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A REVIEW ON TECHNICAL ASPECTS IN MINING EXPLORATION AND EXPLOITATION

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ABSTRACT

Since humans started building big houses with number of steps, inventing transport means like spaceships, plans, automobiles, bikes; we understood the necessity to use some materials like iron, aluminium, cement, copper, quartz, calcareous, granite, marble etc…. and for the production of energy necessary for every development human being stated using some natural resources like charcoal and uranium; for being fashionable we use some elements like diamond, gold, silvers, rubies, slice etc., It's almost impossible to imagine our life without those above elements and all of their are coming from earth by extraction made by human. The process to extract all those above elements from the earth is called mining and the places where the mining process is completed is known as mines. In this paper, the authors reviewed different modern technologies in mining operations.

Keywords: mines; mining; new technologies, exploration, exploitation

I. INTRODUCTION

Mining brings natural earth minerals to the surface in a safe, efficient, and responsible way without causing undue disturbance to the environment, to satisfy societal and industrial needs, and to promote significant contributions to the economy. To make mine operations more productive, safe, and economical using modern technology and highly sophisticated equipment methodologies, the industry needs intelligent, responsible, creative, and skillful practitioners. The job responsibilities of Mining Engineers include designing layouts for both surface and underground mines, preparation of short- and long-range mine plans and production sequences, selection and scheduling of equipment, designing blast patterns for rock fragmentation and excavation, designing ventilation plans for underground mines, monitoring safety of personnel and equipment, optimizing processes, etc.

Mining is the extraction of valuable minerals or other geological materials from the earth usually from an orebody, lode, vein, seam, reef or placer deposits. These deposits form a mineralized package that is of economic interest to the miner.

Ores recovered by mining include metals, coal, oil shale, gemstones, limestone, chalk, dimension stone, rock salt, potash, gravel, and clay. Mining is required to obtain any material that cannot be grown through agricultural processes, or created artificially in a laboratory or factory. Mining in a wider sense includes extraction of any non-renewable resource such as petroleum, natural gas, or even water.

Mining of stones and metal has been a human activity since pre-historic times. Modern mining processes involve prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials, and final reclamation of the land after the mine is closed.

Mining operations usually create a negative environmental impact, both during the mining activity and after the mine has closed. Hence, most of the world's nations have passed regulations to decrease the impact. Work safety has long been a concern as well, and modern practices have significantly improved safety in mines.

Levels of metals recycling are generally low. Unless future end-of-life recycling rates are stepped up, some rare metals may become unavailable for use in a variety of consumer products. Due to the low recycling rates, some landfills now contain higher concentrations of metal than mines themselves.

Modern mineral exploration has been driven largely by technology. Many mineral discoveries since the 1950s can be attributed to geophysical and geochemical technologies developed by both industry and government. Even though industrial investment in in-house exploration research and development in the United States decreased during the 1990s, new technologies, such as tomographic imaging (developed by the medical community) and GPS (developed by the defense community), were newly applied to mineral exploration. Research in basic geological sciences, geophysical and geochemical methods, and drilling technologies could improve the effectiveness and productivity of mineral exploration. These fields sometimes overlap, and developments in one area are likely to cross-fertilize research and development in other areas.

As well as people are using new technologies to make our everyday life better than before with comfort and control facilities; mining engineers are also to be developed.

Mine development and lifecycle

The process of mining from discovery of an ore body through extraction of minerals and finally to returning the land to its natural state consists of several distinct steps.

Prospection:

The first is discovery of the ore body, which is carried out through prospecting or exploration to find and then define the extent, location and value of the ore body. This leads to mathematical resource estimation to estimate the size and grade of the deposit. This estimation is used to conduct a pre-feasibility study to determine the theoretical economics of the ore deposit. This identifies, early on, whether further investment in estimation and engineering studies is warranted and identifies key risks and areas for further work. The next step is to conduct a feasibility study to evaluate the financial viability, the technical and financial risks, and the robustness of the project.

Industrial research and development in geophysical methods of mineral exploration have been ongoing since World War II. Canada has led the world in geophysical innovations, primarily through industry support for academic programs and through in-house corporate development of new techniques. An example of the latter is the recent development by the mining industry of a prototype airborne gravity system. Gravity measurements are a typical means of locating dense metallic mineral deposits and of mapping different rock types in the Earth's crust. However, traditional ground-based surveys are time consuming and therefore expensive. As an NRC report in 1997 pointed out, the ability to gather gravity data from an aircraft would significantly increase prod1uctivity and reduce the invasiveness of mineral exploration (NRC, 1997b).

Magnetic surveys are commonly conducted by aircraft that must fly at a fixed distance above the ground surface for optimal data acquisition. These surveys are difficult to conduct and risky in rugged terrain.

The recent development of drones, primarily by the U.S. military, has made more effective geophysical surveys possible. This technology is currently being explored by industry-government consortia in Australia.

Hyperspectral technologies are being developed to gather additional data that can be used to map the mineralogy of the ground surface. A high-altitude aircraft system, airborne visible/infrared imaging spectrometer (AVIRIS), has been developed by the National Aeronautics and Space Administration (NASA). Data from this sensor have been successfully used for both mineral exploration and mine closures at several sites in the United States. Spaceborne hyperspectral systems are also being developed.

II. RECOMMENDATIONS FOR RESEARCH ON EXPLORATION TECHNOLOGIES

Numerous opportunities exist for research and development that would significantly benefit exploration, many of which involve the application of existing technologies from other fields. Support for technological development, primarily the miniaturization of drilling technologies and analytical tools, could dramatically improve the efficiency of exploration and improve the mining process. Although industry currently supports the development of most new geochemical and geophysical technologies, basic research on the chemistry, biology, and spectral characterization of soils could significantly benefit the mineral industry. Continued government support for space borne remote sensing, particularly hyperspectral systems, will be necessary to ensure that this technology reaches a stage at which it could

III. OPPORTUNITIES FOR RESEARCH AND TECHNOLOGY DEVELOPMENT IN EXPLORATION

Geological Methods

- more robust thermodynamic and kinetic geochemical data
- new ore-deposit models, particularly for deposits with less environmental impact when mined
- better geo hydrological models
- geological maps of more mineralized areas
- databases for mineralized areas

Geochemical/Geophysical Methods

• hand-held and down-hole analytical instruments
• cross-bore-hole characterization
• better understanding of element mobility in soils
• drones for airborne geophysics
• low-cost, shallow seismic methods
• better intrepretation of hyperspectral data

Drilling Technology

• application of existing petroleum and geothermal drilling technologies to minerals sector (directional drilling, better bits, down-hole logging)
• novel drilling techniques (e.g., improvements in slimhole drilling and in-situ measurements)

Mining Systems

The industry needs improved overall mining systems. Alternative systems may bear no resemblance to existing systems, although they may be innovative adaptations of the productive components of existing systems (e.g., the deployment of rapid mine-development procedures, truly continuous mining methods, continuous haulage systems, more effective ventilation procedures, and rapid isolation techniques to enhance health, safety, productivity, and resource recovery). From technological and management perspectives several characteristics of a mineral enterprise must be taken into account. Each mineral deposit has unique geological features (e.g., location and physical, mineralogical, chemical characteristics) that have overriding influence on technical and economic decisions. For example, the environment of an underground mine is totally enclosed by surrounding rock. Because mine development is an intensive cash-outflow activity, the current long lead times must be decreased through new technologies.

Mining systems that make a clear break with present systems, such as the chemical and biological mining of coal, should also be investigated. In-situ chemical comminution might be possible if the solid coal could be reduced to fragments by treatment with surface-active compounds, such as liquid or gaseous ammonia, and transported to the surface as a suspension in an inert gas. The literature on the biosolubilization of coal and the aerobic and anaerobic conversion of coal by microorganisms and enzymes has been evolving for some time (Catcheside and Ralph, 1997). Biodegradation of coal macromolecules could potentially convert coal carbons to specific, low-molecular-mass products. Research will be necessary to determine the basic mechanisms, as well as to develop conceptual schemes that would make biodegradation cost effective. For all in-situ mining concepts the obvious environmental benefits of limiting surface disturbances and waste generation must be weighed against the potential of adverse impacts on groundwater quality during operation of the mine and upon its closure. Research on chemical or biological mining of coal must also include evaluations of environmental risks posed by reagents and process intermediates.

Mining techniques

Mining techniques can be divided into two common excavation types: surface mining and sub-surface (underground) mining. Today, surface mining is much more common, and produces, for example, 85% of minerals (excluding petroleum and natural gas) in the United States, including 98% of metallic ores.

Targets are divided into two general categories of materials: placer deposits, consisting of valuable minerals contained within river gravels, beach sands, and other unconsolidated materials; and lode deposits, where valuable minerals are found in veins, in layers, or in mineral grains generally distributed throughout a mass of actual rock. Both types of ore deposit, placer or lode, are mined by both surface and underground methods.

Some mining, including much of the rare earth elements and uranium mining, is done by less-common methods, such as in-situ leaching: this technique involves digging neither at the surface nor underground. The extraction of target minerals by this technique requires that they be soluble, e.g., potash, potassium chloride, sodium chloride, sodium sulfate, which dissolve in water. Some minerals, such as copper minerals and uranium oxide, require acid or carbonate solutions to dissolve.

Surface mining

Surface mining is done by removing (stripping) surface vegetation, dirt, and, if necessary, layers of bedrock in order to reach buried ore deposits. Techniques of surface mining include: open-pit mining, which is the recovery of materials from an open pit in the ground, quarrying, identical to open-pit mining except that it refers to sand, stone and clay; strip mining, which consists of stripping surface layers off to reveal ore/seams underneath; and mountaintop removal, commonly associated with coal mining, which involves taking the top of a mountain off to reach ore deposits at depth. Most (but not all) placer deposits, because of their shallowly buried nature, are mined by surface methods. Finally, landfill mining involves sites where landfills are excavated and processed.

Underground mining

Sub-surface mining consists of digging tunnels or shafts into the earth to reach buried ore deposits. Ore, for processing, and waste rock, for disposal, are brought to the surface through the tunnels and shafts. Sub-surface mining can be classified by the type of access shafts used, the extraction method or the technique used to reach the mineral deposit. Drift mining utilizes horizontal access tunnels, slope mining uses diagonally sloping access shafts, and shaft mining utilizes vertical access shafts. Mining in hard and soft rock formations require different techniques.

Other methods include shrinkage stope mining, which is mining upward, creating a sloping underground room, long wall mining, which is grinding a long ore surface underground, and room and pillar mining, which is removing ore from rooms while leaving pillars in place to support the roof of the room. Room and pillar mining often leads to retreat mining, in which supporting pillars are removed as miners retreat, allowing the room to cave in, thereby loosening more ore. Additional sub-surface mining methods include hard rock mining, which is mining of hard rock (igneous, metamorphic or sedimentary) materials, bore hole mining, drift and fill mining, long hole slope mining, sub level caving, and block caving.

Machines:

Heavy machinery is used in mining to explore and develop sites, to remove and stockpile overburden, to break and remove rocks of various hardness and toughness, to process the ore, and to carry out reclamation projects after the mine is closed. Bulldozers, drills, explosives and trucks are all necessary for excavating the land. In the case of placer mining, unconsolidated gravel, or alluvium, is fed into machinery consisting of a hopper and a shaking screen or trammel which frees the desired minerals from the waste gravel. The minerals are then concentrated using sluices or jigs.

Large drills are used to sink shafts, excavate stopes, and obtain samples for analysis. Trams are used to transport miners, minerals and waste. Lifts carry miners into and out of mines, and move rock and ore out, and machinery in and out, of underground mines. Huge trucks, shovels and cranes are employed in surface mining to move large quantities of overburden and ore. Processing plants utilize large crushers, mills, reactors, roasters and other equipment to consolidate the mineral-rich material and extract the desired compounds and metals from the ore.

Improved Machine Performance

Better automation and control systems for mining equipment could also lead to large gains in productivity. Some equipment manufacturers are already incorporating human-assisted control systems in newer equipment, and improvements in man-machine interfaces are being made. Additional research should focus on alternatives, however, such as more autonomous vehicles that have both sensor capability and sufficient processing power to accomplish fairly complex tasks without human intervention. Tasks include haulage and mining in areas that are too dangerous for human miners. Semiautonomous control methods should also be explored, such as “fly-by-wire” systems in which the operator’s actions do not directly control the vehicle but give directions to a computer, which then decides how to accomplish the action. A good example of this technology is currently being used in large construction cranes; the motion of the crane to move a load from one location to another is controlled by the operator through a computer, which controls the rate of movement of the crane in such a way as to minimize the swing of the load. This technology has considerably improved safety, speeded up cycle time, and enhanced energy conservation in the motion of the crane.

Materials Handling

The design and proper operation of clearance systems for transporting mined materials from the point of mining to processing locations are critical for enhancing production. In many cases the system for loading and hauling the mineral is not truly continuous. Belt and slurry transportation systems have provided continuous haulage in some mining systems. Longwall systems in underground mines, bucket-wheel excavator systems in surface mines, and mobile crushers hooked to conveyor belts in crushed-stone quarries are successful steps in the development of a continuous materials-handling system. Even in these systems haulage is regarded as one of the weakest components. In most cases, both in underground and surface mining, the loading and hauling functions are performed cyclically with loaders and haulers.

Equally important to improving the performance of materials-handling machinery will be the development of new technologies for monitoring equipment status and for specific automation needs. In addition, for underground applications the interruption of the line of sight with satellites and thus the impossibility of using the GPS means a totally new technology will have to be developed for machine positioning.

Transporting ore for processing can take considerable time and energy and can contribute significantly to the overall cost of production in both surface and underground mining operations.

The initial transport of materials is currently done by powered vehicles. In underground mining the use of diesel-powered loading and hauling equipment presents both safety and health challenges. Electric equipment has similar disadvantages, even though it is cleaner and requires less ventilation, because power transmission and cabling for highly mobile equipment complicates operations. Equipment powered from clean, onboard energy sources would alleviate many of these health and safety problems. Research could focus on powering heavy equipment with alternative energy sources, such as new-generation battery technology, compressed air, or novel fuel-cell technology. The development of such technologies may have mixed results from an environmental standpoint. On the one hand, a reduction in the use of fossil fuels would have obvious benefits in terms of reduced atmospheric emissions. On the other hand, the manufacturing and eventual disposal of new types of batteries or fuel could have environmental impacts.

Technology Needs

In simple terms mining involves breaking in-situ materials and hauling the broken materials out of the mine, while ensuring the health and safety of miners and the economic viability of the operation. Since the early 1900s, a relentless search has been under way for new and innovative mining technologies that can improve health, safety, and productivity. In recent decades another driver has been a growing awareness of the adverse environmental and ecological impacts of mining. Markers along the trail of mining extraction technology include the invention of the safety lamp, and safe use of dynamite for fragmentation, the safe use of electricity, the development of continuous miners for cutting coal, the invention of rock bolts for ground support, open-pit mining, technology for mining massive low-grade deposits, the introduction of longwall coal mining, and recently in-situ mining and automated mining.

Mining environments also present unique challenges to the design and operation of equipment. Composed of a large number of complex components, mining systems must be extremely reliable. Therefore, innovative maintenance strategies, supported by modern monitoring technologies, will be necessary for increasing the productive operational time of equipment and the mining system as a whole.

The second major area that requires additional research is data processing methods for interpreting sensor data. The mining industry has a critical need for processing algorithms that can take advantage of current parallel-processing technologies. Currently, the processing of seismic data can take many hours or days. Real-time turnaround (in minutes) in processing will be necessary for the data to be useful for continuous mining.

The third area of need is data display and visualization, which are closely related to the processing and interpretation of data. The data cannot be quickly assessed unless they are in a form that can be readily reviewed. The need for visualizing data, especially in three dimensions, is not unique to the mining industry. In fact, it is being addressed by many technical communities, especially in numerical analysis and simulation. Ongoing work could be leveraged and extended to meet the needs of the mining industry.

Look-Ahead Technologies

Unexpected geological conditions during the mining process can threaten worker safety and may decrease productivity. Geological problems encountered in mining can include local thinning or thickening of the deposit, the loss of the deposit itself, unexpected dikes and faults, and intersections of gas and water reservoirs. Even with detailed advanced exploration at closely spaced intervals, mining operations have been affected by many problems, such as gas outbursts, water inundations, dangerous strata conditions, and severe operational problems, that can result in injuries to personnel, as well as major losses of equipment and decreases in production. Advances in in-ground geophysics could lead to the development of new technologies for predicting geological conditions in advance of the mining face (defined here as look-ahead technology). Three major technology areas are involved in systems that can interrogate the rock mass ahead of a working face: sensor systems, data processing, and visualization. All three areas should be pursued in parallel to effect progress in the development of a usable system.

Research on the development of specific sensors and sensor systems has focused on seismic methods. In underground mining the mining machine (if mining is continuous) can be used as a sound source, and receivers can be placed in arrays just behind the working face. For drilling and blasting operations, either on the surface or underground, blast pulses can be used to interrogate rock adjacent to the rock being moved. However, numerous difficulties have been encountered, even with this relatively straightforward approach. Current seismic systems are not designed to receive and process multiple signals or continuous-wave sources, such as those from the mining machine.

Environmental effects:

Iron hydroxide precipitate stains a stream receiving acid drainage from surface coal mining.

Environmental issues can include erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes. In some cases, additional forest logging is done in the vicinity of mines to create space for the storage of the created debris and soil. Contamination resulting from leakage of chemicals can also affect the health of the local population if not properly controlled. Extreme examples of pollution from mining activities include coal fires, which can last for years or even decades, producing massive amounts of environmental damage.

Mining companies in most countries are required to follow stringent environmental and rehabilitation codes in order to minimize environmental impact and avoid impacting human health. These codes and regulations all require the common steps of environmental impact assessment, development of environmental management plans, mine closure planning (which must be done before the start of mining operations), and environmental monitoring during operation and after closure. However, in some areas, particularly in the developing world, government regulations may not be well enforced.

Renewable energy and mining:

Many mining sites are remote and not connected to the grid. Electricity is typically generated with diesel generators. Due to high transportation cost and theft during transportation the cost for generating electricity is normally high. Renewable energy applications are becoming an alternative or amendment. Both solar and wind power plants can contribute in saving diesel costs at mining sites. Renewable energy applications have been built at mining sites. Cost savings can reach up to 70%.

While exploration and mining can be conducted by individual entrepreneurs or small businesses, most modern-day mines are large enterprises requiring large amounts of capital to establish. Consequently, the mining sector of the industry is dominated by large, often multinational, companies, most of them publicly listed. Various other industries such as equipment manufacture, environmental testing, and metallurgy analysis rely on, and support, the mining industry throughout the world. Canadian stock exchanges have a particular focus on mining companies, particularly junior exploration companies through Toronto's TSX Venture Exchange; Canadian companies raise capital on these exchanges and then invest the money in exploration globally. Some have argued that below juniors there exists a substantial sector of illegitimate companies primarily focused on manipulating stock prices.

Mining operations can be grouped into five major categories in terms of their respective resources. These are oil and gas extraction, coal mining, metal ore mining, non-metallic mineral mining and quarrying, and mining support activities. Of all of these categories, oil and gas extraction remains one of the largest in terms of its global economic importance. Prospecting potential mining sites, a vital area of concern for the mining industry, is now done using sophisticated new technologies such as seismic prospecting and remote-sensing satellites. Mining is heavily affected by the prices of the commodity minerals, which are often volatile. The 2000s commodities boom ("commodities super cycle") increased the prices of commodities, driving aggressive mining. In addition, the price of gold increased dramatically in the 2000s, which increased gold mining.

Recommendations

Substantial research and development opportunities could be explored in support of both surface and underground mining. The entire mining system, including rock fracturing, material handling, ground support, equipment utilization, and maintenance, would benefit from research and development in four key areas:

1. fracture, fragmentation, and cutting, with the goal of achieving truly continuous mining in hardrock as is done with coal
2. small, inexpensive sensors and sensor systems for mechanical, chemical, and hydrological applications
3. data processing and visualization methods (especially taking advantage of advanced, parallel-computing architecture and methods) that would provide real-time feedback
4. automation and control systems (especially for mining equipment used in hazardous areas).

The above four areas represent a very broad summary of technology advances that would greatly enhance productivity and safety in mining.

IV. EXAMPLES OF ENVIRONMENTAL AND HEALTH CONCERNS THAT SHOULD BE IDENTIFIED DURING EXPLORATION

- groundwater and surface water quality
- trace elements in existing soils
- trace elements in ores, particularly elements of concern, such as mercury and arsenic

- the presence of asbestiform minerals associated with industrial-minerals operations
- the potential for acid-rock drainage (amounts of sulfide minerals and buffering minerals, climate, and hydrology)
- location of aquifers in relation to ore bodies
- existence and location of sensitive biological communities
- climatological impacts on mining operations, including precipitation and prevailing winds
- socioeconomic and cultural issues, including sustainable development

V. CONCLUSION

As a conclusion the authors wish to say that as well as modern technologies are used in mining to:

Insure the safety of miners

Increase the productivity of mines

Reduce waste of chemicals

Reduce the impact of mines in their surrounding environments etc.,

There must be some more strict regulation about mining exploitation around the world. Of course, surely it is needed that the mining products to make the life more and more pleasant but one may not forget that it took millions of year to the earth to generate those resources so one should not waste then. There for reduce soil, air and water pollutions people should utilized new technologies in number of ways. Then only it will be possible to find a good balance between the mining production and their ecological impact.

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