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RESEARCH, INOVATION AND TECHNOLOGY TRANSFER IN MINERAL INDUSTRY

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Abstract: *Mining produces three types of mineral commodities (metals, industrial minerals, and fuels) that all countries find essential for maintaining and improving their standards of living. Mining is a strategic industry because it provides critical needs in times of war or national emergency. Neither economy could not function without minerals nor the products made from them. In countries or regions where mining is concentrated, this industry plays an important role in the local economy. Mining faces nowadays major constraints due mainly to the scarcity of resources and its social and environmental impacts. Solving in a balanced way the conflict between positive effects on growth and development and the negative impacts on human being, communities and surrounding environment is the main driving factor towards technological improvement based on research and innovation.*

Keyword : research, R&D, technology transfer , innovation, mining

Overview of technologies in exploration, mining, and processing

Mining involves a full life cycle, from exploration through production to closure with provisions for potential postmining land use. The development of new technologies has benefits for the mineral industries throughout this full life cycle and for every major component of the mineral industries: exploration, mining (physical extraction of the material from the Earth), processing, associated health and safety issues, and environmental issues. It is widely accepted that research and development be focused on technology areas critical for exploration, mining, in-situ mining, processing, health and safety, and environmental protection (Table 1).

The mining industries has always and constantly are undergoing incremental or evolutionary changes as uses are found for new technologies developed for other applications. Occasionally, revolutionary changes occur when new technologies, developed either inside or outside the industry, take hold.

TABLE 1 Key Research and Development Needs for the Mining Industries

Research and Development Needs	Exploration,	Mining,	In-Situ Mining	Processing	Health & Safety	Environmental Protection,
Basic Research						
Basic chemistry – thermodynamic and kinetic data, electrochemistry	X		X	X		X
Fracture processes – physics of fracturing, mineralogical complexities, etc.		X	X	X		
Geological, geohydrological, geochemical, and environmental models of ore deposits	X	X	X			X
Biomedical, biochemical, and biophysical Sciences	X	X	X	X	X	X
Applied Research						
Characterization – geology (including geologic maps), hydrology, process mineralogy, rock properties, soils, cross-borehole techniques, etc.	X	X	X	X	X	X
Fracture processes – drilling, blasting, excavation, comminution (including rock-fracturing and rubblization techniques for in-situ leaching and borehole mining)	X	X	X	X		
Modeling and visualization – virtual reality for training, engineering systems, fluid flow	X	X	X	X	X	X
Development of new chemical reagents and microbiological agents for mining-related applications (such as flotation, dissolution of minerals, grinding, classification, and dewatering)			X	X		
Biomedical, biochemical, and biophysical sciences			X	X	X	X
Water treatment						X
Closure					X	X
Alternatives to phosphogypsum production and management						X
Technology Development						
Sensors – analytical (chemical and mineralogical; hand-held and down-hole), Geophysical (including airplane drones, shallow seismic data, and hyperspectral data), surface features, personal health and safety, etc.	X	X	X	X	X	X
Communications and monitoring		X		X	X	X
Autonomous mining		X			X	
Total resource recovery without environmental impact		X	X	X		X
Fine and ultrafine mineral recovery (including solid-liquid separation, recovery of ultrafine particles, disposal)				X	X	X
In-situ technologies for low-permeability ores (includes some of the technologies under fracture processes as well as directional drilling, drilling efficiencies, casing for greater depths)	X		X	X		
Biomining		X	X	X		
Fracture processes – applications of petroleum and geothermal drilling technology	X	X	X			

Given the current rapid pace of technological development in broad areas (from information technology to microbiology), it is expected that mining industries will be able to take advantage of some of these developments to the benefit of consumers, producers, workers, and the environment. Progress towards these revolutionary changes will produce concrete developments for industry. These revolutionary changes which can result from basic research, applied research, or technology development are:

- In-situ mining of a broader range of commodities
- Biomining (using biological agents to extract metals, minerals, and coal)
- Autonomous (fully robotic) mining
- Geophysical techniques that can "see" through solid rock
- Total resource recovery and/or waste utilization
- Wasteless mining technologies
- Minimal adverse environmental impacts
- Rapid development of soils on mine wastes

Health and safety risks and benefits

Advances in technology have greatly enhanced the health and safety of miners. However, potential health hazards arising from the introduction of new technologies, which may not become evident immediately, must be addressed as soon as they are identified.

Research opportunities in environmental technologies

The need for a better understanding of the scientific strengthen of the environmental issues and for more effective technologies to address them cannot be overemphasized.

Technologies that attempt to predict, prevent, mitigate, or treat environmental problems will be increasingly important to the economic viability of the mining industry. Improved environmental technologies related to mine closures present now the greatest opportunity for increasing productivity and saving energy, mainly in transition economies, passing trough a lowgrading of mining production. Research is also needed on water-quality issues related to mine closures, which are often challenging and costly to address for all types of mining.

Basic and Applied Research and Development

- **Basic Research** – creates new knowledge; is generic, nonappropriable, and openly available; is often done with no specific application in mind; requires a long-term commitment.
- **Applied Research** – uses research methods to address questions with a specific purpose; pays explicit attention to producing knowledge relevant to producing a technology or service; overlaps extensively with basic research; can be short-term or long-term.
- **Fundamental Technology Development** – develops prototypes; uses research findings to develop practical applications; is of general interest to a sector or sectors, but full returns cannot be captured by any one company; is usually short-term, but can be long-term; is not developed for one identifiable commercial or military product; often makes use of new knowledge from basic or applied research.

Automation of longwalls, mobile and development equipment are clear priorities for the future. Automation of longwalls is required to promote consistent performance and the removal of persons from hazardous face areas. Repetitive operations like coal haulage vehicles are relatively easy to automate, but technology to protect and exclude personnel requires development. The ultimate in roadway development systems will be a fully automated TBM type machine and there are many steps of technical development required to achieve this outcome.

Controlling mine operations within a virtual mining environment is not something for the future, it is an imperative for here and now. Ninety per cent of the technology required has been developed and it only requires cooperation from manufacturers and the vision from mining companies to realise its potential. The paybacks from consistency, safety and increased quality flexibility of operations are enormous. One only needs to look at the developments in coal processing to realise the economic potential of “hands off” mining.

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