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First International Conference

Mining in Europe

18 - 19 May 2016

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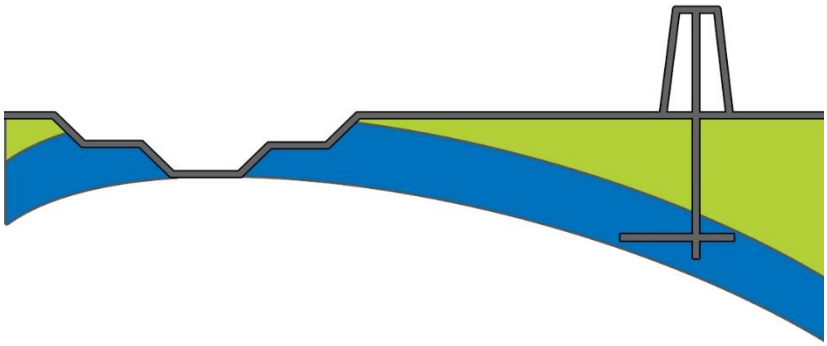

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KEYNOTE LECTURES

Project Generation in Mineral Exploration – from Conceptual Targeting to Resource Definition

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Across the entire mineral resources sector, every project commences with a generative assessment. This initial stage is typically instigated, managed and coordinated by a group of multi-disciplinary experts with a background in geology, investment, finance, mining engineering, etc., and who constitute a mining company's 'Project Generation' Team. The exact nature of each case-by-case assessment depends on whether the project is categorized as 'greenfield' or 'brownfield'; it may be 'early-' or 'late-stage' in nature; or centre on an already producing mine. Regardless, project generation plays a vital role during almost every stage of the minerals value chain. So-called 'white spots' on the Earth's surface, as well as 'immature' (from the view point of exploration) terrains are diminishing, yet the competition to discover and develop new mineral deposits is immense. Even in relative 'mature' terrains, opportunities remain as a result of new insight into geological processes, more cost-effective analytical technologies becoming available, and the application of innovative targeting methods such as GIS-based mineral prospectivity modelling and remote sensing tools. Thus, it is critical for generative geologists to keep abreast of latest developments and research, be driven by curiosity, combine and apply all fit-for-purpose exploration 'tools' and, wherever possible, question the existing paradigm and think 'outside the box'. In this presentation, I will focus on a geological perspective and illustrate how project generation utilizes scale-dependent techniques in order to identify regions that are considered prospective and as such, have a high potential to host significant deposits of the commodity sought. Initial selection, and ranking, may involve entirely desktop-based studies and literature reviews, mining and interpretation of all available data, and the formulation of a conceptual targeting model. This first stage is typically followed by ground acquisition and the generation of geophysical, geological and geochemical data. These data enable the explorer to reduce the search space further while also ground-truthing, validating and refining the initial targeting model. If results are promising, generative efforts will advance towards the delineation of highly favourable zones and the delineation of specific drill targets. Positive output from reconnaissance drilling then may lead to increasingly closer-spaced in-fill drilling and eventually, the definition of a mineral resource.

Mineral Exploration at All Scales: from the Continent to the Mass Spectrometer

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The decision to conduct mineral exploration in any particular area is made following a careful examination of the globe at all scales, and not just for “normal” geological signals. New approaches and first entry into an area may produce the highest returns, but also carry significantly increased risk. The decision by AREVA to commence exploration in the Peräpohja Belt, Finland was primarily made on regional geological grounds. An understanding of the Proterozoic regional geology from Russian Karelia, through Finland and Sweden and into eastern Canada was combined with a superb understanding of the geochemistry of uranium. The "Great Oxidation Event" happened some 2.45 - 2.3 billion years ago where the levels of oxygen in the atmosphere built rapidly affecting the solubility of uranium in the crust. Follow-up of the continental-scale ideas by field geologists substantiated the hypothesis for the Peräpohja Belt as a successful U-target with not only significant uranium discovered, but also gold. In fact, Finland’s best drilling gold intersection yet reported – 6 metres at 617 g/t Au – at the Rompas Prospect resulted from this work. An area of approximately 10 x 10 km was found to contain over one hundred boulders and outcrops with over 0.5 g/t Au. Most of the area is covered by glacial till and requires drilling to find the source of the boulders and test for depth extent of gold anomalous outcrops. Further fieldwork and drilling defined a different low-U style gold prospect at Palokas, some 8 km east of Rompas. Field examination of outcrops, logging of drill core, petrography, preliminary metallurgical test work and use of electron microscopy and mass spectrometric methods have all aided in our understanding of a large-scale gold-transporting system now understood to be approximately 1.78 Ga – at least 150 million years younger much of the uranium mineralisation.

Mine Water Concept of the RAG AG

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RAG Aktiengesellschaft, Germany

Once coal production ends in 2018, an important chapter in German industrial history comes to a close. However, RAG activities will continue. In the former RAG mining areas, mine dewatering will be the most important task in future. Therefore, RAG is developing in close coordination with political decision makers and statutory authorities a concept for the long-term completion of this task. The highest priority has been assigned to the protection of drinking water supplies. The concept is designed to conduct the long-term task of mine water management in an efficient and responsible manner. Once the last coal mines' operation closes in 2018, mine water will be pumped to prevent mixing with drinking water supplies. RAG currently discharges more than 70 million cubic meters of mine water per year into the Lippe, Emscher, Ruhr and Rhine River. Consequently, RAG operates 13 mine water management facilities in the Ruhr area. In the long term, six facilities will remain. An additional post-closure task, which can be realized with the reduction of mine dewatering facilities, is the rehabilitation of a large number of smaller creeks and streams into quasi-natural environments. The discharge of mine water impacts on water quality of smaller waterways. To centralize mine water pumping at a small number of facilities, the mine water level needs to rise, using appropriate pathways underground. While active mine sites require underground infrastructure, such facilities are no longer needed in future. Part of the mine water management concept includes the conversion of mine site facilities into bore water management systems.

EIT RawMaterials, a European Knowledge and Innovation Community in Raw Materials

K Hanghøj
EIT RawMaterials HQ, Germany

The European Institute of Innovation and Technology (EIT) has awarded a Knowledge and Innovation Community (KIC) on Raw Materials, which is now in its first operational year. With this KIC, EIT RawMaterials aims to boost the competitiveness, growth and attractiveness of the European raw materials sector via radical innovation and entrepreneurship. EIT RawMaterials has three strategic objectives, *1. Securing raw materials supply, 2. Designing solutions, and 3. Closing material loops.* The activities carried out by EIT RawMaterials include *Matchmaking and Networking*, *Education*, *Validation and Acceleration* and *Business creation and Support*, and cover six main knowledge and innovation themes along the raw material value chain: 1) Exploration and raw materials resource assessment, 2) Mining in challenging environments, 3) Increased resource efficiency in mineral and metallurgical processes, 4) Recycling and material chain optimisation for End-of-Life products, 5) Substitution of critical and toxic materials in products and for optimised performance, 6) Design of products and services for the circular economy. The KIC consortium consists of more than a hundred partners from all parts of the value chain and from all sides of the knowledge triangle, research, industry and education. The EIT RawMaterials activities integrate disciplines across the whole raw materials value chain within the knowledge triangle. EIT RawMaterials works to generate significant impact on European competitiveness and employment through the introduction of innovative and sustainable products, processes and services, and through focus on education in raw materials related fields. Educational activities span from graduate courses through life-long-learning programmes to wider society learning, and prioritise industry involvement and entrepreneurial skills that will deliver increased economic, environmental and social sustainability to European society.

EU Raw Materials Production till 2050 – a Critical Outlook

C Hebestreit
Euromines, Belgium

Current markets are down in many commodities and OECD economic forecasts are painting a rather difficult picture for the Western World. In this context the raw materials supply for Europe finds itself between contradicting EU policies and national disinterest. However, the European raw materials production has a vital function for the EU economy and will continue to do so. The presentation will highlight latest developments and will try to assess possibilities for future developments.

The Importance and Management of Point and Diffuse Source Pollution in the UK's Abandoned Mining Districts

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Management of the legacy of coal and base metal mining in the UK has, to date, focused primarily on the remediation of point sources of pollution, such as discharges from abandoned mine entrances. Remediation of such discharges has resulted in measurable benefits to the aquatic environment, especially for abandoned coal mines, for which there are now more than 60 full-scale water treatment schemes across the UK. However, research at Newcastle University over the last 5 to 10 years has demonstrated that diffuse pollution sources are very important, though variable, contributors to absolute metal flux to receiving watercourses. For example, in a ~10 km^2 upland base metal mining watershed instantaneous zinc flux increased sharply, from 1.2 kg Zn/d to 13.9 kg Zn/d under low and high flow conditions respectively, but the point source contribution to the high flow total was only ~3 kg/d. In an 800 km^2 lower-lying watershed a similar pattern was observed, with flux values rising from 5.1 kg Zn/d (low flow) to 1678 kg Zn/d (high flow). Similar examples from abandoned coal mining and watersheds are presented. The dynamics of water pollution in abandoned mining catchments has implications for the benefits of point source treatment initiatives. Careful monitoring of metal flux across different hydrological conditions allows assessment of key sources of point and diffuse pollution, and also quantification of the benefits of mine water treatment systems. Finally, in the UK and elsewhere around the world, hydrological extremes associated with climate change appear increasingly evident. The implications are discussed, with particular reference to the 10 km^2 mining watershed above, which was acutely impacted by intense rainfall in December 2015.

20 Years of the Governmental Rehabilitation Program in East Germany

F von Bismarck
GS StuBA, Germany

With the transformation process from the GDR to a market oriented economy in the early 90th of last century mine closure became a major issue in East Germany. The largest part of the industry formed a legacy of huge areas of 'lunar landscapes', hundreds of kilometres of unstable pit slopes, about 100 closed industrial plants, over 1200 toxic waste dumps, and a severely disturbed water balance. Un-employment rates were rising dramatically in East-Germany. The Federal Government together with the provincial governments of Brandenburg, Saxony, Saxony-Anhalt and Thuringia agreed to take action and a joint rehabilitation program was established in 1992. Now after more than 20 years the landscape in the GDR mining regions has changed remarkably. Technically the remediation works started with stabilizing the post-mining land and filling the residual holes with water. Then new uses became into the focus. Old coal-energy districts turn into renewable energy districts and new forms of agriculture are realized. Other industries are settling on the site of closed down industrial coal-plants. Canals between mining lakes are enlarged to allow boats to travel from lake to lake supporting tourism into the area. But besides all the success, the program had also had to witness some drawbacks like landslides and ground-breaks and regionally high content of iron oxide in the rivers. So even after 20 years there are still a number of rehabilitation works waiting to be completed. The total financial engagement (10.3 billion Euros up to the end of 2015) had proved to be a good investment for the future. East-Germany has become an example, where the process of mine closure is functioning as a catalyst for development.

ORAL PRESENTATIONS

Mining Productivity Re-imagined

R Allen
Dassault Systèmes GEOVIA, France

Recent mining commodity price fluctuations have highlighted the requirement for transformational change in the approach to mining operations. While mining companies have traditionally refined elements within the production chain (i.e. process, equipment, applications etc.) that provide incremental improvements across the mining value lifecycle, this presentation will illustrate the vision of how mining productivity can be re-imagined. With operational stability as the foundation for change, the presentation explores how to build a framework for mining execution excellence that will help increase confidence in an operations' ability to meet production targets, control costs, and improve efficiencies.

Institutionalizing Responsible Mining: A University-Based Approach

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AUA Center for Responsible Mining, Armenia

Since the mid-2000s, Armenia's mining sector, particularly metal mining, has experienced rapid growth. Mining-industry advocates have touted the industry as an engine of growth for Armenia's lacklustre economy. Social activists, on the other hand, have cast doubt on the economic benefits of this sector. They have also brought attention to its environmental and social costs. There is a tense impasse between the opposing sides while there is dearth of knowledge in the country on world best practices in mining that aims to be socially, environmentally, or economically responsible. The AUA Center for Responsible Mining, established in 2014, has been a response to this impasse and knowledge gap. The Center is a university-based, mission-driven focal point that offers independent, evidenced-based advice to promote the creation and adoption of global best practices in socially, environmentally, and economically responsible mining. It creates a platform where knowledge on the subject can be institutionalized and managed. It also offers a point through which world-class expertise can enter Armenia and the region. It may be possible to emulate this model elsewhere in the world. The presenter will review the Center’s activities and unique attributes and offer suggestions on how it may be replicated elsewhere.

Speed Is the Key Factor: Optimizing Grinding Process in Comminution Circuits by Using Variable Speed Drives

I Atutxa
Ingeteam Power Technology, SA, Spain

Mines are challenged with increasing production rates while reducing costs. Strategies to increase plant throughputs and thereby produce more metal may not always allow simultaneous reduction in operating costs per unit ton processed. Pushing the limits of comminution is often the key to increase the metal production rates. But this requires more energy (kWh/t) which represents the main operating costs. While operating variables such as ball size and ball charge can be adjusted, such changes are time consuming and are not responsive to variations in ore properties. Variable Speed Drives (VSDs) offer a flexible and responsive means of adjusting conditions to achieve the operating goals. While VSDs are common in SAG mills, most ball mills still use fixed speed drives. Among operations with VSDs, there may be opportunity to develop improved control strategies for the ball mill circuit to maximize the benefits. This paper summarizes the potential operational and maintenance benefits of using VSD drives for ball mills. The benefits are demonstrated by simulating a typical ball mill and hydrocyclone circuit treating an ore with varying hardness (BWI). The aim is to show the effect of VSD on specific energy consumption and costs, which are directly related to energy efficiency. The VSD allows higher throughputs while decreasing the specific energy consumption as compared to a fixed speed circuit.

The Effect of the Commodity Downturn on the Coal Export Industry

G Bartkowiak
Independent Coal Industry Advisor, Germany

Demand for import coal doubled in the first decade of this century, believed to be the start of a commodity super cycle, and enticed producers to invest massively in new capacity. The marginal cost of production pricing model suggested that even high cost mining operations would deliver acceptable returns in an undersupplied market which drove up the transactional costs of both greenfield developments and existing mines. Operating costs rose too, driven by rising salaries, material costs, equipment costs, royalties etc. Demand growth started to slow down in 2011 and is continuing to be subdued, leaving the market in oversupply and the prices low. Falling prices have driven many producers into a loss making situation. For a while, companies have continued with business as usual, diminishing their funding facilities in the process, and hoped that markets would pick up again. It is clear by now that markets will not return to levels that will allow companies to mine at acceptable returns any time soon. Facing depleted funding resources, tumbling share prices and massive amounts of corporate debt, producers are finally being forced to take action. There are no easy options, though. Trying to reduce unit costs through increased production only adds to oversupply and risks weakening prices even further. Reducing production, by putting mines into care and maintenance, has its own cost implications and is often in conflict with contractual agreements or mining lease conditions. Other options include: Increasing mining efficiency, trying to lobby for the relaxation of administrative regulations, debt refinancing and asset disposals. Some operations will navigate their way through the downturn and be in a stronger position thereafter, while others will have to close down. When supply and demand are in balance again, producers will have become more competitive, but the producers' landscape will be much more fragmented than today.

Why Mines Fail

SC Bartlett
Micon International Co Limited, United Kingdom

The fact that mines fail to live up to their production expectations and fail to provide adequate returns to investors is in part why money for exploration is so scarce these days. It unreasonable to assume that investors will continue to provide funding, when there is such a high risk that new mining operations will fail to deliver the returns promised by mine developers. In spite of many examples from the past of failed mining developments our industry has not learned the “how not to” lessons of mine development. There are many new examples of projects that failed to meet the promises of the feasibility study. The purpose of this presentation is to point out some of the more common factors that contribute to mining development failures in hope that pitfalls can be avoided in future and the confidence of investors in mining projects can be restored.

Mining 4.0 – More than Automation

T Bartnitzki
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The German term “Industrie 4.0” is currently on everyone's lips. However, what is really behind it? In 2006, the German federal government has defined a High-Tech Strategy (HTS) with the aim of becoming the global innovation leader. The term Industrie 4.0 is one of ten projects for the future in the context of the New High-Tech Strategy, which promotes the computerization of manufacturing. The first industrial revolution mobilized the mechanization of production using water and steam power. The second industrial revolution then introduced mass production with the help of electric power, followed by the digital revolution and the use of electronics and IT to further automate production. The term Industrie 4.0 was first used in 2011 at the Hannover Fair. Set against this background, the term Bergbau 4.0 combines Industrie 4.0 and the current research and development activities for digitalization in the mineral raw materials sector. The term wants to make clear that the German mining supplier industry can only survive on the international market if they combine reliable technology with high-tech and innovative business models to new products. This presentation discusses the background and the definition of Mining 4.0 and connects it to the latest research for the mining machinery industry. The difference between automation and digitalization will be pointed out. Selected research projects will be presented and a concept will be discussed how the mining suppliers could transfer this knowledge to new products and services.

The HRE – A Narrow Tunnel Roadheading System

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HAZEMAG & EPR, Germany

C Kuchinke
HAZEMAG & EPR, Germany

T Katz
GHH Fahrzeuge, Germany

The tunnelling industry as well as the mining industry is frequently facing the challenge to drive small-scale tunnels and roadways. For this purpose, the usually applied conventional system consists of a combination of jumbos, loaders and dumpers. While developing the tunnel, the machines have to pass each other regularly which require either wider roadways or additional niches, leading to an increased in time, manpower, and machinery demand. In addition with other specific site characteristics such as complex geology, infrastructure, and ventilation requirements, the efficiency is reduced and the project costs rise. Consequently, for developing small-scale tunnels efficiently, a roadheading system is crucial which is able to carry out various roadheading without a large portion of manoeuvring and which handles the muck along the tunnel axis. The solution is the newly developed HRE Roadheading Excavator as a multipurpose machine for conventional drill and blast-roadheading. The options of using a cutter head and other attachments in small-scale roadways larger than 9 m² are also included. Thus, the machine's working cycle includes face drilling, loading (loading bucket and chain conveyor) and face cleaning, as well as installing roof support in terms of roof bolting, arches and/or shotcreting. Within the presentation, the focus is on both the machine design of the HRE and the workflow in combination with a GHH MK-A 20 dump truck within a 9 m²-road. Furthermore, the advantages over a conventional machine fleet are illustrated by the results of a discrete event simulation supplemented and validated by empirical values.

Small Spaces, Big Machines – Collision Awareness Systems for Hazardous Areas

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Becker Mining Systems, Germany

A Hettrich
Becker Mining Europe GmbH, Germany

The mechanization in underground mining continues to evolve the available space for underground transport routes and logistical areas have to be kept to a minimum due to both economic and geological aspects. Due to this lack of space, close encounter situations between vehicles, other vehicles and people are inevitable. Poor visibility, seating positions in vehicles and not paying attention can lead to critical situations while hauling and mining is in progress. The collision awareness system is an early warning system that can help support the vehicle's driver in critical situations within his surroundings. He will be warned that a critical situation is about to happen long before he is even aware that something could happen. CAS informs the driver of the presence and the number of persons and vehicles which are located within the system's predetermined vicinity. Collision warning or collision avoidance systems are a "must have" in many mining regions of the world due to legislative changes for mines. There are various technologies for the detection of persons or vehicles. On one hand, one can find a simple UHF based system, on the other hand there are complex systems for larger machines working additionally with SHF and electromagnetic measurements, penetrating rock and steel obstacles. Since the EM pulses for this three technology systems need a lot of power, there is currently no possibility to create the CAS as an intrinsically safe system. For this reason we designed and built the Compact CAS that is packed into a compact flameproof housing with all of its non-Ex electrical components inside with the intrinsically safe antennas and display. After many successful extensive tests on customer's vehicles and mine sites, the product evolved by decreasing the size and weight of the prototype. This evolution has left us with a turnkey solution that is ready for multiple applications.

Sudbury, Canada - A Lifetime of Healing and Creating a Novel Functional Ecosystem on a Smelter-Impacted Landscape

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Laurentian University, Canada

G Spiers
Laurentian University, Canada

K Nkongolo
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By the mid 1970's, a hundred years of industrial activity (forestry, nickel and copper mining and smelting) in the Sudbury area had resulted in 17,500 ha of landscapes within regional watersheds devoid of vegetation with another 64,000 ha of semi-barren birch woodland. Research in the 1970's led to the development of the 'Sudbury Recipe' employed by the City of Sudbury's Land Reclamation (now Regreening) Program. The internationally acclaimed program commenced in 1978, directed by a Municipal advisory committee (Vegetation Enhancement Technical Advisory Committee or VETAC. The original 'Sudbury Recipe' used: 1) dolomitic liming (10 t/ha); fertilizer (400 kg/ha) and sowing of a grass - legume nurse crop (40kg/ha). Subsequently, 2) major trees and shrubs native to the regional forest were planted, often by community volunteers. Approximately 3,450 ha have received stage one treatment and nearly 10 million trees mostly pines and spruce (*Pinus banksiana, Pinus resinosa, Pinus strobus* and *Picea glauca*) have been planted. Following an ecological risk assessment of Sudbury from 2002 to 2009 the risk management plan developed as the Sudbury Biodiversity Action Plan. Additional native trees and shrubs (45 species) are now utilized along with changes in the seed-fertilizer regimes as the 'Sudbury Protocol' together with deliberate transplanting of forest floor sods. The developing Sudbury ecosystem is a mixture of the planted trees and shrubs, in a matrix of natural invaders of birch (*Betula spp*.), poplar (*Populus spp*.) and willow (*Salix spp*.), with over 100 species of herbs, mosses and lichens contributing to the plant biodiversity. Plant growth and biomass in this novel ecosystem are similar to control areas outside Sudbury; metal content of the vegetation is slightly elevated. The outcome of the Regreening Program is a new image for the city and has helped to attract new business enterprises and tourists. Reclaimed areas support wildlife, and are now used for recreation.

Process Control Made Easy – Which Technology Do You Prefer?

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F Portala
Bruker AXS, Germany

Different X-ray fluorescence (XRF) technologies can be applied in most cases to every routine application in the mining field: Simultaneous wavelength-dispersive instruments (WDXRF) are often seen as high speed solutions for high throughput labs, but at the same time they are very inflexible. Sequential wavelength-dispersive WDXRF instruments are rated as very flexible and precise, but at the same time as slow. Benchtop EDXRF instruments are making their way into the WDXRF domain in process control. With latest instrumental developments this view seems outdated and need to be revised. Examples for typical mining applications, like the analysis of iron ore with the different instrument types are shown and guidance is given on which instrument should be selected for the purpose. When moving production to other regions or starting a mining operation in Africa, automation is the key to success by delivering precise and accurate results. Requirements and solutions for the successful integration of XRF into an automated lab are shown with special focus on GLP. Nevertheless, the biggest source for efficiency improvements is the immediate real-time analysis without delaying the analysis due to the sample transport and sample preparation. An instrumental setup will be shown for online analysis in mining operations and mineral beneficiation plants which could complement lab based XRF instruments as a new tool for process control. Applications examples will be presented for iron ore, copper, lead and zinc ores.

iDeepMon - Intelligent Deep Mine Shaft Monitoring

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The presented project proposes the further development of existing shaft surveying systems towards an automated and remotely controlled shaft inspection system which allows an advanced maintenance approach for deep mine shafts with automatic tracking of shaft degradation process. The project is one of the first so-called upscaling projects within the EU Framework EIT RawMaterials (see also key note speech by Mrs. Karen Hanghoy). The project idea contributes in particular to the strategic objectives of the EIT RawMaterials, improving safety of operations, in particular mining automation, remote control and advanced maintenance systems. DMT, as leading partner, has already developed operational shaft surveying systems and research and university partners within the project team have strong experience in development of sensors and software tools which can make the systems more automated. The existing systems, sensors and software tools at the partners have achieved in minimum TRL 5 and are a suit-able basis for further development to TRL 7. The paper will give an overview of the existing technologies as well as the planned innovation work and the expected outcomes. The project has started recently and the project team will ask in particular mining companies to contribute by answering a questionnaire about the operational requirements for shaft inspections.

Real-Time Mining: Sensor Based Continuous Process Control and Optimization in Mineral Resource Extraction

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The flow of information, and consequently the decision-making along the chain of mining from exploration to beneficiation, typically occurs in a discontinuous fashion over long timespans. In addition, due to the uncertain nature of the knowledge about deposits and the inherent spatial distribution of material characteristics, actual production performance often deviates from expectations. Reconciliation exercises to adjust mineral resource and reserve models and planning assumptions are performed with timely lags of weeks, months or even years. The key concept of Real-Time Mining promotes the change in paradigm from discontinuous intermittent process monitoring to a continuous process and quality management system in the resource extraction process. The framework includes a real-time feedback control loop that rapidly links online data acquired during extraction at the mining face, during material handling and processing with a sequentially up-datable resource model. This will allow near real-time optimization of decisions related to long-term planning, short-term sequencing and production control. The proposed framework integrates the building blocks automated sensor based material characterization, online machine performance measurements, underground navigation and positioning, underground mining system simulation and optimization of planning decisions and updating techniques for resource/reserve models in a holistic manner. The contribution introduces to the Real-Time Mining concept and highlights recent project developments within the fields of sensor based material characterization, rapid resource model updating, production optimization as well as data management and visualization.

Exploration Drilling for a Major Potash Deposit in NE England

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A programme of exploration drilling comprising nine vertical boreholes and eight sidetracks was carried out to explore the presence and characteristics of polyhalite deposits in North Yorkshire, NE England. The boreholes were destructively drilled to just above the evaporite formations and then cored using a German designed and manufactured heavy duty mining wireline system to final depths of up to 1,650 m. The exploration proved an overwhelming success from a technical, environmental and health and safety perspective. A total of 4,600 m of core was successfully recovered with a core recovery of over 99%. The information confirmed that the deposits of polyhalite in North Yorkshire are one of the thickest and highest grade deposits discovered anywhere in the world. The coring system used on the project was developed some 30 years ago and was the workhorse string used for coal exploration in Germany in the past. A similar system has been used for several geoscience investigations including for geological and hydrogeological characterisation of potential sites for mined radioactive waste repositories. This robust coring system was selected due to its strength and suitability for deep coring together with the core quality and high levels of core recovery. The paper briefly describes the project, the coring system and presents some typical results and last, but not least, an outstanding partnership for more than 30 years between British/German partners.

From Waste to Value – Resource Estimation for Mine Tailings

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E Clausen
Clausthal University of Technology, Germany

Changing lifestyles significantly affect the type and demand of raw materials. Wide use and fewer sources lead to high economic importance combined with supply risks, which characterizes a Critical Raw Material (CRM). A way to lower supply risks is to unlock alternative sources for CRMs. Tailings resulting from former mining activities could become such an alternative source by transforming waste to value. An advantage compared to conventional sources, which often require great effort in exploration to provide deposit information, is the plurality of data collected during operation, which can be used for determining the potentials. This paper evaluates and demonstrates the potential of tailing ponds as a source for indium, which is identified as a CRM by the European Commission. The objective is to determine the indium content of tailings based on historical mining, processing and production data. On the basis of existing resource estimation models, an adaptation to the requirements and frame conditions of tailing-deposits were made and a mass flow model was developed. The new model will be demonstrated and applied to the tailings ponds of former ore mining activity and present UNESCO World Heritage Site Rammelsberg located at Bollrich, Goslar, Germany. Future perspectives on drawbacks and opportunities are given as the model, which can then be used as basis for equipment selection or production planning within the feasibility study.

How to Combine Better Particle Liberation and Particle Size Reduction with Significantly Less Energy Consumption? High-Velocity Comminution by VeRo Liberator®

G Borg
PMS GmbH and Martin Luther University Halle-Wittenberg, Germany

F Scharfe
PMS GmbH, Germany

Comminution is the biggest single cost factor in mineral processing and is critical for the success of subsequent recovery processes such as froth flotation. Obstacles to highly efficient comminution are either unsatisfactory size reduction ratios and incomplete particle liberation or overgrinding with excessive energy consumption and poor recovery rates due to the loss of middlings. Additional challenges stem from the consumption of process water, noise pollution, and flattening of ductile components by milling, such as native metals in process smelter slags. Each of these challenges alone warrant major research efforts to achieve much acclaimed resource efficiency, needed to make the mining and recycling industry fit for the technical, environmental, and economic challenges at hand and ahead. The new VeRo Liberator® offers highly significant improvements to the above challenges, due to a completely new, mechanical comminution principle, which is high-velocity and high-frequency impact comminution. The industrial scale 100 t/h VeRo Liberator® prototype features a vertical four-fold axle-in-axle system, equipped with up to 144 hammer tools, which rotate on three levels clockwise and anticlockwise against each other. The resulting high-frequency, high-velocity impacts cause a highly turbulent particle flow and trigger fracture nucleation and fracture propagation preferentially at and along phase boundaries. This improved breakage behaviour results in a drastically reduced energy consumption of between 3.0 and 2.3 kWh/t, an extremely high degree of particle liberation, size reduction ratios of up to 1,000 in single pass comminution, embrittlement of ductile metal particles, very low noise levels, dry operation, and even a drying effect for moist or wet feed material, allowing for subsequent dry sieving. The VeRo Liberator® can thus either replace several conventional comminution steps or can reduce the application of less (energy) efficient technique to a minimum.

Underground Mine Communications Technology

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In the explosion at the Sago Mine in 2006, 12 miners died, in part due to the inability for these miners to communicate with the outside, and the inability of mine rescuers to communicate with the miners. Following this disaster, regulators and research institutions have made a concerted effort to improve communications technologies for underground mines. Both wired and wireless technologies are now used for voice and data communications, and systems are being designed to withstand catastrophic explosions, inundations, rock falls and other accidents that would typically destroy common phone lines. Several technologies are being explored, including leaky feeder systems, WiFi-based wireless radio, Through-The-Earth (TTE) radio and Broadband-over Power Lines (BPL). Advantages and limitations for each of these technologies will be discussed with specific consideration for room-and-pillar mining methods.

Information System in the Mining Industry

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DOHMEN, HERZOG & Partner GmbH, Germany

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Nowadays information management for the mining industry includes the provision, administration, representation and documentation of extensive information. Due to the wide variety of the data it is a big challenge to setup such systems in practice. Enhanced by a mixture of generic industry applications used in the mining industry the practical implementation often fails. Next to the collection and administration of data, the data content must be represented in several company departments with very different requirements. Instead of conventional prints, excel sheets, plots and emails, today relational databases, web technology and the inter-/intranet offer new opportunities of information exchange. The key building blocks of modern information and monitoring system are databases, Internet Information Service (IIS) and web map services (WMS) to provide relevant information to employees, partners and suppliers with easy access by using web pages. SQL databases are used to map all alphanumerical information like borehole and analysis data, land parcel and licence information, process data and contract details into models. In addition all relevant documents will be stored in the database. Even graphical information like approval limits, borehole coordinates, etc. can be included. Within the database the structure of the different models to display the operational reality is essential. A central server provides the information via web pages to the clients. By using web pages the information will be transmitted and the user can request data, add new values or change existing data sets. A reporting tool will automatically generates reports based on parameter defined by the user. A viewer interface integrated in the web browser present graphical information from the database or external WMS-services. By using web technology the system can be used anywhere by PC, tablets or smartphones. The presentation will give an overview of the implementation of information systems in the aggregate, limestone and gypsum industry based on practical experience in the last ten years.

Quantifying the Potential for Deep Marine Mineral Resources along the North Atlantic MAR

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The Norwegian University of Science and Technology (NTNU) and Nordic Ocean Resources AS, with support from Statoil ASA established in 2012 a project to assess the ocean mining potential in Norway. The focus has been on increasing knowledge of massive sulphide mineralization along the North-Atlantic Mid-Ocean Ridge. In this area, seafloor massive sulphides (SMS) are formed from the volcanic and hydrothermal activities along the ridge. A large part of the North-Atlantic Mid-Ocean Ridge between Jan Mayen and Spitsbergen is located inside Norwegian jurisdiction. To quantify the amount and the associated uncertainty of undiscovered mineral resource along this part of the ridge, multibeam data has been analysed by NTNU in cooperation with the Russian Institute for Geology and Mineral Resources of the Oceans. This analysis has located several promising areas. Based on these data, a probabilistic mineral resource evaluation (play analysis) has been performed. Given commodity prices from 2013, these estimations resulted in a gross value estimate for the copper, sink, gold and silver containing SMS deposits on the Norwegian part of the Ridge of USD 75 billion. However, the uncertainty is considerable. To further strengthen the delineation of the permissive tracts that define the most promising areas along the ridge, additional layers of publically available data and information has been added and analysed as part of the interdisciplinary project Deep Sea Mining Pilot Project (DSM-Pilot). Along with results from the upcoming MarMine-cruise to the North-Atlantic MAR the DSM-Pilot work is expected to reduce the uncertainty in the input parameters used in the resource quantifications. A framework for the resource quantification and status of the updated prediction of the potential for undiscovered marine minerals inside the Norwegian jurisdiction will be presented and discussed.

The Future of Lignite Mining in North-Rhine-Westphalia

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To ensure the continuous electricity supply for industry and private households in Germany, lignite needs to be mined and utilized in the Rhenish lignite mining area. Between 90 and 100 million tons of lignite are extracted from the Garzweiler, Hambach, and Inden opencast mines each year. Lignite mining is a continuously developing process. Concerning productivity, economic and environmental aspects mining in the Rhenish area has achieved very high standards. Emission control, automation and biodiversity-protection measures as integral components of the mining process are only a few examples. Resettlements with intensive participation of the people concerned ensure high social compatibility and acceptance. Today, much of the mined lignite is used to generate electricity in the Company's own power plants. More than 10 GW in power plant capacity is currently installed our region, producing more than 40% of the electricity demand in NRW and some 13% of the demand in Germany. In addition to generating power, about 15% of the raw coal is annually used in refining, processing it into approximately 5.5 million tons of products. In total, RWE employs about 10,000 people (incl. apprentices) in the lignite mining area. Due to developments in climate protection policies, measures have been taken both by the government of North-Rhine-Westphalia and Germany to reduce carbon dioxide emissions caused by the electricity generation based on lignite. In the following, the area of open pit mine Garzweiler II will be reduced and five 300 MW block-unit power stations will be decommissioned until 2023. The article to be presented at AIMS 2016 will show that current planning processes in lignite mining do well correspond with current developments in climate protection, giving the opportunity of lignite mining in the Rhenish lignite mining area at least until the middle of the century.

Economic Benefits of Mine Safety Improvements

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This study presents an evaluation of a classification system for safety improvements in the German mining industry. Safety in the mining industry plays an important role. An example for a safety improvement program in Germany is the Vision Zero program developed by the German professional association for the raw materials and chemical industries (BG RCI). Researchers at the Colorado School of Mines have investigated the correlation between safety performance and profitability in several mining companies. The goal of this research project is to use engineering and economic methods to determine whether mines with lower accident frequencies and severity rates are more productive and profitable operations. The research aims to quantify economic benefits of safety improvements in the German mining industry, with special regards to salt and potash and aggregates mining. The research focuses on the evaluation of incident rates across the last decades and its correlation to business numbers like profit and productivity. Another aspect studied is the comparison of incidence rates between the western and eastern States of Germany.

Prediction of the Short-Term Quality Fluctuations of the Nickeliferous Ores and Mineral Fuels Used in LARCO Ferronickel Plant by Using Autoregressive Neural Networks

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More stringent market requirements on costs, quality, environmental legislation and the increasingly competitive market situation in energy intensive sectors affect the metallurgical industry leading to the need for optimization of resources quality and improvement of production facilities efficiency. In this context, advanced process control and optimization systems are very beneficial for the modern mining-metallurgical industry in its quest for higher profitability. This study is focused on optimization of the operation parameters of the rotary kilns used in the pyro-metallurgical process of ferronickel production in GMM LARCO SA (Greece). More specifically, the study aims to develop an advanced feedforward quality control algorithm for ores and fuels which are fed in the rotary kiln. The basis of the feedforward quality control is the use of a time series of past quality-variables values in order to predict future values. Thus, a data-driven model for the prediction of short-term quality variation of ores and fuels, based on Non-linear AutoRegressive Neural Networks (NAR-NN), was developed. For the training and validation of NAR-NN production data of the last ten years were used. The accuracy (relative RMS error) of the obtained predictions varied between 5 and 20%, depending mainly on the type of ore or fuel and on the specific quality parameter. Variability forecasting allows rotary kiln operators to take all corrective action required to maintain feed composition within the tolerance limits and adjust accordingly the required operating parameters in order to optimize the process of reduction roasting.

Special Applications of Optical Borehole Tools for Geotechnical Rock Mass Assessment under Difficult Mining Conditions

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For the geotechnical structural investigation modern optical image acquisition systems have proven to be a very effective method. Geotechnical characteristics of the rock mass are being acquired from digital images of pit walls, underground heading faces as well as from the inside walls of boreholes. The benefit is primarily the acquisition of a vast amount of geotechnical data, especially the structural information, without need of direct access to the location under observation. From optical logging of boreholes such information are being collected for the in-situ rock mass. The structural and geotechnical data are essential information with respect to excavation planning and stability. They should be obtained for all mining projects, i.e. for open pit slope design as well as for underground excavations. For these reasons, new optical tools have been developed for special applications and requirements. Based on developments that originate from the demands of German hard coal mining, unique instruments for optical borehole logging have been constructed. In addition to a slim, hand-driven borehole scanner (SBS) for utilization in roof-bolt or other slim boreholes, especially an optical borehole shuttle has recently become a promising and requested tool for optical inspections of boreholes. The benefit of such technology is that logging can be easily done in all deflection angles, i.e. in horizontal as well as upward boreholes. Additionally, the instrument is protected inside the core barrel, if possible. The optic shuttle has shown its advantages for example in the inspection and determination of lithological and structural rock composition of floor heave in underground gate-roads, structural investigations of joints and other discontinuities in long horizontal drill holes in quarries, and investigation of coalesced old drifts in salt. As demanded for coal mining, the shuttles are firedamp-proof. Also a camera shuttle for recording videos can be used to inspect boreholes.

HeidelbergCement's Biodiversity Strategy and Partnership Approach: A Win-Win for Business and Nature

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Land management that aims to maximize biodiversity and reduce environmental impacts during and after mining is part of HeidelbergCement's sustainability strategy. The Group's ambition is to establish itself as a leader in the promotion of biodiversity at its mining sites. To achieve this goal, HeidelbergCement encourages an open dialogue with stakeholders, including environmental authorities and nature conservation organizations. This pro-active approach is fundamental to local public support and in securing our licence to operate, meaning safe and long-term access to the raw materials we need for our products. Often there is also a business case for adopting a biodiversity-friendly management and rehabilitation approach that gives us better control over potential liability risks such as presence of protected species, sensitive habitats and invasive species. It is recognised that quarries play an important role for biodiversity. Thanks to the variety of habitat conditions, the dynamics of the landscape, the low presence of nutrients and the marginal disturbances at site, quarries offer indispensable habitats for many rare and endangered species. Nature protection organisations, authorities and the local communities perceive post-mining areas as valuable landscapes, combining opportunities for nature protection, recreation and education. This explains the great interest among these stakeholders to get involved in our biodiversity or rehabilitation projects and to contribute their expertise and local knowledge. This collaboration increases the success of such projects. Partnering with nature protection NGOs is a win-win scenario for nature and our business. NGO partnerships are extremely beneficial but require time, consistency, flexibility and investment of human and material resources. This presentation will give an insight into HeidelbergCement's biodiversity strategy and will detail the outcome of its partnership approach.

Numerical Simulation on Product Gas of Underground Coal Gasification Based on Laboratory Scale Experiment

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Underground Coal Gasification (UCG) is a technique to recover coal energy in the form of gas in the surface by burned and gasified in an underground coal seam abandoned for either technical or economic reasons. The product gas consists of several combustible gases: carbon monoxide, hydrogen, methane, and other hydrocarbon gas. It is, however, difficult to predict accurately the compositions of product gas because UCG is a complicated phenomenon interacted with heat transfer, airflow, and chemical reactions each other. Therefore, a coupled analysis model combining these factors was created by using COMSOL Multiphysics software. The results of analysis were also compared to that of a laboratory experiment in order to discuss the suitability of the model. As a result, the tendency of increasing temperature and the compositions of product gas shows good agreement between calculated and experimental data. The analysis model created in this study is useful to simulate the product gas generated from UCG.

Energy Neutral Mineral Development Processes - An Overview

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There is an increasing need to put all components of mined resources to good use, to protect the environment from mine waste disposal and to maximize resource and energy efficiencies at mine sites. Total resource utilization or "zero waste activity", where all of the material mined is put to good use, is a challenging concept for researchers and miners. Similarly, "energy neutral mineral development processing" is a concept to extract uranium/thorium from the gangue of the primary ore and use it as raw material for nuclear reactor fuel. This work presents mineral development processes for which the approach may be relevant in the near future (phosphate rock, copper, gold, rare earth elements), and discusses the necessity to consider the technology in the far future. Energy neutrality is reached when the amount of alternative uranium/thorium resources is used to produce energy equivalent or larger than the amount of energy required for mineral processing of the primary ore and uranium/thorium extraction. An elegant solution to use the extracted raw material efficiently is by using it after enrichment and fuel manufacturing in a high temperature reactor erected in the vicinity of the mineral processing plant. High temperature gas-cooled reactors have been operated as research and prototype reactors since the 1960th and currently experience a renaissance with two research reactors operating in China (HTR-10, since 2000) and Japan (HTTR, since 1998), and a prototype plant under construction in Shandong province China (HTR-PM). The greenhouse gas lean energy source provides process heat at up to 950 °C, while being able to desalinate water with no power reduction and maintaining inherent safety characteristics relevant in ever more critical societies. This topic is currently being researched on by fourteen member states of the International Atomic Energy Agency (IAEA) in a Cooperative Research Project.

Microwave Irradiation as Means of Alternative Rock Extraction Technology

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The mining industry is constantly seeking for new and innovative approaches for fast and flexible excavation of raw materials. This paper deals with alternative and innovative concepts in order to improve the cuttability of strong and abrasive hard rocks. On basis of laboratory tests it will be shown how microwave irradiation leads to significant damage in a rock mass. This pre-damage will be exploited for cutting of very hard and abrasive rocks with a linear cutting tool. It will be shown how the crack network initiated by 24 kW microwave irradiation leads to a significant reduction of cutting forces when cutting hard rocks. Furthermore numerical studies underline the potential of the technology for the exploitation on an industrial scale.

Distribution of By-Products in Coarse Aggregate Production

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The production of hard rock products such as gravel, chippings, or “aggregates” in general is inevitably generating by-products. Only a restricted amount of these by-products can be sold, while the bigger amount has to be disposed. Their quantity differs from quarry to quarry and can total 10% of the entire raw material extraction. The significance of this potential can be easily derived from the annual extraction. Just the German hard rock extraction sums up to about 220 million tons per year. The resulting problems are complex. At some of the production sites the by-products pass all extraction and processing stages, leading to related costs. They have to be removed and stored. If an operator, located in Germany, wants to discharge these materials, they are categorized as “waste” and have to be treated in accordance with the German Cycle-and-Waste Management Act. In order to achieve a nearly complete exploitation of the deposit, the protection of natural resources and a higher profitability, it is desirable to develop marketing strategies which allow using at least an increased share of these by-products. Therefore a systematic approach is needed whose extent outreaches the usual utilization of the entire aggregates group. If an application for the by-products is found, it can be expected that their sales are much lower compared to those of the low-revenue bulk goods common for this branch. Additionally, a modified idea of profitability applies. Every saleable product can distribute to the coverage of the total costs. The basis for the development is among others the detailed knowledge of the characteristics of the by-products and the possibility of adapting them in a market-oriented way if necessary. Starting with an overview of the nature of by-products and resulting operational challenges, a basic procedure for a systematic opening up of potential markets will be presented. Furthermore the discussion includes economic conditions as well as market characteristics.

Application of Portable Spectrometers to Mineralogical and Geochemical Exploration: State-of-the-Art, Limitations and Potential

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Portable X-ray fluorescence (pXRF) and infra-red (pIR) spectrometers are novel, state-of-the-art tools for on-site screening and in-situ analysis of the bulk geochemical abundances, ore and soil mineralogy, respectively, and have been increasingly applied in geochemical prospection, mineral exploration and environmental monitoring during the past decade. Unlike most of the conventional laboratory methods (e.g. XRF, LA-ICP-MS), pXRF and pIR spectrometers are non-destructive, fast, cost-effective and relatively easy to operate and may, therefore, have major implication, particularly in small- to medium-scale mining where financial support and human power are limited. With respect to geochemical exploration, the use of pXRF spectrometry mainly focused on the detection of heavy metals (e.g. Fe, Ni, Cu, Pb, Zn) and is reported to have been successfully applied for the analysis of pathfinder elements in Au exploration, of Ni and Fe contents in laterites and for the characterization of carbonatite-hosted Nb mineralization. Portable IR spectrometry distinguishes between a large number of different minerals at near-visible, short-wave and thermal IR wavelengths. One of its major advances is the identification of clays and phyllosilicates and consequently the fast characterization of (hydrothermal) alteration zones and ore types (e.g., porphyry coppers, IOCGs, epithermal Au-low sulfidation, channel iron ore deposits). Limitations of pXRF and pIR spectrometry are known to occur e.g. due to moisture content of sample material, or as a result of overlapping spectral data, respectively. Although there have been tremendous efforts to improve data acquisition and sampling methodology during the past years, the full applicability and potential, as well as the limitations of pXRF and pIR spectrometers remain largely unexplored. Further investigations are therefore needed in order to develop and fully explore the immense potential of these robust techniques for industrial, scientific purposes and, in particular, small- to medium-scale mining.

Open Questions of Mine Rescue Hazard Evaluation – How Can Academic Research Assist?

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Although the development of workplace health and safety in underground mine rescue operations has faced remarkable progress during the past three decades, there are still some white spots on the map. These cover explosion hazards, particularly in collieries with a room and pillar respectively multiple entry mine layout, as well as climatic strain under breathing protection and heavy work load. An increasing deficiency of mine rescuers' physical skills is attributable to a, generally welcome, reduction of regular hard work underground, and to a growing number of rescue brigade members coming from desk jobs. The likewise rising age of mine rescuers is, in reverse, corresponds to a lack of practical experience, due to an overall reduction of larger emergencies in developed countries. In addition, a couple of mine rescue safety issues are still waiting to be dealt with systematically, such as rules for mine rescue operations on vehicles. Small and remotely located mining enterprises are more and more unable to establish a full scale mine rescue brigade of their own, or to count on mutual assistance from their immediate vicinity. Last not least, underground self-rescue guidelines are frequently not based on an effective quantifiable approach, and are often not taking into account the mandatory prerequisites of a safe escape, particularly regarding measures of fire and explosion protection. The paper illustrates the above open questions with examples from mine rescue practice and gives suggestions for addressing them in the framework of bachelor and master thesis work at mining universities focused on covering the topic of underground emergency response.

METALert - An Emergency Response System for Heavy Metals in the Environment

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Accidental releases of heavy metals into the environment can have widespread and long-term impacts on environmental quality and on the health of humans and ecosystems. Therefore appropriate responses to emergency environmental incidents related to heavy metal pollution are necessary and tools to forecast the impact of incidents are a prerequisite for this. METALert is a generic Emergency Response System (ERS) for accidental pollution incidents caused by key heavy metal related industries. The METALert tool is based on environmental models for forecasting, simulation and visualisation of dispersion of heavy metal pollution in water, air and soil. The tool has been applied in several regions in China, a country with a very important heavy metal mining and smelting industry and the world top producer for many heavy metals. The tool contains a generic database with typical emergencies in the key heavy metal related industries (at this moment this database is operational for China). Starting from an incident scenario it can calculate the impact of an accident in the environment. It takes into account incident emissions as well as the effect of the legacy contamination present in a region. METALert is flexible to be set-up for any mining area and can be used to prioritize actions in a region, guide monitoring strategies and perform environmental impact assessments. The tool is evaluated and demonstrated for a Chinese river basin in the Chenzhou area, an important heavy metal mining area. The setup of the tool, the background models and the application will be presented.

Research and Development in the German Coal Industry – Reflecting on Company Development through the Years

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With the signing of the company's articles of association on 27 November 1968, the German hard coal mining company Ruhrkohle AG (RAG) assumed overall responsibility for the Ruhr mining industry under the terms of the Coal Act of 15 May 1968. This Act was adopted by the Federal Government of the day as a measure to promote 'the adjustment and recovery of the German coal mining industry and coal-mining areas". When subsidised coal mining comes to an end on 31 December 2018, RAG can look back on some fifty years of industrial history. The paper uses the R&D work undertaken during this period to examine how the company developed over the years, how the focus of its work shifted between key areas such as rationalisation and workplace safety, and what its future functions and responsibilities will be. The company's remit will not conclude when coal production comes to an end; research will still be needed to deal with long-term liabilities and the problems of the post-mining age. Future themes on the agenda include geothermal energy, wind power, photovoltaics, renewable resources and pumped storage power plant. Early 2015 for example, we realized the launching of the geothermal R&D project 'Heat storage in mines', which is being funded by the Federal Ministry for Economic Affairs and Energy (BMWi), among others.

Predicting the Performance of Transverse Type Roadheaders from the Needle Penetration Index in Mine Roadway Excavation

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Roadheaders have been widely used for the excavation of mine roadways for about 60 years. Having some prior knowledge of the potential performance of a selected roadheader is very important for the planning and cost estimation purposes in mining projects. Several researchers have suggested some performance prediction models for roadheaders. However, these models generally include direct testing methods. The aim of this study is to investigate the predictability of roadheader performance from the needle penetration test which is a simple and practical test, and can easily be applied in the field. The performance measurements of the two transverse type roadheaders were carried out during roadway excavations in Eynez Underground Coal Mine (Soma/Turkey). The net cutting rate (NCR) values were calculated by dividing the volume of the material cut by the cutting time. The needle penetration tests were also performed at 10 points of the gallery faces during performance measurements and the needle penetration index (NPI) values were calculated. The correlations between the NCR and NPI values were investigated for each machine. It was seen that increasing the NPI values decreases the NCR values. It was also seen that the NCR value of the machine having high power was higher than that of the machine having low power. Multiple regression analysis was carried out to develop a performance prediction model for roadheaders. The developed model including cutter head power and NPI has a very high correlation coefficient ($r = 0.97$). The validation of the derived equation was checked by the t-test and the F-test. A concluding remark is that the derived model is significant and can be practically used for the estimation of the NCR of transverse type roadheaders in coal excavations.

Temporal and Spatial Prediction of Lignite Mining Waste Rock Pile Stability by Using Artificial Neural Networks

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Terrain deformation, due to soil liquefaction in lignite mining waste rock piles of the northern Lausitz area (Schlabendorf and Seese), has been modelled as time series for the years 2009 to 2013 by using artificial neural networks. The model has clearly recognized the influences of various lithological and non-lithological controlled parameters on the occurrence of geotechnical events, and these have been quantified and weighted in terms of their importance. The model is able to predict the temporal evolution and the exact spatial location of the event occurring in the dumps as a function of changing groundwater levels and surface morphology. The predictive success of the model was demonstrated through forecasting of events for the years 2014 and 2015 and their comparison with the observed events of those years. The following risk factors were identified: (1) Important destabilizing factors are: (a) a monotonous lithology with the following composition: 96% sand, 3% silt, <1% gravel, lime, clay, coal; (b) kf-values between 10-4 and 10-4.5 m/s; (c) a surface to groundwater distance of 3.45 meters; (d) high gradients of non-lithological controlled parameters: waste dump surface, groundwater level, depth to groundwater and thickness of saturated dump. (2) Important stabilizing factors are: (a) a high heterogeneity of lithology; (b) a low proportion of sand; (c) high proportions of gravel, silt, clay, lime, or coal; (d) a high depth to groundwater; (e) low gradients of non-lithological controlled parameters: open pit surface, groundwater surface, depth to groundwater, thickness of saturated dump; (f) strongly changing kf values between 10-7 and 10-2 m/s. The model can be used as a dynamic tool for risk management before and during the rehabilitation of lignite waste dumps, and for constructing stable waste dumps. By means of varying the model parameters, the geotechnical effects of dump design and remediation scenarios can be predicted.

Repository Konrad - Challenges Regarding the Expansion of the Shaft Landing Station

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The former iron ore mine Konrad (Germany) is being converted into a repository for low and intermediate level radioactive waste. In this context, it is necessary to expand the shaft landing station in the future control area so that waste containers can be transferred from the shaft to the drift. One significant challenge is the expansion itself from a cross section of 3.5 m to 12.5 m over a distance of 55 m in a clay stratum at a depth of 850 m. The expansion method is part of the plan approval decision and cannot be modified; all other modification steps need to undergo a comprehensive approval process. Furthermore, for radiation protection reasons, the waste handling infrastructure has to be maintenance free during the emplacement period of 40 years. Prior to the expansion, safety platforms have to be installed in the part of the shaft that overlies the shaft landing station while the underlying part has to be backfilled temporarily. The work will be carried out in three steps and starts from the shaft with the excavation of a new drift above the crown of the existing shaft landing station. In a second step, the bench between the old shaft landing station and the new drift will be excavated. In a last step, the floor of the new shaft landing station will be dug out to reach the required diameter. The work is accompanied by the installation of a yielding support system according to the New Austrian Tunnelling Method. All measures are subject to an extensive geotechnical monitoring program and complex numerical stability calculations. The project is carried out by DBE mbH, the German Company for the Construction and Operation of Waste Repositories, on behalf of the Federal Republic of Germany represented by the Federal Office for Radiation Protection.

A Review of the German Pilot Mining Tests for Marine Minerals in the Late 70's of the Last Century and Future Perspectives for Manganese Nodules

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In 1978 the "Ocean Management Incorporation" (OMI) consortium with the German "Arbeitsgemeinschaft meerestechnisch-gewinnbarer Rohstoffe" as one of its members conducted a "Pilot Mining Test" in the "Clarion-Clipperton Fracture Zone" (CCZ) of the Pacific Ocean to recover approximately 600 t of manganese nodules in 5,300 m water depth. From 1976 onwards the Saudi-Sudanese Red Sea Commission and its main contractor Preussag cooperated in exploring the hot brine deposits in the central Red Sea and gaining about 5,000 m³ of metalliferous sediments from 2,200 m water depth with lifting technologies based on OMI. In 1985 Gemonod (France) and Preussag started a joint development of key technologies. The OMI nodules collector was further developed and simulation models for an air-lift transport system were validated on two large scale test benches. In 1989 the German DISCOL (disturbance-recolonization) research project started on the abyssal sea floor of the Peru Basin in the Pacific Ocean. A long-term, large-scale "Benthic Impact Experiment" was conducted to simulate impacts from future mining. Since the 1990's several research programs have been established by the pioneer investors of the CCZ and IOM. In 2006 a license for manganese nodules in the CCZ was granted to Germany, followed by increasing interest from members of the German Association of Marine Technology, conceptual system design, a positive economic feasibility study in 2012 and the establishing of the DeepSea Mining Alliance in 2014 for research and international cooperation for a pilot mining test. In 2015, the scale of benthic recolonization, the ecosystem status, and the biogeochemical situation after 26 years at the DISCOL experimental site were investigated. Mandatory pilot mining tests will enable scientists and policy makers to better assess the impact of mining activities and to define detailed boundary conditions and a better legal framework for sustainable deep sea mining activities. It is anticipated, that similar to the 70's, also a new pilot mining test requires international consortia with cooperation between several license holders in the CCZ. Germany with its substantial background and experience has a very good outset situation to provide environmentally friendly technologies for this new emerging international cooperation.

Production of Alkali Activated Materials from Chalcopyrite Tailings and Industrial Wastes

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During the last years, the need for waste valorisation is increasing and is in line with the principles of a zero-waste approach and circular economy. Alkali activation of various mining and metallurgical wastes for the production of construction and other materials looks like a very promising and sustainable waste management approach. This experimental study aims to investigate the alkali activation potential of chalcopyrite tailings obtained from the Hellenic Copper Mines Ltd, Nicosia, Cyprus, when combined with fly ash from the Megalopolis power station in Peloponnese, Greece and ferronickel slag from the LARCO S.A. plant in Larymna, prefecture of Lokris, central Greece. Specimens were produced by alkali activation of each raw material or their combinations using a solution consisting of NaOH, distilled water and sodium silicate solution. The resulting paste was cast in cubic metal moulds of 5 cm edge and remained at room temperature for two hours. When the paste hardened the specimens were demoulded, sealed in plastic bags, heated at 60 or 80 °C for 24 hours, cured for 7 days at room temperature and subjected to compressive strength testing using an MTS load frame. The effect of the activating solution molarity and the different mixing ratios of the raw materials on the compressive strength of the produced specimens was investigated. The morphology of the final products was elucidated through XRD, SEM and FTIR studies. The results show a limited alkali activation potential for chalcopyrite tailings since the strength of the specimens produced did not exceed 10 MPa. However, when tailings were mixed with slag or fly ash alkali activation occurs and the produced specimens acquire much higher strength. For example, mixing slag with chalcopyrite tailings (weight ratios 80 and 20%, respectively) resulted in the production of specimens with compressive strength exceeding 40 MPa.

GIS Based Resource Identification and Resource Cadastres for Existing Buildings

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The urban mining concept is based on the identification of usable resources in anthropogenic deposits. The majority of those resources are found in settlements, dumps and landfills, infrastructure and other durable goods, which form the so-called anthropogenic stock. The paper describes two methods to identify and quantify resources in buildings. A GIS-based procedure to capture and document the quantified resources in a specially developed resources cadastre for an exemplary residential area in Germany was developed. Gruhler et al. (2002) analysed ten multi-family houses constructed between 1880 and 1990 and eight single-family houses constructed between 1960 and 1990. For each building material characteristic values were calculated. Thoughts have been given to building types, structural design, construction elements and installed construction materials. The second method from Lichtensteiger et al. (2006) analyses average values of buildings material for four types of use and four construction epoch. Using the above described methods, resources in buildings have been analysed on the example of a residential area in Germany. In a second step the results were stored in a GIS-based resource cadastre. GIS data has been verified, complemented and updated to create a specific resource data catalogue. Related to the energy efficiency of the analysed buildings CO_2-emissions can additionally be stored in the resource cadastre. Resource cadastres are originally used to quantify resources in landfills. In this study it could be shown that cadastres are also usable for the identification of resources in the existing building stock. These resource cadastres contribute to promote the recycling economy and the use of secondary materials.

Cooperation Opportunities between German and Iranian Mining Companies

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Iran is ranked among the major mineral-rich countries in the world. 68 types of minerals with 37 billion tons of proven reserves and more than 57 billion tons of potential reservoirs can promote Iran to become a global player in the mining sector. Reducing Iran's dependence on oil and developing the mineral and mining industry in Iran is imperative – especially due to the decline of the oil price. The transformation process from an oil exporter to a diversified economy with a focus on the mining sector has to be viewed as one of the most important issues for the Iranian industry in the upcoming years. The industrial development in Iran was inhibited by the sanctions against the country in the previous years which also applies to the mining sector. Thus the sector faces a tremendous lack of new technologies and mining equipment. Now that most sanctions on the Islamic Republic of Iran have been lifted, international companies will be able to position themselves in the opening Iranian market. The opportunities for international enterprises and investors in the mining sector have to be regarded as very promising though new technical equipment and machinery are desperately needed. After the restrictions for foreign companies and investors have been lifted, Germany has declared a huge interest in re-establishing its business cooperation with Iran. Since Iran and Germany have had a long-lasting tradition of collaboration in many fields, many German companies and investors are familiar with Iran's working environment, rules and culture. This knowledge provides an advantage for German companies in comparison to those from other Western countries. A win-win situation for both partners can be achieved. On the one side Iran can improve its proficiency level by cooperating with German companies and obtain new technologies for mining and processing; on the other side Germany will gain by opening-up new markets for the mining sector and winning Iran as a strategic partner and supplier for highly demanded raw materials.

„Blue Mining“ – The Sustainable Future of Mines

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Based on continuously growing resource demands on one hand and consequently increasing requirements for sustainability, safety and environmental protection on the other hand, the mining industry is being subjected to these raised requirements. Over the past decades, progress has been made in all topics. Already in 1987, the United Nations published the following in the Brundtland Report: development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The introduction of the term “Blue Mining” took place in June 2013 at the Milos (Greece) Conference on Sustainable Development in the Minerals Industry. It was also presented in August 2013 on the World Mining Congress in Montreal, Canada and is published in magazines. The term “Blue Mining” should offer the opportunity to work as a whole sustainably, economically, ecologically and efficiently while also improving ergonomics, for example by increasing automation. This approach could be reached by planning the abandonment and the post-mining in a very early stage. Some examples of how mining can actively be involved will be shown; one is of course the topic energy. First successful evaluations were concluded for the use of underground cavities for energy storage. The planning and construction of underground pump storage plants both in active and inactive mining operations was investigated.

Critical Raw Material Potential in Finland

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Critical raw materials (CRM) as defined by the European Commission (Sb, Be, borates, Cr, Co, coking coal, fluorite, Ga, Ge, graphite, In, magnesite, Mg, Nb, phosphate rock, PGM, REE, Si metal, Ta and W) are commodities, which are needed by the EU industry, but produced elsewhere, creating a possible supply risk. The global production of CRM is concentrated in just a few countries, the single most important being China. The discovery potential of CRM in the bedrock of Finland has recently been estimated by the Geological Survey of Finland (GTK). Some of the commodities are currently produced from mines (Cr, Co, PGM, phosphate rock and silica sand) and Finland also has had minor refinery production of Ge from imported material. The discovery potential of borates, coking coal, fluorspar, Ga and Ge in the bedrock of Finland is estimated as low to non-existent based on the lack of known occurrences and suitable geological formations. In and Mg are currently considered to have low potential, although the Mesoproterozoic Rapakivi granites may have some In potential and magnesium carbonate deposits are known in Finland. All other commodities are estimated to have moderate to good discovery potential based on the number of known occurrences and deposits and historical or current mine production. The recent field investigations of GTK have revealed several new targets for REE and phosphate rock exploration. The most interesting targets are mainly found in central and northern Finland and they comprise carbonatites (e.g., Sokli, Kortejarvi) and alkaline intrusions (Iivaara) that commonly have potential for both REE and phosphate rock production. The potential for undiscovered PGM deposits in the Finnish bedrock has already been estimated by GTK and the potential for undiscovered Cr and REE deposits will be estimated in the next years.

OreVal – A European Network for Ore Characterisation and Valuation

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Europe was the cradle of mining and metallurgy. However, over the past centuries, mining activities in Europe have dramatically declined up to the point that metal supply became of concern for the European industry. Time is now to reinvest in the sector. This will require an accurate assessment of new ores in terms of environmental impact and financial risks. A holistic approach integrating geological aspects, residue valorisation opportunities and process efficiencies from the early exploration steps will be mandatory. New ores might as well come from greenfield and brownfield projects, or could consist in the valorisation of former landfill or secondary material sources. Any of these might necessitate advanced characterization or even the design of new evaluation tools or protocols (i.e. automated mineralogy, core scanning and testing, process design or X-ray computed tomography).To target this specific need a European network of infrastructure was launched by the EIT Raw Materials. This network is called OreVal and aims to provide relevant and state of the art expertise for the investors having specific characterization needs. The OreVal consortium gather industrial partners, research centres and universities with complementary expertise and capabilities both for routine or customized characterisation needs. The network is also an entry point for sharing the industrial needs and assessing the opportunity for new partnerships and technology development.

Advanced In-Situ Leaching Technology for Uranium – From Innovative Exploration to Optimized Recovery

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The recovery efficiency in in-situ leaching (ISL) applications is mainly determined by the appropriate control of both wellfield hydrology and geochemistry. The paper summarizes recent advancements to optimize ISL wellfield design and operation in compliance with environmental conditions and regulatory requirements. This review comprises advanced exploration of sedimentary-hosted deposits by geophysical surveying and innovative borehole logging methods; 3D structural modelling of the deposit including hydrological and mineralogical/geochemical data; advanced wellfield design by applying 2D/3D hydrological modelling embedded in a regional-scale model to minimize environmental impacts; operational control of wellfield chemistry on the basis of reactive-transport simulations considering; leaching kinetics in competition to interfering reactions; geometry effects demonstrated by 1D, 2D and 3D reactive transport studies; and post-mining aquifer restoration including natural attenuation effects.

Evaluation Method of Soil Conditions in Rehabilitation Area in Consideration of the Effects of Acid Soil on Vegetation in Coal Mines in Indonesia

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Rehabilitation is necessary for environmental conservation after the operation in mines. It is important for successful rehabilitation to establish soil conditions suitable for vegetation at the stage of backfilling waste rocks and topsoil in waste dumps. However, soil acidification caused by mixing topsoil with waste rocks results in plant death in rehabilitation area in coal mines in Indonesia. While waste rocks which cause soil acidification are separated on the basis of the geochemical properties and buried deep in the ground in waste dumps during the operation, it is not uncommon that topsoil is mixed with the rocks during the process of backfilling. Moreover, the method to assess the soil conditions in rehabilitation area in terms of the effects of soil acidification on plant growth has not been taken into consideration in Indonesia. In this study, a laboratory vegetation test was conducted with *Acacia mangium*, which is one of the plant species preferred for re-vegetation in waste dumps in mines in Indonesia, under various soil conditions for the purpose of establishing the assessment method for rehabilitation: Pyrite was mixed in simulated topsoil to simulate acid soils. The results indicated that soil acidification prevented the growth of plant or resulted in plant death after certain period of time. On the other hand, *Acacia mangium* with the height of more than 15 cm showed steady growth in acid soils with pH less than 4.0. These results indicated that the soil conditions in rehabilitation area for vegetation should be evaluated in terms of a balance of buffering capacity and acid potential in soils, the timing of the transfer of plants to acid soils, and the types of plants.

Evaluations of Inclinometer Measurement Results in a Lignite Open-Pit Mine

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The in-situ inclinometer measurement system was used to monitor unstable slopes in the TKI-owned Gumuspinar lignite open-pit mine in Turkey. The horizontal deformations by nine boreholes drilled in the mining area were measured by inclinometer probes with 0.01 mm precision for 105 days. The graphical outputs were prepared by Smart and Incli2 software. Also the depths of the shear plane were determined. The deformation values determined in the shear plane ranged 0.25 to 20 mm (0.01147 - 0.25316 mm/day). Also the deformations measured in borehole heads were ranged 1.5-19 mm (0.00917 - 0.13475 mm/day). The deformation direction determined on shear plane indicated that the crack propagation was in direction of the failure plane. In addition, the deformation direction occurred in borehole heads indicated that the dead load of the unstable rock mass was in movement direction. The conclusions also refer to the direction of in situ stresses (Ï$\int$) which are named as compression (+) and tension (-). In this study, even though in-situ stress measurements have not been taken to explain formation of tension cracks observed in the field, the certain approaches have been improved. First, the deformation directions observed in borehole heads and share planes in OINK-2, 3, 5, 7 and 8 boreholes were opposite to each other. The compression stress in borehole heads were effective, however, the crack propagation formed in the shear plane has not yet reached to the topography surface. Second, in OINK-1, 4, 6 and 9 boreholes, the deformations were same direction. The crack formed along the shear plane has reached to the topographical surface. It is due to effective of the tension stress existed in borehole head. Third, the shear stresses (Ï„) occurred in deformation directions determined along shear plane. As a result, it is shown that the in-situ stress directions will be able to be determined by deformation directions, using inclinometer measurement results.

Efficient Mining of High Seams with LTCC Operations

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Longwall mining is an expensive undertaking, from the preparation of the site itself to capital investment in the equipment. This is why the owners of longwall operations have extremely high performance expectations, especially in tough economic times when commodity prices are low. If the seam height is significantly higher than the normal dimensions of roof supports, mines tend to leave unmined material behind, mine several times through a seam in different layers or even skip the mining of a seam in total. Here, the longwall top coal caving method (LTCC) is a valuable solution for very efficient longwall mining in high seam heights. This paper explains the principle of the Longwall Top Coal Caving and the necessary additional equipment needed to run a longwall system in such an operation. The paper shows how LTCC longwalls are to be automated and what types of automation modes are possible. Furthermore, the paper provides an overview on the global regions where LTCC operations are applied, gives an outlook on expected production rates, and finally discusses the benefits of this special mining method.

Estimation of State and Properties of Coal-Rock Mass Based on Inverse Problem Solution

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Designing optimal flowsheets for pre-degassing of coal beds before starting mining, planning and implementation of gas-dynamic hazard mitigation procedures is a long list of problems to be handled with the knowledge on gas-kinetic characteristics and permeability of coal as well as natural stresses. An almost universal approach to the assessment of the majority of the listed characteristics is formulating and solving inverse problems. Typical examples of such problems are given below. Estimation of diffusion-and-capacity characteristics of coal bed structured as regular patterns of blocks. The authors offer a method of inversion of data on gas pressure P(t) measured in hole under mode of “pressure drop,” which allows finding gas content C, diffusion D and mass transfer B coefficients. The method is based on sequential minimization of two objective functions, one depending on D and B, the other - only on C. Determination of permeability and natural stresses in coal-rock mass: Based on the concept of representative equivalent volume, the geomechanical model of jointed-porous rock mass with regard to swelling-shrinkage deformation is used to formulate an inverse problem on “estimation of permeability K and horizontal natural stress S” by the pressure P(t) in shut-in well and to study resolvability of this problem. The numerical experiments show that with time P tends to a steady-state value which is a linear function of S and independent of K and gas-kinetic parameters. This enables finding S and then, by minimizing a pertinent objective function, K. New approach to interpretation of “canister test” data: “Canister test” is a known method to determine gas content of coal. However, the test data on pressure P(t) in a sealed vessel with a coal specimen contain much more information on the gas-kinetic characteristics of coal. With the developed model of gas emission from coal specimen with regard to grain size composition and desorption kinetics, the inverse problem on determining C, D and B by P(t) measured in the “pressure drop” mode is posed. The numerical experiments show that the inverse problem is unambiguously resolvable at the noise level up to 50%. The method is tested using in situ data from a coal mine in Kuzbass. *The authors are grateful for the support provided by the Russian Science Foundation, project no. 16-17-00029.*

Update on Mechanized Shaft Sinking

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Two Shaft Boring Roadheaders (SBR) are in operation since 2013, to sink two shafts for a potash mine in Saskatchewan in Canada. In the first part of the presentation a brief introduction to the machine technology will be given. As the machines are prototypes they have been subject to a learning curve in the past years and thus modifications have occurred. An overview will be given to these modifications and technical developments. To react to the jobsite requirements, the de-dusting system of the Pneumatic Mucking System has been redesigned to cope with wet martial as well dry as originally planned. Since the SBR was launched the shaft lining was done by shotcrete application, jump form or tubbing installation. Especially for tubbing installation the step change was done with the hands-off erection of the so called “Blairmore Ring”, which is a requirement for shaft sinking in the Saskatchewan area. These steel casted segments are handled by a ring erector on the SBR with a distance of 1,4 m above the bench. The safe handling of the segments and the implementation of this feature to the existing SBR generated benefits for the owner BHP Billiton and the contractor DMC mining services. The second part of the presentation will introduce the segment installation on Shaft Boring Machines. Herrenknecht provides segment handling devices for TBMs all over the world. The industrial production method of building tunnels by erecting segmental rings can be transferred to shaft sinking. Based on the state of the art tunnel boring machine equipment, tailor-made solutions are developed for shaft sinking applications as stand- alone or integrated solutions. The segment erector can handle liner plates, pre-cast concrete or steel segments. In terms of performance the segment installation has potential benefits for shaft production.

Ultra-Wideband Technology for Mining Automation

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As the automation in the mining and heavy machinery industry is continuously advancing, the industry is adopting the vision of Industry 4.0 more and more. The knowledge about the condition of the machine and its surroundings is a central aspect here. To enable this, the Institute for Mineral Resources Machine Technology (IMR) of RWTH Aachen University is researching new technologies for underground mine automation in the EU funded project Real-Time Mining. The aim of this project is the realization of a comprehensive real-time system for the underground mining process allowing the resource model and therewith the winning process to already be optimized in the exploration stage. Currently, all process steps are being monitored and controlled individually and separately. The novelty of the project lies within the continuous monitoring and fusion of data acquired during the different process steps linked with a sequentially updateable deposit model. One main target of the project is the development of a sensor based positioning of machines by means of different sensor technologies. The combination of these different sensor data introduces a redundancy with which the error rate can be minimized and the accuracy is maximized. The environmental conditions in the underground environment pose additional challenges for the sensors as humidity, dust and mechanical vibrations that have to be endured by all systems. Based on these requirements, one of the central sensor technologies was chosen to be Ultra-Wideband technology. This technology has proven to be robust enough to withstand these conditions and perform positioning and communication tasks. In this work we present the overview over the development of the underground positioning system including preliminary results with the Ultra-Wideband technology as well as test measurements from the project.

Competence Centre for Effective and Ecological Mining of Mineral Resources (CEEMIR) - Reevaluation of Raw Minerals in the Czech Republic

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The Competence Centre for Effective and Ecological Mining of Mineral Resources (CEEMIR) operating since 2014 under leadership of VSB - Technical University of Ostrava associates partners from academy (VSB-TUO, Czech Geological Survey) and industry (DIAMO, Sedlecký kaolin, RPS Ostrava corp., Watrad). CEEMIR is based on the national oriented research priorities and focuses on strengthening the sustainability of mineral supply. It concentrates on the review of reserves of selected non-energy raw materials that rank among the EU critical raw materials. In general, CEEMIR is dealing with evaluation of current mineral potential of the Czech Republic covering known mineral deposits and existing mining waste. Subsequently, for the selected perspective deposits the effective and environmentally friendly mining and mineral processing techniques are due to be proposed. Furthermore, mineral reserve estimation standards for the EU critical raw materials in the Czech Republic are being reconsidered. CEEMIR consists of several work packages (WPs) considering various aspects of mining. Potential resources are under scrutiny in WP2 to create data sheets for perspective localities in terms of contents of the critical raw materials and draw raw material maps. In WP3, mineralogical and geochemical characteristics of perspective resources are studied to determine useful components, mineralogical and physical parameters and potentially harmful substances. Based on archive data reevaluation, WP4 visualizes the selected deposits using digital modelling. WP5 analyses regulatory framework related to mining and evaluates the selected localities with regard to the environment. The aim of WP6 is to analyse mining and technical conditions of the selected mineral deposit or mining waste deposits and propose suitable underground or surface mining methods. WP7 studies mineral and waste processing technologies and recommends optimal technologies to obtain the useful components in the form of optimized technological line project. Finally, WP8 justifies importance of the selected deposits economically.

Dynamic Prospectivity Mapping Tools for Mineral Exploration

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The expanding mineral exploration and mining activity in Europe set demand for the development of time-saving, cost-effective and environmentally neutral exploration techniques as a simple-to-use toolbox. Enhanced spatial data analysis techniques are essential due to increasing amount of digital data which is collected during mineral exploration campaigns. These data include high resolution geophysical surveys, geochemical surveys and geological mapping. In addition, any other relevant map data, e.g. digital elevation model, can be integrated and used as an input for modelling. The selection of applicable data is typically based on a mineral systems model, which defines the critical parameters that are needed to define the deposit type in question as a spatial model. We propose new workflows and tools for mineral prospectivity mapping. These tools are implemented on top of a geographical information system (GIS) platform and utilize advanced spatial analysis techniques like fuzzy logic, logistic regression, weights of evidence and neural networks. Dynamic model optimization in target scale prospectivity mapping with increasing information during the execution of an exploration campaign will make the modelling a flexible tool for mineral exploration. The model optimization can take into account the data acquired via drilling the targets during the exploration. This will be demonstrated in a pilot case study within the Central Lapland Greenstone belt, northern Finland, which is one of the most important exploration terrains within Europe. The methodology described in this paper can be used for the strategic planning of mining companies for making land claims for further target scale exploration.

Investigation of a Newly Designed Ultrasonically Assisted Flotation Cell

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Ultrasound is used for surface cleaning purposes in mineral processing. The effects of ultrasound with particular frequency, time and power levels on flotation of some industrial minerals, such as borates, quartz and magnesite, especially coal slimes have been investigated by researchers. Ultrasonic energy may produce positive or negative effects on mineral surfaces when applied before, during and after mineral processing methods, especially on flotation where mineral, water and air phases are present together. In the recent literature, it has been stated that in conventional flotation conditions, although the density of mixture of hydrophobic coal particles, reagent and air bubble together are lower than water's density, slimes or clays are present. They prevent reagent adsorption and as a result flotation recovery decreases. However, in ultrasonic flotation conditions cavitation bubbles replace with clay particles due to surface cleaning. Reagents are also more effective when ultrasound is used due to thorough surface cleaning effects, therefore this phenomenon may cause higher adsorption of reagents onto coal surfaces and lower ash values and higher combustible recoveries in concentrates. Within this study, a special attention was focused on floatability of representative hard coal slimes from Prosper-Haniel colliery in Germany. For experiments, a Retsch-type ultrasonic bath with single frequency was re-constructed as a flotation cell and combined with a Humboldt Wedag type flotation machine. The test results indicate that application of ultrasound helps immediate flotation of coal particles in a short period of time as well as the quality and quantity of the floated coals increase while consuming lesser reagent dosage than a conventional flotation system.

In-Pit Crushing - Iron Ore Mining in Australia

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In quarries all over the world in-pit crushing has proven its strengths mainly regarding possible savings in transportation costs, short ramp up times and flexibility. As mining applications usually require output of several thousand tonnes per hour which cannot be realized cost competitively by mobile equipment, it has never really found its place in big mines. Kleemann with its subsidiary in Australia nevertheless found a niche for its machinery in the biggest mines in the world â□“ in iron ore mines in the Pilbara in Australia. Due to a high demand for steel in fast growing countries especially in Asia, iron ore prices have risen strongly over the past decades reaching a peak in 2011 of almost 180 $/t. High prices broke up market structures and let relatively small producers (165 mt in 2014) rush into the market and a number of deposits became mineable. To leverage high iron ore prices, producers needed to ramp up their production capacities as quickly as possible. This is where customers really took benefit from Kleemann's mobile equipment. Building up stationary plants (OPF) raised expenses without producing anything. During that time Kleemann's crushers were set up in the mines in a very short time, took over mechanical processing and generated revenue. Moreover, when the market demand exceeded the OPFs' capacity, customers could easily boost their production capacity through quickly setting up satellite crushing spots all over the mines. These plants were capable of producing up to 1200 t/h (feed size 0 - 1200 mm, final product 0 - 10 mm). Another benefit of Kleemann's equipment was its flexibility. As actual production sites changed within the mines, the equipment was easily able to follow and reduced transportation costs significantly. Whenever iron ore mining is facing better times again, Kleemann's equipment will make sure to profit from rising prices as quickly and good as possible.

Martin Cleanscrape – A Revolutionary Innovation in Belt Cleaning Technology for the Mining Industry

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CleanScrape Primary (CSP) as our innovative new development makes customer expectations in clean belts come true. Conventional cleaning systems operate typically parallel to the pulley axis and are installed with a fixed mounting suspension. Our CSP is operating diagonally on the surface and is fixed at both sides. This causes a lower pressure onto the belt. Since there is no more need of resetting caused by the wear of belt and scraper, the system is nearly maintenance-free. CSP is tensioned diagonally under the material flow in a certain angle and is generating a „space curve“. The single scraping elements of tungsten carbide are vulcanized into a matrix and are positioned with low pressure to the belt. The average of cleaning effort is up to 95%. All these parameters are depending on kind of material, speed, splices and surface of the belt. The Martin Cleanscrape is the one and only metal-tipped peeling angle cleaner that will clean perfectly, accommodate splices and which does not damage your belt. Our special know-how is „inner workings“ with tension-system, vulcanized in a self-distinguishing and anti-static special rubber. It achieves the ATEX standard and is approved for applications in coal mines.

Subsurface Spatial Planning - Challenges for Research and Practice

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Both underground and open-pit mining projects are of spatial significance, which overlap each other with different underground and surface forms of usage such as drinking water production, tunnel constructions, and construction projects with deep foundations. Related to mining a form of usage of subsurface cavities, apart from the production of mineral resources, are the storage of natural gas and oil and the disposal of different types of waste such as residual materials from the chemical industry as well as spent nuclear fuel. The constructive management between different usages of the underground and the surface requires, due to the complexity of connected issues and possible influences, a comprehensive approach to achieving a systematic interaction. For purposes of an overall approach, the term 'subsurface spatial planning' will be implemented. All spatial data in relation with the production of mineral resources are pooled within the mine surveying departments of mining companies and mining authorities. Therefore, mine surveyors are predestined for the processing of this challenging task. The utilization of the underground is of increasing importance and is of high interest of the common good as well as future generations. The connection of the topic of subsurface spatial planning to the state chancellery of North Rhine-Westphalia emphasizes its current high significance. Subsurface spatial planning requires expertise in geomonitoring, geohazards, geomodelling, geodata management, and judicial aspects concerning mine subsidence: (a) Projection and monitoring of ground- and rock movements related to mineral resources; (b) Surveying and registration of deposits; (c) Monitoring and preservation measurements; (d) Analysis and prognosis of impacts related to mining activities; (e) Registration of ground movements both on and below surface; (f) Avoidance of geohazards by optimized extraction planning; (g) 3D underground modelling (static, kinematic); (h) Support of a sustainable extraction planning for a more efficient exploitation of the existing reserves; (i) Exploration and evaluation of the underground as well as reserve calculation of deposits; (j) Gathering, processing, storage and analysis of spatial data; (k) Visualization of gathered data via cartographic representations which can be utilized for purposes of orientation, navigation, documentation and planning; (l) Processing of licensing procedures and issues; (m) Optimization of existing regulations on utilization of subsurface spaces; (n) Mediation in case of conflicts of interest regarding the utilization of subsurface spaces; (o) Simulations of the utilization of subsurface spaces; (p) Planning of subsurface infrastructure; (q) Concepts for final disposal; (r) Licensing procedures related to subsurface spatial planning. This article provides an insight into the challenges mine surveyors have to face in cooperation with other geosciences and describes the complexity of these tasks.

New Developments for Tunnel Boring Machines in Mining

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Herrenknecht develops tunnel boring machines for civil application since more than 30 years. Limiting factors to apply a tunnel boring machines in mining have always been the large curve radius of TBMs with often more than 250 m, as well as the size of components. The proven “of the shelf”-gripper TBM technology as used for the Gotthard base tunnel has been downsized to the Mining Gripper TBM concept. The optimized weight, size and curve radius has to be balanced out by a reduced performance. To continue the optimization of mining concept Herrenknecht would like to introduce a partial face excavator called Haulage Boring Machines (HBM) that can be applied in hard rock for haulage tunnels and horizontal developments. By reduction of the cutting forces a lighter and more flexible concept with a minimum radius of 50 m and 100 to machine weight is developed which is capable to achieve advance rates in 250 MPa rock of approx. 6 m/day with 12 h cutting time. The cutting process of the new concept is comparable with the standard Gripper TBM’s process. The advancing unit pushes the rotating cutting drum with mounted disc cutters against the rock face. The standard disc cutters roll on the rock face and break off small sized rock chips. The cutting drum itself will be rotated around the horizontal axis and thereby excavate a round shaped tunnel. The HBM will be presented as well as the machine technology explained. Together with a high level of mechanization and an increase of labour safety this machines will add to the cost effectiveness of mining projects.

Mine Rescue: Drilling Criteria Explained by the Pingyi Rescue Operations in China

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On Dec. 25th, 2015 a deserted gypsum mine in Baotai town, Pingyi County in the Shandong Province of China collapsed in approx. 215 m depth. This collapse lead to another collapse in an active mine nearby, trapping numerous miners. These were searched for by drilling pilot holes. One of these pilot holes established contact with 4 miners that had survived the collapse in the mine in a depth of 213 m. A large diameter rescue hole was attempted and unexpected geological difficulties caused abandonment of the well. A new well was started near the first large hole. After 36 days, the 4 miners could finally be brought back to surface alive, with modern, patented German-made technology. China had purchased 6 units of 90 t pullback capacity drilling rigs explicitly for mine rescue purposes in 2012 (as a result of the successful rescue of 33 miners in 2010 in Chile) one of which now came into operation, with basic drilling equipment suitable for drilling 28'' with a DTH Hammer (this had been the equipment that had been successful in saving the 33 Chilean miners). This equipment proved to be inadequate in the geological setting found in Pingyi. Therefore, drilling equipment for large diameter reverse circulation air-lift drilling and direct circulation mud rotary drilling were used and in the end led to the successful finish. Another major difficulty proved to be drilling a vertical hole, especially in reasonably soft rock and a minor inclination of the beds. The consequences recognized by the Chinese Authorities included better training of drilling crews, and have more plans worked out in advance to respond better and faster to new challenging situations while drilling.

Slag Valorization by Ore Dressing Processes

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The Manganese and Nickel division of the ERAMET group extracts and process ores in Gabon and New Caledonia to produce alloys for the steel industry. Several ERAMET Mn and Ni metallurgical plants are producing slags from their furnaces SiMn and FeMn from worldwide plants; FeNi from Caledonian plant. Most of these slags are stockpiled, recycled in furnaces, or sold for other applications at low benefit. The ERAMET research center currently develops methods to separate metal inclusions from slags, on ERAMET products, and on slags from client companies in other fields (Pb slags, casting bed sands, etc.). Current investigations show a common issue with respect to the identification of the best method to efficiently recover the metal included in the slags. A first solution consists of a complete liberation of the metal by non-conventional comminution processes such as the HPGR (High Pressure Grinding Roll) or electrical mill. Metal can then be easily recovered by screening. Grinding tests with HPGR technology were performed by refining FeNi slags. A particle size reduction from d90=23mm to d90=6mm resulted in an increase of 20% of the fines fraction <500µm and additionally a liberation of some larger metal particles. Classical grinding technologies are presented as an alternative, combined with gravimetric or magnetic beneficiation tests. By using the diverse processing units at ERAMET Research, it was also possible to upgrade slags in Pb. An uncrushable Pb-rich fraction (76.9%) was isolated from a slag feed with a low Pb content 20.8%, by crushing and screening steps. The slags were then enriched by dry density separation to more than 30% Pb with a mass recovery of around 10%. By presenting ERAMET Research capabilities, this presentation details several recycling processes which have led to the production of economically valuable metal concentrates originating from by-products of various pyrometallurgical plants.

Trends in Mineral Production in Europe, 2005-2014

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The National Minerals Information Center (NMIC) of the United States Geological Survey (USGS) is the primary organization in the world that collects, aggregates, analyses, and disseminates data on country-level and global supply of and demand for mineral commodities, both raw and processed. Our minerals statistics data are second to none in terms of comprehensive coverage of countries and commodities, accuracy, and availability to potential users. This paper uses USGS data to provide an overview of mineral production in Europe during the past decade and outlines major observed trends. For this analysis, we compile world production data for over 40 major mineral commodities and pay special attention to those that either have been mined in Europe or have a potential to be produced in the region. In particular, we use USGS data to demonstrate the role of the European continent in mining and processing of specific mineral commodities in overall world production. An analysis of sub-regional tendencies is conducted and compared with mining trends observed in the rest of the world. The presentation is structured as follows: First, we analyse output data to see how mineral production in Europe has changed over time in the past decade. Then we look at the geographic distribution of mineral production in Europe and analyse probable economic, institutional, and policy factors that may have impacted this distribution. We also analyse the balance between production and consumption of mineral commodities in Europe as a whole and in sub-regions of Europe. Finally, we offer a brief overview of mineral production outlook for the European continent in the short to medium terms.

Quantitative Evaluation and Prediction Method of Cutter Bit Wear for Drivage Machine

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It is unavoidable to have cutter bit wear during tunnel excavation. In recent years, because of a variety of ground conditions being excavated, problems caused by excessive cutter bit wear sometimes happen in projects. Many studies on cutter bit wear have been done in past but quantitative evaluation method of cutter bit wear in advance of excavation has not been established yet. In this paper, data has been collected from an actual project where a hard gravel layer was excavated by a drivage machine and the data are compared with characteristics of the excavated ground and mechanical durability of the cutter bits measured in laboratory tests.

The Contribution of Urban Mining to Alleviate Phosphorus Supply Security Concerns

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Urban mining is a buzzword when it comes to recycling of anthropogenic materials from urban areas. Not less frequent the term peak phosphorus (P) has been infiltrated into the consciousness of scientists and public during the past decade. There is an ongoing discussion about the scarcity of phosphate rock reserves. However, available data do not support such apprehension. P is an essential plant nutrient and a sufficient P supply is required in order to maintain a high level of crop productivity. P has an eminent and well-known relevance as an ecological contaminant, too. Thus it is vital for sustainable crop production to develop strategies and measures to close the agricultural and anthropogenic P cycle. The entire annual P demand of German agriculture accounts for roughly 560,000 tons. About 110,000 tons P are applied with mineral P fertilizers. Sewage sludge might provide approximately 50,000 tons P. This P source might replace more than 45% of the mineral P fertilizer input if fully utilized. Thus urban mining of P and its beneficiation into a suitable fertilizer product contributes to alleviate P supply bottlenecks and price volatility of mineral P fertilizers. Mono-incineration of sewage sludge combined with technical processing should deliver a product which complies with the concept of P=100% Zero. This concept postulates that P in fertilizers should be completely (100%) plant available and without (zero) contamination of environmentally relevant compounds. In case of heavy metals the loads should not exceed off-take by harvest products in order to avoid accumulation in soils. The aim of this contribution is to evaluate the potential of urban mining to mitigate phosphate supply security risks and to outline a general framework for a sustainable use of P in agriculture in Germany.

BARRACUDA® – A Revolutionary New Mining Concept

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One of the most expensive areas in hard rock mining is the drilling and blasting. In densely inhabited areas blasting may even stop the operation because of non-compliance with the environmental regulations. So far the only technically feasible solution to overcome this problem is the cutting/milling technology which is used e.g. by surface miners. These machines cut the stone in thin chips in a horizontal way by moving over the bench – a technique which requires a relatively large and flat area and which normally does not allow for continuous transport because the machine is just moving too fast. Their effective long time capacity is also limited due to its operational requirements. Since many years miners and equipment manufacturers all over the world are therefore looking for high capacity equipment which does not have these limitations but is on the other hand still economically feasible. One of these companies is ThyssenKrupp. ThyssenKrupp started its first development more than 20 years ago. While first machines proved to be successful (examples are shown in the following) they still could not be economically employed in material which was harder than approx. 15 MPa. The limit was the optimum design in the bucket and teeth configuration. This optimum design has only been developed in the last years after extensive research. Today ThyssenKrupp is able to offer a bucket wheel excavator which can economically dig in material of up to 50 MPa - the BARRACUDA®. The BARRACUDA® combines now the cutting technology of the surface miners and the block operation of a bucket wheel excavator. The entire new BARRACUDA® concept will be presented. It is built up in a modular way (Compact-Flexo-System) and by extending simple elements to the basic machine it can be easily adjusted to the miners needs and required economics. The BARRACUDA® - Compact and Flexo can be integrated in any mine without new mine infrastructure being required. The BARRACUDA® - System is finally based on conveyor transport, the most economical way of handling large volumes in mines.

Reframing Design Objectives for Fine Grinding Equipment

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Mining by definition cannot be a sustainable activity due to the finite lifespan of its operations. Mining operations, however, can contribute to sustainable development by providing opportunities for economic growth, while minimising environmental impact. Efficient consumption of energy is one of the major sustainability metrics for mining operations. It is estimated that about 4 to 5% of the total energy produced globally is consumed by mineral processing plants, particularly in terms of size reduction processes (comminution). The economic importance of comminution systems becomes greater when thinking that comminution contributes to about 60% of the total capital cost in concentrator equipment, 40 to 50% of the total operating costs, and more than 60% of the total energy consumption in processing plants. Recent studies also indicate that among the two main steps of comminution, i.e. crushing and grinding, the latter contributes up to 90% of total operating costs. As a result, over recent years a great demand for improving comminution systems has emerged. The low efficiency of current designs is mainly due to the fact that grinding stresses are applied to the whole material volume yielding an excess of elastic energy that eventually is dissipated as heat. To some degree current technology has improved, e.g. using compressive load and careful choice of the grinding media; yet it is still far from ideal. This study aims to identify the defects in the design of various grinding equipment that result in energy dissipation. The research provides a strategic reframing of the design objectives for grinding equipment. Based on the data analysed, a generic design methodology that proactively anticipates the expected efficiency of a new equipment design is proposed.

The Benefit of HMPE Fibre in Mining

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DSM Dyneema, Netherlands

M Roeters
DSM Dyneema, Netherlands

The mining industry is going through a difficult period, commodity prices are down, investors and lenders have fled the sector and profits are under pressure. Mining companies need to act differently to overcome this downturn and find ways to increase their production and adopt lean processes from other industries: innovation is becoming a critical theme. The companies that become leaner, stronger and more innovative in how they operate will emerge as the leaders. Replacing steel wire ropes with synthetic or hybrid ropes based on HMPE fibre could be the differentiator in mining performance mining companies are looking for. HMPE fibre can improve the productivity of a mine and can be applied in both open pit as well as underground mines. In open pit mines, mining output is for example influenced by the downtime / changeover time of replacing steel wire ropes on e.g. draglines and rope shovels. Changing an HMPE rope can be done faster with fewer personnel. In underground mines, the limiting factor for hoisting capacity from relatively great depths is the self-weight of the steel wire ropes. Switching to HMPE fibre will allow greater payloads due to the weight reduction of the synthetic rope or hybrid rope (consisting of a combination of steel wire and HMPE) versus steel wire rope up to a factor 7. HMPE fibre is 15 times stronger than steel, lighter than water and extremely durable. HMPE, like Dyneema® is a proven technology and applied in many high risk markets. As a producer of HMPE fibre, DSM Dyneema has, jointly with renowned institutes and rope makers, created new guidelines and certificates to safely replace steel wire rope with HMPE. DSM Dyneema invests in scientific research to create a trusted and highly valued brand Dyneema® - which is widely adopted in many industrial markets.

Areas of Expertise of the German Mining Equipment Manufacturers

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The German Engineering Federation (VDMA) and its member companies recommend the expertise in engineering mining equipment gained by decades of cooperation with the mining industry worldwide. The situation in the mining sector is changing. The perspective for power generation by coal in principle is not very brilliant, not only in Germany but also in the EU and in the US too. The aim to reduce carbon dioxide emissions leads the power generating industries more and more to curb the use of coal. On the other hand the mining of commodities to be used in environmentally-friendly energy generation plants will become more important in the years to come. Besides that the principles of Industrie 4.0 create great opportunities to improve production of equipment as well as extraction processes in the mining industry. These aspects guide the activities of German mining equipment manufacturers organized in VDMA. Through innovation and continued investment in research and development, German equipment and service providers are meeting the needs of today's and tomorrow's miners. The presentation focuses on work being done by VDMA Mining member companies to increase efficiencies, optimize operating costs and improve safety.

Integrated Mine Management System

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This presentation discusses best practice mining operation in Europe (arguably in the world) through implementation of an integrated mine management system with central monitoring in collaboration with Sandvik and their partners. This integrated mine management system through the use of Sandvik Trans4mine, has enabled a continuous improvement model to maximize mine productivity & reduce operational waste through effective utilization of equipment, people, process and system. Pundits put this mining operation at 75% of plan compared to an industry standard of 35% to plan which is a quantum change to performance. Sandvik Trans4mine has steps towards a fully integrated system including underground physical audit, production modelling, dynamic mine simulation, drilling and blasting as well as loading and hauling optimization. Each continuous improvement project, carried out in different phases, is identified by four guiding principles, which are “investigate, analyse, identify and optimize”. As a part of the integrated mine management system, Sandvik has implemented real-time monitoring and process control solution in the mine; generally called OptiMine. The monitoring includes real-time data collection and reporting of utilization, productivity and health and condition monitoring of each piece of equipment. The equipment data is integrated into maintenance management system for preventative and scheduled maintenance planning and scheduling. The process control solution is enabled by Sandvik task management; through a portable tablet. The task management is integrated with long-term production planning and maintenance scheduling system of the mine. The annual production target is broken down into monthly, weekly, daily and shift based targets. Thus, shift based targets are communicated to each operator through MineLAN. The central control room is utilized for real-time progress monitoring, control and interventions during the shift. Hence, the integrated mine management system with central monitoring provides the mine with effective tool to plan, monitor and optimize productivity.

Highwall Mining: A New Futuristic Coal Mining Technology for Recovery of Locked Coal

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Indian coal industry is shifted towards opencast mining due to failure of longwall and other underground mass production technologies. At present more than 85% of coal production comes from opencast mining. Many more opencast mines have gone to higher depths leaving much more coal reserve locked in highwall sides and many of them are reaching their pit limits. Hence full recovery of coal became difficult. Highwall mining is a highly mechanized method which has a huge potential to recover coal locked in highwall side at rapid rate. Around the world this technology has been introduced in USA, Australia and recently in India. The first highwall face was designed at OCP-III in SCCL later on West Bokaro (TISCO) and Medapalli OCP. Highwall mining is a highly mechanized method associated with several advantages such as high production rates and low production costs. There is no requirement of supports ventilation and blasting. Production leads to added recovery, which is otherwise lost in ultimate pit. In this paper, a few case histories of highwall mining from Indian have been discussed with special attention to design of web pillar. The major safety problem in this method is associated with design of web pillar as no other supports are provided in the entries. Web pillar differ from usual coal pillars in respect w/h ratio being < 3.0, with an exceptionally longer length compared to its width, to the tune of 50 to 500 m. Several empirical coal pillar strength equations were critically analysed. Laboratory experimentations were done in addition to numerical modeling on UDEC. Final experimentation resulted in arriving with new modified equation for design of web pillar to ensure safety of highwall mining. All these aspects have been thoroughly discussed in this paper.

Determining Aspects of Institutional Design of Sustainability Initiatives Including the Mining Sector

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Like many other industrial activities, mining and beneficiation is associated with a variety of social and environmental impacts. Armed conflicts, use of toxic substances like cyanide and mercury or management of tailings are a few of possible impacts. To avoid or reduce these problems, several voluntary sustainability initiatives have emerged in the last decades. Their overarching goal is to reduce social and environmental impacts by setting sustainable requirements (social, environmental and economic). Furthermore, they need to ensure compliance of these requirements. The initiatives can be characterized by means of different aspects. On the one hand, the standard (in the narrow sense), which includes sustainable requirements, is a core element of every initiative. However, in addition to that, several institutional aspects are also important. These aspects of institutional design describe structure and functioning of initiatives. Aspects include but are not limited to revision of the standard, certification, stakeholder involvement, decision-making and financial aspects. There are many possibilities to establish the institutional design, for example, the revisions of the standard could be enforced every 3 or 5 years. Furthermore, it can be observed that some initiatives seem to be more successful than others, as can be inferred from the increasing dominance of FSC and PEFC in the timber sector. The main goal of this investigation is to ascertain, if there is a relationship between institutional design and success of initiatives and, if this is the case, which characteristics are more relevant to success. In a first step, relevant characteristics need to be determined. A systematic literature review and a subsequent expert survey for validation are conducted. Information about initiatives from other sectors like fishery, wood and paper are also included.

The Stimulation of Rock Massive

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Hydraulic fracturing techniques are well-stimulation methods in which a rock is fractured by a pressurized liquid. These techniques are used worldwide in oil and gas production or deep geothermal. The group of Czech research institutions and companies applied a new approach to the stimulation of rock massive during the four years (2011-2014) lasting Stiromas project. The project focused on comparison of the efficiency of pulse pressure and common linear pressure fracturing method. For this purpose, new laboratory equipment determining necessary fracturing pressures was developed. The laboratory tests confirmed the breakdown pressure in pulse fracturing method is lower in comparison with the linear fracturing method. Based on the laboratory experiments results, there was developed the in-situ hydraulic fracturing device enabling both linear and pulse fracturing. Afterwards, in-situ pulse hydraulic fracturing tests were carried out at the Josef Underground Laboratory (Czech Republic). The effect of the performed fracturing was evaluated by means of the change in hydraulic conductivity of the rock environment given by the Lugeon tests before and after the fracturing. The new in-situ fracturing device was later on successfully employed within the Nova research project in Aspo Hard Rock Laboratory (Sweden) where once again linear and pulse hydraulic fracturing methods were compared in terms of energy and effect.

POSTER PRESENTATIONS

Compositional Variations of Selected Rock Salt Horizons in Context of an Increase of Deposit Utilization

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The German rock salt mine Braunschweig-Lüneburg, located in the vicinity of Helmstedt at the boarder of Lower Saxony and Saxony-Anhalt, is part of the Allertal fault zone, a NW-SE striking lineament, which is host to several complex salt structures. Although the internal deformation structures of these evaporite bodies have been subject to intensive research since more than 100 years, the understanding of the interplay of the various genetic processes and tectonic evolution in this area is still very scant. Extensive and compressive deformation, intensive salt flow and extreme rheological differences (rock salt, potassium rich salts, anhydrite, clays and carbonates) of individual layers within the evaporite body generated very complex internal salt structures in the Allertal. Therefore, extensive exploration activities have been necessary in order to ensure the extraction of high purity rock salt of Zechstein III (Kristallsalz) in Braunschweig-Lüneburg. Information from this high exploration density, however, may be used to increase deposit utilization by evaluating the usability of less pure rock salt horizons for the existing product range and by integrating these rock salt horizons into the mine layout. Accordingly, besides the pure rock salt horizon Kristallsalz, two other potential mining areas were characterized by using geochemical data from drill core samples: The Staßfurt Steinsalz of the Zechstein II cycle (z2NA) and the younger Schwadensalz of the Zechstein III cycle (z3NAh). The results of the statistical and spatial evaluation show, that the Schwadensalz has high potential for being integrated into the mining activities, whilst the Stassfurt Steinsalz is in general too impure for profitable mining. Another important finding is that the chemistry of the Kristallsalz shows a strong spatial heterogeneity and, thus, will need further detailed investigations in order to improve mine utilization.

Evaluation of the New HRE Roadheading Excavator – A Scenario Based Comparison Using Discrete-Event Simulation

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The commonly applied tunnelling system consists of a combination of jumbos, loaders/LHDs and dumpers. While developing the tunnel, the machines have to pass each other regularly requiring either wider roadways or additional niches, especially for small-scale tunnels. This leads to an increasing cycle time, manpower and machinery demand, and hence increasing costs. As a consequence for more efficiently developing tunnels, a roadheading system should be able to carry out multiple roadheading functions (drilling, loading, shotcreting, etc.). An innovative solution is the newly developed multipurpose Hazemag Roadheading Excavator (HRE) for roadheading small-scale tunnels. Multipurpose means that the machine combines the working cycles face drilling, loading (loading bucket and chain conveyor), scaling, roof bolting and shotcreting. Beside the conventional tunnelling system (LHD scenario) a common competitor or alternative is the ITC system, which is also able to carry out several functions, namely loading and scaling. The missing drilling and shotcreting functions have led to the new HRE machine design. This study aims to estimate and compare the advancement rate between the LHD, ITC and HRE scenarios using discrete-event simulation. Furthermore, the simulation allows statements concerning tunnelling costs, energy consumption and carbon emissions. The presentation is concluded by sketching an interesting picture of tunnel roadheading using the new HRE Roadheading Excavator. The study has been prepared by the Institute of Mineral Resources Engineering (MRE) of RWTH Aachen University for HAZEMAG & EPR GmbH in cooperation with GHH Fahrzeuge GmbH.

Latest Developments in Modularized Rail Haulage Systems - Is the Underground Mining Industry Missing a Chance?

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The mining industry is currently facing multiple challenges, such as lower ore grades, smaller and deeper deposits and longer transportation distances. In the past, the most remarkable innovations have been derived by economies of scale for both, the equipment and the type of mining method in which they are used. This resulted in an increased use of bulk mining methods like sublevel and block caving, higher productivity and reduced costs. It is especially the haulage which plays a major role here. Current techniques are continually being reviewed since they take up between 15 and 30 percent of the overall capital investment in a mine and an ever more significant part of the operating costs. The aim of this project is to point out the limits of cost-efficient usage of main haulage systems in underground mining. Therefore, the life cycle costs of the three most common underground main haulage systems rail, truck and conveyor in combination with vertical haulage systems to the surface, namely hoists, truck and conveyor, are calculated based on a developed simulation tool. The impacts of production rate, life of mine, depth and transport distance for the considered haulage systems are identified by sensitivity analyses. Furthermore, these analyses are useful for identifying application limits for a cost-efficient usage. Generally, the considered parameters show various impacts and must be discussed in cross dependencies. Increasing production rates in interaction with a higher life of mine, for example, have a positive effect on high investment haulage systems, as rail and conveyor systems. However, the impact of the project period (life of mine) decreases on the total costs for conveyor systems at short underground distances. Truck haulage is the most cost-efficient and flexible system at lower production rates and shorter transport distances.

Electromagnetic Investigation of the Pb-Zn Deposit of Lontzen, Belgium

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The synclinorium of Verviers district (Eastern Belgium) has produced the overwhelming majority of the Belgian Pb-Zn concentrates (more than 2 million tons) from historical time until the beginning of the 20th century. However some unexploited ore deposits are still present in the basement such as in Lontzen. During the 1980's a drill hole campaign has been conducted in Lontzen to explore the root of the Pb-Zn mineralization under the old mining works and to explore if the extensional faults are also mineralized. Three (non-connected) ore bodies have been evidenced: Lontzen, Poppelsberg East and Poppelsberg West. The drillings have crosscut Pb-Zn mineralization at depth between 5 and 110m according to the places. Three geophysical techniques have previously been used in this project to inspect this MVT ore deposits: electrical, gravimetric and magnetometric methods. These observations are now completed with a conclusive electromagnetic survey. This survey has been made with a Geonics EM 34-3 using coaxial and coplanar configuration with 20 m and 40 m spacing between the two coils. The frequency is fixed in function of the coil spacing: 1.6 KHz for 20 m spacing and 0.4 KHz for 40 m spacing. Due to a large amount of electric wires and railway catenaries, the prospected area has been restricted to the Poppelsberg East vein. An electromagnetic anomaly has been detected on the Northern part of the Poppelsberg E vein by the four EM configurations. This excellent result on a part of the Pb-Zn deposit of Lontzen/ Poppelsberg is probably due to the local amount of pyrite and marcasite with the sphalerite and galena. On the other parts of the prospected area, where the mineralization is nearly exclusively composed of sphalerite, no significant anomalies have been evidenced. The EM technique is efficient on the deposit of Poppelsberg when the sphalerite is present with conductive mineral.

In-Situ Zinc Bioprecipitation with Glycerol and Vegetable Oil in a High-Flow Aquifer

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A large plume with zinc has developed in groundwater at a galvanizing site in Maasmechelen, Belgium. The considerable surface of the plume (15000 m²) is due to the high hydraulic conductivity of the aquifer (45 m/day), resulting in a high groundwater velocity (0.2 - 1 m/day). Zinc concentrations in the plume fluctuate from 1 to 100 mg/L. Groundwater is oxidized, naturally low in DOC (< 1 mg/L) and low in sulphate (40 to 50 mg/L). We have investigated whether remediation through in-situ zinc bioprecipitation is feasible under local conditions. Laboratory feasibility tests and two field pilot test were conducted. Laboratory microcosm tests have demonstrated that zinc precipitation was induced after addition of organic substrate and sulphate, removing 99% of zinc from the groundwater. Sodium lactate, glycerol and vegetable oil were equally effective as substrate. Anaerobic leaching tests over 28 days indicated that the precipitates were stable. However, they suggested that groundwater concentrations of arsenic and manganese had increased. During one year of field testing, an overall zinc concentration reduction of 96 to 97% was observed both in the zone injected with glycerol and in the zone injected with vegetable oil. Neither one of the test zones showed mobilization of arsenic, while field observations for manganese corresponded with the laboratory feasibility tests as manganese groundwater concentrations have increased. The results showed that bioprecipitation of zinc is a valuable groundwater remediation technology in highly permeable, poorly reduced aquifers. A full-scale remediation plan was designed, starting with a 7 year monitoring campaign to obtain longer term information on the behaviour of the metal precipitates. Monitoring results for a period of 4 years are given.

Integrated Planning Concept on Post-Mining Land Use for Quang Ninh, Vietnam

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The joint R&D project RAME (Research Association Mining and Environment), funded by the BMBF, started its first activities in Vietnam in 2005. The project developed methods to reduce the environmental impacts due to hard coal mining in Quang Ninh province, Vietnam, using selected technical measures and enhancing of the environmental management. One of the topics was the post-mining land use planning. Post-mining land use planning is an important task for mining sites. In Quang Ninh hard coal is mined since about 160 years. The mining areas are embedded into the rapidly developing urban areas of Ha Long city, next to Ha Long Bay, one of the touristic hotspots of Vietnam. The transition from opencast mining to underground mining results in significant land use changes. After suitable preparation (filling in of opencast mines, securing of embankments, recultivation), these areas become available for post-mining land use. According to the planning of mining companies, opencast mining will cease in the next 5 to 10 years. Based on the legal and the planning framework in Vietnam, RAME has developed a systematic approach for post-mining land use planning and its integration into urban planning. The concept links urban and mine planning with each other and shows potential areas for the urban development in the far future. Post-mining land use under the framework conditions as found in the project region can only be successful if the relevant stakeholders are involved in the planning considerations. RAME developed GIS based thematic and planning maps as basis for discussion with and between all stakeholders. 3D visualizations developed on the basis of the RAME post-mining planning concept, additionally provided the opportunity to more easily initiate and accompany the stakeholder communication.

Mine Development, Mine Closure, Community and Activation of Mine Town

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Mine development is economic development and social development, and also creates new towns and growth in existing towns. Mine development and operation yields a lot of impacts, such as economic impacts, social impacts, infrastructure impacts, and environmental impacts. Those impacts are mainly positive impacts but include some negative impacts as well. Mine development and production provides many benefits. These benefits are in addition to various other influences on other sectors of the national economy. We also should consider the influence on the environment. Mine development can be sorted out in many cases. One way is that mine development and operation is executed by national companies, and another is that mine development and operation is executed by foreign companies. Another way to categorize it is that the mine site is in developed countries or that the mine site is in developing countries. And one more way to categorize it is that the mine site is where the mineral products are consumed in their own countries or that the mine site is where the mineral products are exported to foreign countries. The reason why we classify those groups is that foreign company management is isolated management in comparison with national companies. The impacts and influences by mine development and mine closure are different in the above situations. And other important matters are culture, custom and people etc. which the mine site has. Mine stakeholders including community should make communication very much. Mineral resources are depletable resources. So mines will be closed in time by exhausting their resources. After mine closure, those impacts will be changed. And mine closure affect mine town very much. Activation of mine town is important issue, each mine and town made efforts very much for it.

Gold Deportment and Geometallurgical Variability, Certej, Romania

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Certej is an epithermal gold-silver project located in western Romania. Gold mineralization is hosted within Cretaceous sedimentary rocks and Neogene conglomerates, grits and volcanic and intrusive units. Widespread clay-sericite-pyrite-calcite alteration surrounds a silica-adularia core. Ore styles include disseminated mineralization in sedimentary units and at the contacts of intrusive rocks, hydrothermal breccias, stockworks and veins. Gold occurs in arsenian pyrite and as native gold; variable amounts of sphalerite and galena are also present. In this case study, applied mineralogy is being used to determine precious metals deportment and variability in ore across the deposit. A comparison to results from recovery testing will be used to ascertain mineralogical controls on expected precious metals recovery. Methods used to analyse ore samples include geochemistry, petrography and reflected light microscopy, scanning electron microscopy, mineral liberation analysis and laser ablation inductively coupled mass spectrometry plus X-ray diffraction and spectral analysis of drill core. Characterisation of the variability of ore and host rocks will help to optimise extraction of the valuable phases in addition to identifying potential problems with mining, ore processing and waste rock management.

Operational Experiences of the Cat® GH800B Plow Systems in Very Low Coal Seams at the Ibbenbueren Mine

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Nowadays technically efficient and economically effective underground mining systems play a more and more important role worldwide. Longwall mining systems present the most effective extraction method, capable of producing annually several million tons of output from a single longwall face. The extraction of thick seams is fully occupied by shearers which work effectively even under difficult geological conditions. In thin seams in contrast plows deliver the highest efficiency. Contemporary plow systems are designed to extract seams with a thickness below one meter up to three meters, capable to stay in a seam without cutting the adjoining rock in the roof or in the floor. The Ibbenbueren Mine in Germany is the deepest hard coal mine in Europe, extracting anthracite coal from very thin seams. In recent years two novel Cat GH800B plow systems were introduced and successfully implemented at Ibbenbueren. Those plow systems present the newest version of Caterpillar's low seam longwall mining method, allowing extracting seams lower than 0.9 m height with high efficiency. The Cat GH800B presents the lower version of the proven Cat GH1600 plow system, based upon very robust cast plow guides. Because of lower guidance height the extracted coal can be in spite of very low face height efficiently loaded on AFC. Another important novelty constitutes drives with special pans on both sides of the face. The design of those zones allows on one hand quick and comfortable repairs and on the other hand ensures a smooth flow of high streams of the extracted load. This paper presents the operational experiences from the GH800B plow faces ran at the Ibbenbueren Mine.

The Effect of Water Saturation on the Strength of Sedimentary Rocks

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Uniaxial compressive strength (UCS) and Brazilian tensile strength (BTS) are important properties of rocks. These strengths are generally used for designing surface and underground mines. On the other hand, knowing the strength of rocks is necessary for blasting and excavation operations. It is generally known that the rock strength is strongly influenced by the water saturation. Sometimes geo-engineers need to convert the dry strength values to the water saturated strength values when designing rock structures. Although some researchers have investigated the effect of water saturation on the strength of some rocks, these studies are limited. In this study, rock samples were collected from six different locations in Turkey in order to investigate the effects of water saturation on the strengths of sedimentary rocks such as limestone, sandstone and travertine. UCS and BTS tests were carried out on the both oven-dried and water saturated core specimens. After the tests were completed, the data was evaluated and it was seen that the ratios between saturated and dry strength ranges from 42.8% to 91.6% for UCS, and ranges from 35.0% to 97.2% for BTS. The evaluation of the results also showed that the strength losses due to water saturation range from 8.4% to 57.2% for UCS, from 2.8% to 65.0% for BTS. The correlations between strengths and strength losses were also investigated. Good or strong correlations were found between the strengths and the strength losses. The strength loss decreases while increasing strength. Linear regression equations were also derived between saturated and dry-rock strength values. The correlation coefficients of these equations are very strong. The saturated UCS and BTS of sedimentary rocks can be predicted from the dry UCS and BTS values by using the developed equations.

Potential Advances in the Comminution of Kupferschiefer-Type Black Shale Ore by the Utilization of Alternative Impact Crushing Technology

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Mineral processing of black shale-hosted base metal sulphide ores is still representing a challenge; particularly for comminution circuits providing the prerequisite for an efficient beneficiation. Classic crushing and milling of especially fine-grained and finely intergrown ore particles require high-level energy demand, often covering more than a third up to half of a mine site's operational budget. Besides this cost factor, the most distinctive criterion represents the degree of liberation of the ore particles in the final comminution product that regulates if a metal recovery can be effective. Thus, innovative and resource-saving grinding/ milling technologies are needed to meet future requirements for the profitability of copper and byproducts extraction. Black shale-hosted ores from Mid-European Kupferschiefer deposits are characterized by high organic carbon content and complexly intergrown base metal sulphide association and are therefore representing an objection in terms of mineral processing. In our study we compare comminution products of black shale ores generated by a screen ball mill and a new developed vertical impact crusher (Vero Liberator, PMS GmbH, Hamburg). Batch tests have been performed on Central German (Mansfeld/Sangerhausen district) and Polish (Lubin district/Lower Lusatia) black shale ores. Test runs with the VeRo Liberator impact crusher were carried out on run-of-mine ore (-120 mm) at dry single throughput, ball mill feed has been preconditioned to a grain size -3.15 mm by using multi-step crushers (primary jaw crusher, 2-step cone crusher). Our investigations consider the input/output balance by PSD, features process-related particle properties as shape, density or surface roughness and reveals the liberation of ore particles especially for copper sulphides. The examinations carried out on the comminution products comprise granulometric methods, SEM-EDX-based software-guided particle analysis and mineral liberation analysis. The results of sieving tests applied to the impact crusher products demonstrate that P80 passes the 250 micron mesh, whereas P60 corresponds with the particle size range -100 micron. Lasergranulometric data of ball mill and impact crusher products -100 micron show similar particle size distribution. Nevertheless, the impact crusher products contain slightly coarser grain sizes, so that 22% passing the -10 micron fraction compared to 30% in the ball mill product. Liberation analysis of sulphide ore particles shows constantly higher recovery rates (at least 5%) in the impact crusher products. In particular for copper sulphides, significantly higher liberation rates (up to 25% for chalcopyrite) have been achieved by the VeRo Liberator at low energy consumption (3 kWh/t). Thus, the VeRo Liberator impact crusher is capable to merge several comminution steps, to upgrade recovery rates and can offer crucial cost benefits by its application in base metal processing plants.

Bulk Mineralogy of Particles in Mineral Slurries

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Mineral processing efficiency relies heavily on the differential behaviour of particles in mineral slurries or pulps. Therefore, it is of relevance to monitor particle size distribution and mineralogy in mineral processes. The objective of the research project is to develop a camera-based instrument able to timely analyse mineral slurries for their particles bulk mineralogy. The mineral identification will rely on the analysis of the spectral reflectance of individual particles dispersed within a flow cell.

Occurrence of Potential Harmful Elements (PHEs) around Abandoned Mines in South Africa: A Case Study at Albert Silver Mine, Mpumalanga Province

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The study focused on the occurrence of potential harmful elements (PHEs) within and around the abandoned Albert Silver mine. The work involved sampling and analysis of soil, sediments, and waste rocks. The samples were analysed in-situ using portable X-ray fluorescence spectrometry (XRF-Delta Professional Model) set at soil mode. As, Cu and Pb were high in both waste rocks and soil with maximum values (ppm) of 567 and 433 As, 5738 and 5682 Cu, 4002 and 2614 Pb respectively. High concentrations (ppm) of Cr (91), Ni (59) and V (89) were recorded in waste rocks; however Zn (817) and Se (12) recorded high concentrations in soil. From the XRF results, it is evident that the soil around Albert Silver mine is high in As, Cu, Zn, and Se. Consequently, high concentrations (ppm) of As (90) and Cu (205) were recorded in sediments. This study recommends the rehabilitation of the waste rocks dumps in order to minimise the dispersion of PHEs into the environment.

Management Localisation in Ghanaian Mining Industry: A Case Study of Policy and Practice

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The presence and role of multinational enterprises in developing countries is well-documented as is the dependence of these companies on expatriate managers. This has given rise to a substantial literature on the effectiveness or otherwise of such managers and the efficacy of their cross-cultural development. The literature on host countries' attempts to develop local managers to replace expatriates, however, is quite limited. Here the authors examine management localisation policy in the Ghanaian mining industry, and discuss issues of policy and practice with a view to strengthening the localisation process. The research is based on qualitative data collected by interviewing 26 national managers from four subsidiaries of Western multinational mining companies in Ghana. It is concluded that, generally, there are no well-structured and sustainable programs for developing local managers in the Ghanaian mining industry, despite such programs being required by law. Also, the few “young” management development programs in place are saddled with numerous challenges. It is the authors’ view that success of the policy depends to a large extent on the government. Therefore, until the government of Ghana enforces the law on localization and strengthens its monitoring role, industry will continue to be dominated by Western technical management skills as, left to their own volition, MNCs will not implement the policy as they consider it as cost and also as an attempt to force them to relinquish their positions to their subordinates. We offer a five-point recommendation for practice as a way forward to strengthen the policy implementation.

Impact of Artisanal Mining in Idjwi Sud (D.R. Congo) According to Environment Protection and Sustainable Development

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Idjwi Island belongs to the graben of West African Rift Valley inside Kivu Lake. It is an island subdivided in Idjwi sud and Idjwi nord. A Mesoproterozoic belt formation covers largely this region and the Precambrian granitic intrusion has contributed a lot in Sn-W mineralization with rich pegmatite and veins found all over this island. The main mode of mining is artisanal since the discovery of tin and the associated ore deposit. A field trip, environment quantification impact and people interviews allowed mainly making this study. Three exploitation sites constitute our survey: Lusengezi, Buhumba and Bwino. Lusengezi and Bwina are tin deposit while Buhumba is a Tungsten deposit. The artisanal mining in Idjwi started since 1998 and was developed with the mining boom of 2000, when the need in Niobium-Tantalum minerals was at the high level in the world. The three sites are mainly affected by massive destruction of environment, stream and ground water pollution, illness and death of miners, destruction of landscape, radioactive elements contamination and landslide in addits and pits. Even if Idjwi artisanal mining had certainly contributed to a relative development of few people, the measures of environment protection still a great challenge. The sustainable development also should depend on the environment protection. A lot of Idjwi Sud interviewed people consider the high degree of vulnerability due to mining artisanal exploitation and concluded the difficulty of happiness from it. About 30% of nearby environment are destroyed, the education rate of young people is very low because of mining interest, the lack of built infrastructure, and the poverty are problems which could be stopped with a sustainable development of this region. Many measures should be applied in the future to make safe the environment by mining activity and the sustainable development should follow with new perspectives.

Mine Water Related Mine Design - Hydrogeochemical Carbonat Buffering and Geochemical Initial Effects to Sediment Liquefaction

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For the extraction of lignite, about 1 bcm of overburden are moved in Germany annually. Uncontrolled formed tilting may cause geochemical and geotechnical problems in the future. The overburden consists essentially of quaternary units, which often contain buffering carbonates, and tertiary units with partly a high amount of sulphides. This tertiary causes Acid Mine Drainage with a release of iron, sulfate, heavy metals and acid. The goal of a modern mining management must be the minimizing of AMD during mining activities. The geochemical characteristics of the sediments have to be characterized by weathering and buffering tests. Therefore acidifying and buffering units in various mixing ratios were mixed and the release of iron, sulfate and acidity measured. The new standard dumping design must comply geotechnical and hydrogeochemical aspects. By ending of the drainage in the mining area, the new dump sites gets saturated. This leads to the desired mixture of acid and potential alkaline waters. Due to the buffer reactions CO2 as inner Initial for ground-breaking events in the resulting dump bodies will generated. Numerous geotechnical slope failure events were registered, if the sediments without cohesive shares are in a narrow particle size range. In tests the potential geochemical initial were examined for ground breaking events. The mixture of acidogenic and buffering sediments leads to a blocking by iron-hydroxide precipitation and CO2-formation with increased pressures and pulsation of the flow. For large scale, this would be the feared initial for shear strength loss and spontaneous soil liquefaction in the dumps. With this knowledge, a new dumping structure can be created. Sediment that is fragile to soil liquefaction will be dumped at the bottom. “Non-fragile” and buffered acidic sediments will be dumped at the top. In sum of all measures, it’s possible to realize a dumpsite with good geotechnical and hydro-geochemical conditions.

Development of an Indicator to Asses Resource Efficiency in Mining

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Resource efficiency is a policy concept that aims to maximize the supply of resource materials that can be drawn from a mineral resource with minimum waste production. It has become one of the major policy concepts to enable responsible development in mining. While common proxies for resource efficiency use weight-based measures of a system's materials consumption, such proxies are not directly applicable to mining operations. This study introduces a new indicator based on a multi-criteria evaluation of resource efficiency in mining operations and measures that consider intensities in land, water, energy and mineral deposit consumption (i.e. specific resource consumption to produce one unit of output). In this work the case of copper mining is used to establish the newly introduced indicator. Results allow the comparison of different technologies commonly used in copper mining and processing regarding their resource efficiency. This study further demonstrates that deposit properties and geographic location have an impact on resource efficiency. Political measures aiming to promote resource efficiency in mining should therefore focus on region-specific characteristics of natural resources and deposit properties.

Capacitively Coupled Resistivity Imaging

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For the detection of abandoned mine shafts and mine waste, Capacitively-Coupled Resistivity Imaging (CCRI) is a very efficient geophysical method. Resistivity geophysical techniques are based on the ability to detect small changes in the resistivity of rocks and soils caused by changes in their structure, mineral and fluid content. Because of this, within a host medium it has the potential to detect voids, fill, water saturation and disturbance of the host. It is also capable of building a 3D tomograph of these changes. One of the major drawbacks of resistivity mapping is a slow data acquisition rate. This is because it generally requires “ohmic” contact to be made by sinking metal spikes into the ground for each reading. The method “capacitive” coupling with the ground enables much faster data acquisition. This, in turn, gives much higher resolution (resistivity and positional). This Capacitively Coupled Resistivity Imaging (CCRI) enables good visualisation of sub-surface features and well as their precise positioning. Electrical resistivity imaging (ERI) is a widely used tool in near surface geophysics. The Capacitively Coupled Resistivity (CCR) has no need to plant electrodes into the ground. Wall Probing Radar (WPR) or Ground Penetrating Radar (GPR) measures the reflections of high-frequency electromagnetic (EM) waves to image the dielectric changes within the subsurface, CCRI uses an electric current to image electrical resistivity changes at depth. GPR sends short pulses of EM energy into the ground and measures the energy reflected back (as a function of time). Although GPR shows reflections occurring from a variety of interfaces (e.g. thermal, moisture and structural) due to dielectric constant interfaces, the depth of penetration is reduced when electrically conductive sediments are present at the surface. GPR and CCRI techniques effectively complement each other by resolving different characteristics of the subsurface.

Impact of Structural Adjustment Programmes on the Ghanaian Mining Industry

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The Structural adjustment programme (SAP) is the International Monetary Fund (IMF) and World Bank agenda for addressing the economic crises and huge foreign debts of some Third World countries who have limited resources to arrest the situations. To help these ailing countries however, the World Bank/IMF demand some structural reforms referred to as SAP. The privatisation policy (that transfer state-owned enterprises to private investors), one of the conditions of SAP, has been implemented by many African countries including Ghana, which embraced the policy in April 1983 with the hope of achieving economic resuscitation. The phenomenon has resulted in influx of multinational companies into the country and resultant foreign direct investments inflows, which the mining industry alone has attracted more than a half. This presentation evaluates the impact of privatisation policy (of SAP) on the Ghanaian mining industry. Using predominantly academic and popular literature, and industry data from the Ghana Chamber of Mines and World Bank reports on industry, it emerges that the policy has integrated Ghana into the global economy and reshaped the mining industry through introduction of technology, injection of needed capital, and skills transfer to local employees. The policy however falls short of what it was intended to achieve; rather worsening the situations including detachment of the Ghanaian government from her own mineral resources; “subsidiarity” of Ghanaian mining companies by Western multinational corporations; and massive unemployment. The authors advise that, going forward, the Government should encourage private sector-local government link that discourages complete transfer of state enterprises to private sector companies for mutual benefits from the policy.

Productivity Improvement in Mining Operation through Flexibility: Which Potential Does it Have?

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Mining operations are complex operations. The related processes require continuous evaluation and mitigation of risks. The reason is that both external and internal factors that are linked to mining activities anchor uncertainties. The latter have the potential to impact project productivity, and thus its economy, either positively or negatively. In order to overcome uncertainties embedded in mining processes, decision makers need comprehensive tools. The latter should help valuating their options by taking related information into account in order to make the right decision when required. Managerial flexibility bears the possibility to react to changes occurring and has the potential to impact the productivity of a project. Uncertainties in mining processes are embedded in a range of uncertain processes starting from the estimation process of the reserve over the production planning and scheduling, the mining operations, the asset utilization to the quality and quantity of the ore delivered to the mill. Exercising a range of options and therefore implementing flexibility in face of uncertain processes within a mine should help mitigating risks and improve productivity. However, options come at price. The ROV theory is used for valuating operational flexibility. It is a systematic approach and integrated solution using financial theory, economic analysis, statistics, etc. in applying options theory for the valuation of real physical assets, as opposed to financial assets. By putting the focus solely on internal uncertainties in open pit mines, the paper presents a methodology and an approach applied for conducting a joint assessment and mitigation of mining process uncertainties through the development of a framework approach to support strategic decision making processes. The aim of the framework approach is to contribute to tackling one of mining industry's biggest challenges – namely productivity improvement and increase.

Chemical Oxidation Integrated into Bioleaching of Pyrite and Chalcopyrite Using Immobilized Biomass

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Comparative oxidation of pyrite and chalcopyrite by both chemical ferric iron ($Fe_2(SO_4)_3$) solution and biogenic ferric iron obtained through activity of bacteria was studied. Biogenic $Fe_2(SO_4)_3$ was obtained by immobilized biomass of new isolated thermotolerant Acidithiobacillus sp. 13Zn. For immobilization of bacterial biomass natural shungite and activated carbon were used. Intensity of oxidation of sulphide minerals was estimated according to decrease of Fe^{3+} and increase of Fe^{2+} ions in the solution. It was revealed that oxidation of chalcopyrite by biogenic $Fe_2(SO_4)_3$ was 5 times more intensive than that by chemical $Fe_2(SO_4)_3$ solution from point of view of extraction of copper. In case of pyrite oxidation rate by biogenic ferric iron was two times higher than that of chemical ferric iron solution. Besides in case of using $Fe_2(SO_4)_3$ solution for oxidation of pyrite and chalcopyrite intensive precipitation of ferric iron and generation of jarosite was observed, while using biogenic ferrous sulphate the amount of jarosite was significantly lower. It is supposed that in biogenic $Fe_2(SO_4)_3$ ferric ions are in form of complexes with organic compounds produced by bacteria, which prevents its precipitation in the form of jarosite. It is assumed that chemical oxidation integrated into processes of bioleaching of chalcopyrite and copper concentrates may contribute to intensification of copper extraction.

Deep-Sea Mining - Giving Inside into the Blue Mining Project with Special Focus on the Exploitation of Polymetallic Nodules

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Even if seventy percent of our world's surface is covered by water, the deep-sea is in many ways the last great unexplored frontier on Earth. The oceans hold veritable treasures of valuable resources. Vast areas of ocean floor are covered by metal-bearing nodules about the size of potatoes. They contain primarily manganese, but also nickel, cobalt, copper and rare-earth elements. Besides polymetallic nodules, cobalt-rich crusts and copper-rich massive sulphides are most promising. Mining these mineral resources presents mankind with a unique opportunity to advance the world. Not forgetting that the deep-sea is the largest habitat and most pristine ecosystem on Earth, we must treat our environment with the utmost responsibility, particularly in mining. A European consortium of 19 large industry and research organisations with various fields of maritime expertise, the so-called “Blue Mining” project, will develop solutions that will bring sustainable deep sea mining a significant step closer to realization. Over a duration of 48 months, the “Blue Mining” project will address all aspects of the value chain in this field, from resource discovery to resource assessment and from exploitation technologies to the legal and regulatory framework. The project “Breakthrough Solutions for Mineral Extraction and Processing in Extreme Environment – Blue Mining” receives funding from the European Commission’s FP7. The extreme conditions found on the deep-ocean floor raise specific challenges, both technically and environmentally, which are demanding and entirely different from land-based mining. Today, European offshore industries and marine research institutions have some global advantage through their significant experience and technology and are well positioned to develop engineering and knowledge-based solutions to resource exploitation in these challenging and sensitive environments.

Seascape as a Sustainable Transformation of the Lignite Surface Mine Inden

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After the closure of the lignite mine Inden (Germany) in the year 2030 the original aim was to create an agricultural dominated post-mining landscape. External material from the Hambach mine should be dumped into the residual pit in Inden, but meanwhile the conditions have changed. The number of active farmers has significantly dropped, which is also due to the fact that primary production in Europe in the era of globalization has come under economic pressure. Presently, the inhabitants in the region have become more aware of the significance of nature, recreation and leisure structures. Two reference recultivation projects (Blausteinsee, Relocation of the Inde River) were able to prove that a restructuring of a site formerly shaped by industry into an attractive landscape entails some advantages. The regional local authorities developed the idea of creating a large lake with a surface of 1,100 ha as the post-mining landscape of Inden mine bypassing partly the water of the River Rur. After 10 years of serious discussion the lignite schedule Inden was permitted by the public lignite commission (Braunkohlenausschuss). Topics such as employment, value creation, waste avoidance and preservation of resources, environmental sustainability have been expanded on in the planning by the regional local authorities. In addition, this new form of the design of a lignite follow-up landscape in the Rhineland should be a model for the longer operated adjacent lignite mines of Hambach and Garzweiler. Currently technical challenges of creating the large lake were investigated such as the quality and the quantity of the water to be required in relationship to the stability of the final slopes. The prevention of potential danger zones in the unconsolidated rock of the Rhenish area is of vital importance for the success of the seascape project.

Archaeometallurgical Research in Eastern Iran (South Khorasan) Based on Archaeological Evidence Case Study: Mesgaran and Arabkhaneh

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Geological and mineral studies conducted in Iran consider the eastern part of the country as one of the richest mineral areas due to existence of mineral deposits and metal ores- especially copper. South Khorasan province, which makes up the majority of the geographical area of eastern Iran, where the writer has found 110 ancient enclosures and 17 enclosures were ancient mines is highly significant in terms of abundance of copper deposits and the known evidence of smelting metals discovered in the archaeological sites indicate extensive ancient metalworking and mining activities in this region. Unfortunately, despite the importance of the matter, so far no independent research on archaeology of metals in South Khorasan has been conducted. The present paper has studied archaeometallurgical evidence in south Khorasan case study Mesgaran and Arabkhane base on experimental research. For the analysis of chemical compounds and Structural features of archaeometallurgical remains Petrography and XRF has been used. The results indicate that copper was the main metal which was used there.

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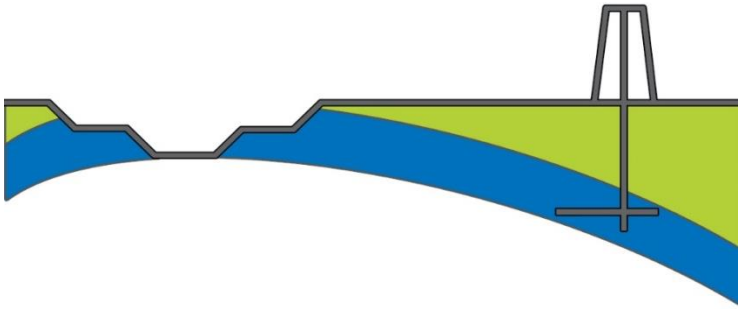

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