for landslide and gully erosion mapping in data-scarce regions: state of the art, challenges and implications for Tigray region, Ethiopia - a review

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ORAL PRESENTATION

Keywords: machine learning; landslide; gully erosion; data-scarce

Landslide and gully erosion are among the catastrophic natural hazards that frequently occur in mountainous regions, leading to loss of life, damage to properties, and economic disruption. This review compares machine-learning approaches for landslide and gully erosion mapping with special attention to four criteria: predictive performance, transferability, uncertainty, and reliability in data-scarce settings. The accuracy and precision of susceptibility models have evolved rapidly from opinion driven models and statistical learning toward the use of machine-learning techniques. Over the past two decades, several machine-learning models have emerged that can be used for landslide and gully erosion susceptibility assessment. These models are broadly classified into unsupervised (k-clustering and hierarchical clustering) learning, supervised (RF, SVM, ANN) learning, deep learning (CNN, RNN, GAN) and ensemble (Gradient Boosting, XGBoosting, stacking) learning. However, the review finds no universally best algorithm, because model performance depends heavily on local terrain conditions, predictor quality, class imbalance, and validation design. Each of these models may use different conditioning factors depending on the distinct assumptions, data characteristics and hyperparameters for susceptibility evaluation. The main methodological challenge in data-scarce settings is not only limited inventory data, but also overly optimistic validation. Many studies use random splits that can inflate accuracy, whereas spatial cross-validation and geographically independent testing provide more realistic estimates. For Tigray region, the strong implication is that reliable hazard mapping should prioritize physically relevant predictors, high resolution DEM, remote-sensing inputs, spatially explicit validation, and interpretable outputs that can support land use planning, future infrastructure development and disaster-risk reduction.



EARTH AND SPACE SCIENCE

Advancing post-mining monitoring through standardized and reproducible UAV-based hyperspectral workflows

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Post-mining landscapes are characterized by complex environmental, geomorphological, and socio-technical challenges. These include mine waste deposits, tailings, mine water impacts, altered soils, vegetation stress, and the transformation of former mining areas into new land uses. Monitoring such environments requires spatially detailed, reproducible, and transferable methods that can support both environmental assessment and long-term transition management.

This contribution presents the framework of a doctoral research project focused on the development and application of UAV-based hyperspectral sensing for post-mining monitoring. The main objective is to establish a standardized and reproducible methodological workflow that transforms raw hyperspectral data into reliable reflectance products and interpretable information for different post-mining applications. The workflow includes sensor-specific preprocessing, dark current correction, empirical line calibration, spectral smoothing, quality control, and integration with field and laboratory measurements.

The approach is tested across different post-mining contexts, including mine water-affected areas, mine waste and tailings deposits, vegetation and soil monitoring, and mining-related infrastructure. These case studies demonstrate how hyperspectral data can support the detection of material variability, iron-related surface features, wet or mineralized zones, vegetation stress, and other indicators relevant to environmental monitoring. By combining UAV observations with in-situ measurements and geospatial analysis, the research aims to bridge the gap between high-resolution spectral data and practical interpretation.

Overall, this doctoral work contributes to the advancement of smart monitoring strategies in post-mining regions. It provides a methodological basis for using UAV hyperspectral data not only as a mapping tool, but also as a decision-support component for environmental risk assessment, remediation planning, resource-oriented evaluation, and sustainable post-mining transition.



EARTH AND SPACE SCIENCE

Integrating Optical and Radar sensor Products with Spatial Decision Support System for Monitoring Ground Movement Events in Post-Mining Areas

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ORAL PRESENTATION

Keywords: post-mining; spatial decision support system; multi-hazard index; multi-risk, remote sensing; ground movement

Post-mining regions require repeated observations to differentiate ground processes driven by legacy mining operations from those induced by natural weather-related impacts. This distinction is critical for risk assessment and for implementing corrective measures in sub-surfaces heavily affected by underground coal mining. Repeated and consistent monitoring enhances safety, supports the detection of risks to infrastructure integrity, and enables effective land-use planning and targeted corrective measures.

In this contribution, we present an updated Spatial Decision Support System (SDSS) software interface developed within the Post-Mining Multi-Hazards Evaluation for Land-Planning (POMHAZ) project, funded by the European Coal and Steel Research Fund. The methodology is applied in the Southern Ruhr region of Germany, a former hard-coal mining area covering approximately 1,000 km². The region is currently populated and characterized by extensive legacy underground workings, where ground movement and deformation can pose hazards to the population and critical infrastructure, including buildings, transportation networks, and utilities. Consequently, subsurface conditions must be systematically evaluated with respect to both anthropogenic and natural hazard drivers. In this context, we evaluate and quantify ground deformation arising from both mining-driven and naturally occurring processes using multi-temporal Small Baseline Subset (SBAS) InSAR analysis based on Sentinel-1 acquisitions from 2020 to 2025. This approach enables the identification of persistent subsidence or uplift patterns and the derivation of displacement time series and velocity estimates. Compared to Persistent Scatterer Interferometry (PSI), SBAS is better suited for areas with vegetation cover and temporally variable coherence, where persistent scatterers are sparse and deformation signals are spatially distributed. Surface conditions are further characterized using Sentinel-2 optical indices, specifically the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI), to describe vegetation status and surface wetness and to support the interpretation of deformation drivers.

The resulting products are integrated into a single ground-monitoring framework within the web-based SDSS to support seasonal decomposition, spatio-temporal pattern analysis, and hazard interpretation. Our contribution updates the Multi-Hazard Index (MHI) by explicitly incorporating interactions between natural and mining induced ground instability. A risk evaluation is then applied by combining the MHI, exposed elements at risk, and a vulnerability index to generate a spatial multi-risk layer. The workflow produces hotspot maps of persistent subsidence, enabling the prioritization of areas for monitoring, mitigation, and land-planning measures. Key benefits of this approach include increased confidence in identifying likely mining-related deformation signals relative to anthropogenic or weather-induced disturbances, achieved through the cross-referencing of coherent deformation patterns with consistent mining and environmental evidence. This work establishes a reproducible and transferable risk-monitoring framework to support land planning and stakeholder decision-making in post-mining regions across Europe.



EARTH AND SPACE SCIENCE

Anti-Repeaters and Quasi Anti-Repeaters as Indicators of Damage Evolution in Anthropogenic Seismicity

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Anthropogenic seismicity occurs in response to human activities that modify the stress and physical conditions of the subsurface. Understanding how seismic sources change during these processes is important for characterizing the evolution of anthropogenic seismicity. In this study, we investigate whether anti-repeaters and quasi anti-repeaters can provide additional information about changes in seismic source behaviour and the damage state of the surrounding rock mass. In contrast to repeating events, which indicate recurrent rupture of a similar source under a similar mechanism, anti-repeaters and quasi anti-repeaters may reveal changes or reversals in the local source mechanism associated with stress redistribution, fracture interaction, and progressive damage evolution.

As a first case study, we analyse seismicity associated with underground copper mining in the Legnica-Głogów Copper District (LGCD), southwestern Poland. A seismic dataset is analysed using waveform cross-correlation to identify relationships between closely located seismic events. Particular attention is given to event pairs showing negative waveform correlation, which are classified as quasi anti-repeaters and anti-repeaters according to their degree of anti-similarity.

The identified event pairs are examined in terms of their spatial and temporal distribution and their relationship with the surrounding seismicity. Further analysis includes spectral characterization of the selected events and moment tensor analysis to investigate possible differences in source mechanisms and radiation patterns. These analyses will help assess whether the observed waveform anti-similarity is associated with changes in the seismic source or can be explained by other factors, such as propagation and recording conditions.

The LGCD dataset represents the first stage of a broader investigation in which the proposed approach will be applied to different types of anthropogenic seismicity. A broader comparison across different anthropogenic environments will allow us to examine whether waveform anti-similarity provides a robust source-related signature under different forcing conditions. This may contribute to a better understanding of how seismic sources evolve in response to human activities and may complement existing waveform-based approaches for monitoring anthropogenic seismicity.

EARTH AND SPACE SCIENCE

Seismicity clustering alone cannot explain the seismic regularity coefficient (dc) minimum in the earthquake preparatory sequences.

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ORAL PRESENTATION

Keywords: seismic regularity coefficient; ETAS; statistical seismology; earthquake dynamics; forecasting

While the Epidemic-Type Aftershock Sequence (ETAS) model remains the benchmark for describing seismicity through point-process triggering, it lacks an explicit physical representations of fault-zone processes such as damage evolution and shear localization. Metrics such as the seismic regularity coefficient (dc) aim to capture complex structural dynamics beyond purely stochastic behavior; however, whether observed dc anomalies reflect genuine physical earthquake preparation or more statistical clustering has remained an open question. To address this, an ETAS simulator was developed to generate synthetic catalogs based on fitted regional models. We evaluate the preparatory sequences preceding mainshocks in three seismic regions using two independent statistical tests: (i) against a temporal random-ordering null hypothesis (applied to both real and synthetic catalogs) and (ii) against 1,000 synthetic ETAS catalogs processed under identical conditions. Our results show that while the real catalogs exhibit a statistically significant dc minimum, the ETAS synthetic catalogs fail to reproduce this anomaly. Consequently, we show that the dc minimum is not a generic artifact of triggering or clustering, and is consistent with a physical signature of transient spatial reorganization associated with shear localization prior to mainshock rupture.



EARTH AND SPACE SCIENCE

Automated detection and temporal reconstruction of glacier surges using Sentinel-1 backscatter differences

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POSTER

Keywords: glacier surges; SAR; Sentinel-1; backscatter; detection

Glacier surges are episodes of strongly accelerated glacier flow, commonly associated with extensive surface deformation and crevassing. These surface changes affect radar backscatter and can therefore provide an indicator of surge activity. However, the identification of glacier surges from backscatter changes has largely relied on visual interpretation, limiting its applicability to large datasets. This study proposes a statistical approach for the automated detection and temporal reconstruction of glacier surges using Sentinel-1 winter backscatter differences. The analysis covers 59 surge-type glaciers in Svalbard and is based on Sentinel-1 SAR imagery acquired between 2015 and 2024. Winter maximum backscatter composites and normalized winter-to-winter differences are generated and characterized using local and global distributional features. Intervals meeting the adopted detection criteria are identified, and the interval showing the strongest surge-related signal is defined as the core interval. Surge periods are subsequently reconstructed by extending the detected activity backward and forward in time. The results demonstrate distinct backscatter changes associated with surge activity and stable conditions during quiescence, indicating that backscatter provides quantitative information on surge-related surface changes and may complement observations of other surge manifestations.





EARTH AND SPACE SCIENCE

Lower Silesian Clays as a Probable Source of Lithium and REE - preliminary study from Rusko-Jaroszów deposit

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POSTER

Keywords: lithium; REE; CRM; refractory clays; lithium recovery

Lithium (Li) and Rare Earth Elements (REE) are classified as Critical Raw Materials (CRMs) by the European Union due to their strategic economic importance and supply risk. The surging demand for lithium is largely driven by the expansion of the electric vehicle (EV) battery industry. The presence of major EV battery production hubs in Lower Silesia (e.g., LG Energy Solution, Mercedes-Benz) emphasizes the need to explore local supply options.

This preliminary study aims to evaluate the Li and REE potential of the "Rusko-Jaroszów" clay mineral deposit, formed via residual weathering of the Strzegom-Sobótka granitoid massif. A total of 35 clay samples were collected across 10 vertical profiles in the "Stanisław" open-pit mine. X-ray diffraction (XRD) revealed a uniform mineral assemblage dominated by kaolinite, with minor quartz, residual feldspars, and micas (illite). Geochemical analyses (ICP-OES, FAES) following alkaline fusion and acid digestion confirmed low lithium concentrations, ranging strictly from 15.9 to 35.4 mg/kg Li. REE contents were dominated by light REEs, mainly Ce (up to 101 mg/kg), La (up to 66.2 mg/kg), and Nd (up to 55.9 mg/kg), while heavy REEs were mostly below detection limits. The absence of an enclosed lacustrine basin during kaolinization prevented the formation of authigenic Li-rich smectites (hectorite), trapping lithium within the aluminosilicate lattice. Primary extraction of these clays solely for Li and REE is currently economically unviable; however, secondary recovery during commercial mining of refractory clays remains a potential long-term option.





EARTH AND SPACE SCIENCE

Analysis of the retention potential of mining areas in rainwater management - case study - Strzegom municipality

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POSTER

Keywords: stormwater retention; post-mining excavations; GIS spatial modeling; surface runoff; flood mitigation

Rapid urbanization and extensive surface sealing challenge conventional municipal drainage networks, highlighting the critical need for sustainable stormwater management and climate adaptation strategies. This study evaluates the stormwater retention potential of post-mining excavations across Strzegom municipality (Lower Silesian Voivodeship, Poland; 143.93 km²), a region heavily transformed by long-standing open-pit extraction of granite, basalt, and refractory clay. Using a three-stage GIS spatial modeling framework, 36 mining voids (~273 ha) identified from the MIDAS database were verified via Sentinel-2 imagery, orthophotomaps, CLCplus Backbone land cover, and 1×1 m LiDAR DTM data. Hydrological inputs from the G2DC-PL+ precipitation model, PN-EN 752 land cover categories, and slope parameters were integrated to assign spatial runoff coefficients ($C = 0.01 - 0.95$) and model maximum annual infiltration ($Q_{\max.a}$) on a 10×10 m raster grid. Results reveal a total cumulative retention capacity of 49.85 million m³, with a highly skewed distribution where the five largest sites account for over 66% (32.72 million m³) of storage. An allometric power-law model ($V = 1.60 \times 10^{-4} \cdot A^{1.33}$, $R^2 = 0.977$, $p < 0.001$) confirmed non-linear depth scaling in larger pits. Simulated rainfall events (10-100 mm) generated municipal surface runoff between 0.22 and 2.25 million m³, indicating that the existing pit volume exceeds the runoff from an extreme 100 mm storm event by over 2,200%. Repurposing post-mining voids as retention basins offers a nature-based alternative to conventional dammed reservoirs, enabling peak flow attenuation without high capital expenditures or land acquisition.





EARTH AND SPACE SCIENCE

Assessing Smartphone GNSS Interferometric Reflectometry under Snow-Covered, Rainy, and Dry Meadow Conditions

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POSTER

Keywords: GNSS-IR; smartphones; reflectometry; GNSS

This study investigates GNSS interferometric reflectometry (GNSS-IR) using smartphones under different surface conditions, aiming to assess the accuracy and quality of the resulting solutions. Synchronous measurements were conducted using three geodetic GNSS receivers and three smartphones: two Xiaomi Mi 8 units and one Google Pixel 5. Measurements were carried out in a meadow during three sessions in 2026: snow-covered conditions on 18 February, rainy conditions on 19 May, and dry conditions on 30 July. The same measurement locations and mounting heights were maintained across all sessions. Four tripods were arranged along a north-south line at approximately 1 m intervals, with the geodetic antennas mounted approximately 1.85 m above the ground and the smartphones approximately 1.80 m above the ground.

Signal-to-noise ratio (SNR) data were extracted using `gnsirefl` and subsequently analyzed to estimate reflector heights and assess spectral characteristics and retrieval quality. The analysis included available observations from GPS, GLONASS, Galileo, and BeiDou. Preliminary results show identifiable reflection signatures in smartphone observations, with differences in spectral characteristics and retrieval quality between devices. Practical limitations included heat-related interruptions during the summer session, when the Google Pixel 5 stopped recording despite being connected to a power bank, and occasional missing headers in RINEX files generated by the logging applications.

Acknowledgement: This research was partly financed by a subsidy for maintaining research potential, no. 16.16.150.545, allocated to the Department of Integrated Geodesy and Cartography, AGH University of Krakow, and was partly supported by the "Excellence Initiative – Research University" (IDUB) program for AGH University of Krakow.





EARTH AND SPACE SCIENCE

Structural Characterization of Planetary Lava Tube Analogues Using Micro-CT Imaging

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Interest in terrestrial lava tubes is growing due to the presence of analogous structures across other Solar System bodies, including the Moon and Mars. Since macro-scale testing of such planetary structures is challenging, alternative techniques such as micro-CT are essential to analyze the micro-mechanical behavior of host rocks and intercalated weak materials (e.g., regolith) for assessing overall structural stability and evolution. In this study, we present a fragment of our proposed methodology, validating the approach on a sample from the La Corona lava tube system in Lanzarote, Canary Islands. Using micro-CT allowed us to successfully identify structural heterogeneities and enabled the differentiation of distinct phases within the sample. Despite data interpretation limitations, micro-CT provides a valuable framework for quantifying micro-scale parameters in heterogeneous planetary analogs. Future research will integrate these micro-mechanical properties with 3D terrestrial laser scanning (TLS) cave geometry and geomechanical numerical simulations to model full-scale lava tube stability under terrestrial and extraterrestrial gravity conditions.





EARTH AND SPACE SCIENCE

Post-mining spoil heaps at different stages of reclamation and ecological succession: case studies from Poland, Germany and Czech Republic

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POSTER

Keywords: thermal activity; vegetation condition; land surface temperature; remote sensing; anthropogenic landforms; coal waste

Post-mining spoil heaps resulting from hard coal mining are highly transformed landforms, whose current condition reflects the history of waste disposal, reclamation, vegetation succession and the processes taking place within the complex material. Particular importance is given to thermal activity, which may persist or re-emerge long after mining operations have been completed.

This study compares three spoil heaps representing different post-mining transformation pathways: Ślupiec in the Nowa Ruda area (Poland), Hoheward in the Ruhr region (Germany) and Heřmanice in Ostrava (Czechia). The sites differ in reclamation history, vegetation development, thermal behaviour and present-day land use. The analysis combines historical and archival information with remote-sensing and topographic data. For each site, NDVI, land surface temperature (LST), spatial variability of thermal conditions and selected morphological parameters, including area and relative height, were analysed. Field observations and high-resolution UAV data were used as supplementary information for selected locations.

Hoheward represents a stabilized site shaped by long-term reclamation and landscape management, with no clear present-day surface manifestations of thermal activity. In contrast, Ślupiec and Heřmanice remain affected by persistent or recurrent thermal processes. The comparison shows that vegetation development alone is not sufficient to assess the condition of reclaimed spoil heaps. Thermal conditions, morphology and reclamation history should also be considered when evaluating post-mining transformation.



EARTH AND SPACE SCIENCE

Comparative Analysis of Active and Passive Sensors in Remote Sensing Mapping of Burn Scar Extent

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POSTER

Keywords: wildfires; burn scar mapping; active sensors; passive sensors; remote sensing

The increasing frequency and intensity of wildfires on the West Coast of the United States, exacerbated by climate change and extreme weather events, pose a significant threat to the country's ecosystems and economy. The main objective of this study was a comparative analysis of the effectiveness of active and passive sensors in remote sensing-based mapping of burn scar extent, using the catastrophic events of 2020 as a case study.

The research utilized data from the Copernicus program, focusing on comparing the capabilities of the passive MultiSpectral Instrument (MSI) aboard the Sentinel-2 mission with the active Synthetic Aperture Radar (SAR) sensor on the Sentinel-1 satellites. For optical data, spectral indices and their differential values were calculated using pre- and post-fire imagery, allowing for the identification of changes in vegetation structure. Concurrently, backscatter intensity changes were analyzed for microwave data from Sentinel-1 to establish precise thresholds defining the burn scar extent.

As a result, the impact of the wildfires on the natural environment was defined, highlighting the destructive effects on land cover. Comparing the results obtained from both types of sensors made it possible to determine surface environmental changes and verify the burned area detection accuracy between active and passive sensors.

The conducted analyses confirmed that integrating data from the Sentinel-1 and Sentinel-2 missions significantly enhances damage mapping precision. Radar data proved to be an essential complement to optical imagery, enabling reliable wildfire impact assessment regardless of limitations associated with cloud cover or atmospheric carbon dioxide concentration.



EARTH AND SPACE SCIENCE

Toward A New Application of Data Registered by Modified Water-Tube Tiltmeters Installed in the Geodynamic Laboratory in Książ (SW Poland)

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POSTER

Keywords: seismic-hazard forecasting; water-tube tiltmeter; rock-mass deformation; Tectonic Activity Function; geodynamic monitoring; underground mining

Strong seismic events pose a major hazard to underground mining operations in southwestern Poland. This study examines the potential of geodynamic observations from the Książ Geodynamic Laboratory to support forecasting of periods characterised by elevated seismic hazard. The proposed approach is based on continuous measurements of rock-mass deformation acquired using two orthogonal water-tube tiltmeters installed in the underground laboratory.

The instruments consist of 65.24 m and 93.51 m long horizontal tubes, half-filled with water, with interferometric measuring modules located at both ends. Variations in water level reflect changes in vertical tilt and provide information on the evolving stress-deformation state of the Świebodzice Depression rock mass. The recorded signals are used to determine the Tectonic Activity Function (TAF) and its derivative, which describes temporal variations in the rock-mass deformation rate.

Comparative analyses of archival tiltmeter records and regional seismicity showed that more than 95% of high-energy seismic events of natural origin with magnitude ≥ 3.6 occurred during epochs of low TAF-derivative values. Conversely, no high-energy events were recorded during epochs characterised by high deformation rates. These observations indicate that low-deformation-rate phases may define time windows of increased rock-mass susceptibility to seismic failure. The method is therefore intended to forecast changes in the level of seismic hazard rather than the exact time, location, or magnitude of an individual event.

The proposed modernisation of the water-tube tiltmeter system will introduce digital dual-frequency heterodyne interferometry, an expected water-level resolution of approximately 50 picometres, sampling frequencies up to 100 Hz, and continuous real-time acquisition. Real-time determination of TAF-derived indicators, combined with radon observations and geological interpretation, may support operational seismic-hazard assessment in the Legnica-Głogów Copper District, the Upper Silesian Coal Basin, and northeastern Czech post-mining regions.





GEOENGINEERING

Information Overload And Cognitive Workload In Managerial Decision-Making In The Raw Materials Industry

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ORAL PRESENTATION

Keywords: information overload; cognitive workload; cognitive overload; managerial decision-making; raw materials industry; mining industry; decision support

The ongoing digitalisation of industry is significantly increasing the volume, availability and speed of information flow used in decision-making processes. At the same time, human cognitive abilities – including attention, working memory and information-processing capacity – remain limited. This problem may be particularly relevant in the extractive industries, where managers must simultaneously integrate heterogeneous streams of information concerning operational processes, market conditions, safety, staff, regulations, environmental and ESG requirements, and changes in the external environment.

The aim of this article is to clarify the relationship between information overload, cognitive workload and cognitive overload in the context of managerial decision-making in the extractive industry. Based on a synthesis of the literature on information overload, human factors, cognitive workload and research concerning the extractive sector, a conceptual framework is presented that describes the transition from the information environment and the characteristics of information, through their processing, to cognitive workload and the potential effects on the decision-making process. Particular attention was paid to such characteristics of the information environment as the volume, complexity, redundancy, inconsistency, relevance and dynamics of information. The approach adopted does not assume that a greater volume of data automatically leads to poorer decision-making, but highlights the need to identify the conditions under which information requirements may exceed the user's available cognitive resources. This perspective serves as a starting point for further research into the measurement of cognitive workload and the design of strategies for filtering, personalising and automating information, with a view to better supporting decision-making and the achievement of sustainable development goals in the extractive industries.





GEOENGINEERING

Accessible Rock Characterization: Methodological Insights into Simplified Testing Techniques for Geotechnical Practice

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ORAL PRESENTATION

Keywords: simplified rock testing; geotechnical characterization; methodological assessment; rapid evaluation techniques; rock strength and durability

Recent developments in geotechnical engineering highlight the need for characterization approaches that combine analytical rigor with practical efficiency, especially during early site investigations where conventional laboratory tests may be limited by time, cost, or logistical constraints. Simplified rock testing methods have emerged as useful alternatives, yet their performance under current analytical standards and their ability to complement established laboratory techniques remain insufficiently explored.

This study presents a systematic assessment of simplified rock testing procedures designed to provide rapid evaluations of hardness, strength, and durability through low-complexity, field-adaptable techniques. Six lithologies were examined using descriptive, mechanical, and durability-focused simplified tests, and the resulting measurements were compared with conventional laboratory data to evaluate consistency, methodological robustness, and lithological sensitivity.

The findings show that simplified testing methods can produce coherent preliminary indicators of rock behavior, offering a practical and technically reliable complement to laboratory-based characterization during early project stages. By detailing both the methodological behavior and practical relevance of these techniques, the study contributes to establishing simplified testing methods as reliable components of contemporary geotechnical characterization frameworks.





GEOENGINEERING

Machine learning and interpretability applied to the bearing capacity of shallow foundations on rock masses

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ORAL PRESENTATION

Keywords: Bearing capacity; rock mass; Hoek-Brown; interpretability; Shapley values; variable ablation

The bearing capacity of shallow foundations on rock masses is computed either with analytical solutions, interpretable but neglecting self-weight, foundation shape, contact roughness and the flow rule, or with numerical models, accurate but expensive. Machine learning replaces neither, it learns from the accuracy of the numerical calculation and answers with the speed of a closed expression.

A model with eight input variables is fitted to 2257 finite-difference simulations based on the Hoek-Brown criterion, and what it has learnt is examined through impurity-based and permutation importance, Shapley values and variable ablation.

One result stands out, variables with negligible averaged importance are not dispensable. Removing self-weight leaves the mean fit unchanged and yet produces errors above 300 % for low-quality rock masses. Averaged importance metrics do not detect conditional factors, and a model that is accurate on average may fail in the very subdomain that governs design.





GEOENGINEERING

Geostatistical Evaluation of Geotechnical Variability in the Lake of Tunis Region in Tunisia.

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ORAL PRESENTATION

Keywords: geostatistics; geotechnical properties; soil heterogeneity; factor analysis; clustering

This study investigates the geotechnical variability of the Lac de Tunis area, Tunisia, using modern statistical and geostatistical methods. Soil parameters such as void ratio, compression index, particle-size fraction ($<2 \mu\text{m}$), effective friction angle, and dry unit weight were analyzed to characterize the heterogeneous subsurface conditions. The results show considerable variability among the studied properties and a strong positive relationship between void ratio and compression index. Factor analysis identified two main factors associated with soil compressibility and shear strength, while K-means clustering distinguished three geotechnical soil groups. Overall, the study demonstrates that multivariate statistical methods provide an effective approach for identifying soil patterns and improving site characterization, engineering design, and geotechnical risk assessment in the Lake of Tunis area.



GEOENGINEERING

Environmental Performance of Energy Groups in Relation to Differences in the Structure of Their Operations – A Comparative Analysis

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ORAL PRESENTATION

Keywords: energy generation mix; environmental impact; greenhouse gas emissions; water management; waste management; mining activities

The environmental impact of energy companies is an important aspect of assessing their operations due to the diversity of energy generation technologies and the scale of raw material use. The energy transition and changing regulatory conditions contribute to the restructuring of energy companies' operations, including a reduction in the share of coal-based generation and the development of low-emission technologies. These changes may be reflected in their environmental performance. The growing importance of sustainable development and related regulatory requirements is reflected in the increasing scope of ESG (Environmental, Social and Governance) information disclosed by companies. In the energy sector, the environmental dimension is particularly important and includes emissions, water resource use and waste management.

The aim of the study is to compare the environmental performance of energy groups, considering the structure of their generation activities and selected aspects related to the use and sourcing of raw materials. The study is based on quantitative secondary data derived from consolidated annual reports and sustainability reports of selected energy groups, covering the most recent available reporting periods. The analysis covers the energy generation profile of the selected groups, including the share of individual energy sources and installed capacity. Information on mining activities is also included for groups engaged in such activities. Environmental performance is assessed on the basis of available and comparable data concerning greenhouse gas emissions, air pollutant emissions, water resource use and waste management.

The study applies indicator-based and comparative analyses to identify differences between the energy groups under investigation and changes over time. The analysis examines the extent to which differences in energy generation structure co-occur with differences in the environmental performance of the analysed energy groups. The findings may provide a basis for assessing changes in the environmental impact of energy groups in the context of the energy sector transition.



GEOENGINEERING

The Role of Criterion Scope and Ranking Stability in Energy Transition Pathway Assessment: An ESG-ECO AHP–TOPSIS Analysis

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ORAL PRESENTATION

Keywords: energy transition; ESG-ECO; multi-criteria analysis; scenario ranking; AHP–TOPSIS; sensitivity analysis

The study examines the extent to which the scope of assessment criteria and changes in modelling assumptions affect the ranking of stylised energy transition pathways. Based on a review of 45 scientific publications, 16 environmental, social, governance and economic criteria were identified and organised within an ESG-ECO framework. The Analytic Hierarchy Process (AHP) was applied to determine criterion weights, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was used to rank four stylised pathways for Poland's energy transition towards 2040. For the purpose of the study, an original five-point scenario assessment scale was developed based on a synthesis of the literature.

Particular attention was given to comparing the full ESG-ECO model with an alternative considering economic criteria only. Extending the assessment beyond the economic dimension changed the ordering of the analysed pathways: the reference pathway, ranked first in the economic-only variant, was overtaken by low-carbon alternatives in the full ESG-ECO assessment. At the same time, the small difference between the two highest-ranked pathways highlighted the need to examine the stability of the resulting ranking.

Sensitivity analysis covered changes in criterion and dimension weights by $\pm 10\%$ and $\pm 20\%$, as well as 117 feasible one-at-a-time changes in scenario scores by ± 1 point. The baseline ranking was preserved in 81.2% of the score perturbation tests, while all remaining cases involved only a reversal between the two highest-ranked pathways. The results indicate that criterion scope can materially affect multicriteria assessment outcomes and that final rankings should be interpreted together with an analysis of their stability.



GEOENGINEERING

A Modeling Methodology for the Taxonomic Classification of Cracking Patterns Associated with Foundation Movements in Brick Masonry Buildings

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ORAL PRESENTATION

Keywords: brick masonry; foundation movements; differential settlements; cracking patterns; taxonomic classification; numerical modelling

Differential foundation movements are a frequent cause of damage in brick masonry buildings. Their interpretation still often relies on qualitative classifications that describe crack shapes but do not always explain their relationship with the processes that produce them. This study proposes a modeling methodology for developing a taxonomic classification of crack patterns from an existing morphological classification. Starting from seven damage families, four cases associated with localized or distributed foundation movements are selected: localized central settlement, localized edge settlement, distributed central settlement, and inclined settlement. Each case considers structural geometry, wall-panel and opening characteristics, support conditions, and the movement under consideration. Foundation movements and pattern characteristics are recorded separately to compare their relationships without assuming that each pattern identifies a unique cause. Masonry response is investigated using numerical models, with material properties kept constant across the cases being compared. At this stage, principal stress maps and their directions are used to examine model response and guide the interpretation of the proposed patterns; they are not presented as verified crack paths or crack widths. The procedure provides a basis for organizing the case studies, preparing their parametric development, and subsequently addressing experimental validation and the diagnosis of damage caused by foundation movements.



GEOENGINEERING

Addressing Equipment Variables in Static and Dynamic Soil Probing

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ORAL PRESENTATION

Keywords: cone penetration test (CPT, CPTu); dynamic probing (DPL, DPM, DPH, DPSH); density index (ID); geotechnical equipment variables

In situ penetration testing plays a fundamental role in geotechnical soil characterisation, with static probing (CPT/CPTu) and dynamic probing (DPL, DPM, DPH, DPSH) being the primary techniques employed. This paper examines the technical and operational variables of probing equipment and evaluates their influence on field measurements and data interpretation. Key hardware factors affecting performance include cone geometry as well as the drive system and chassis type. In dynamic probing, the kinetic energy transferred by the hammer mass directly determines the penetration depth and wave propagation through soil layers. The study highlights critical interpretation challenges when evaluating dynamic versus static probing data. While CPTu provides continuous measurements (q_c , f_s , u_2) with minimal operator dependency, dynamic probing measures blow counts (N_{10} , N_{20}) and is more susceptible to local gravel or cobble interference. Direct comparison of blow counts between different types of dynamic probing is invalid due to variations in impact energy; instead, comparisons must rely on the indirectly derived density index (ID) using method-specific correlation formulas. Strict compliance with applicable standards alongside integrated geotechnical investigations is recommended to ensure data reliability.

