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IMWA INSIGHTS

Mining: The Challenge Knocks on our Door

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Abstract Mining will continue to be an important economic component due to the incessant demand for raw materials, but the industry needs to balance the extraction of mineral resources with its obligations to abide by all laws, benefit the local community, and contribute to regional development. Proper management of mine water through reuse, reduced consumption, and desalination is key to attaining a higher level of public acceptance, as is making sure that the public learns of the advantages that our industry brings.

Keywords Challenges · Economic · Environmental · Future mining · Hydrological · Social · Technical

Introduction

How will mining evolve over the next 20 years? Predicting what two decades will bring should not be difficult, given my perspective; I come from a country with 5,000 years of mining history and have a lifetime of experience with mining in over 50 countries. However, this paper would have been impossible without valuable input from 41 friends, in 14 countries, who together represent a broad spectrum of knowledge about the world of mining.

First of all, the future of mining is bright. Mining will actively continue due to the incessant demand for raw materials extracted from Mother Earth. The needs of the developed nations are being supplemented by the huge requirements of emerging markets, such as China, India, and Brazil. Indeed, we will soon see even greater pressures for mineral resources, as countries with subsistence economies increase their productivity and development. Although the world is learning to optimize recycling, the increased demand for raw materials is unstoppable. Mining has brought social progress, economic growth, and industrialization to countries such as Australia, Canada, Chile, South Africa, and Peru (Thomson and Boutilier 2001). We must not forget that many countries and communities, especially in the southern hemisphere, rely on mining as their main source of income. Mining represents between 15 and 50% of exports in 30 countries, and between 5 and 15% in 18 more. It is a key component of the economy in 51 countries in which some 3,500 million people live (MMSD 2002). Not only does mining represent a high percentage of these country's total exports, it generates substantial foreign exchange earnings, tax revenues, and royalties (Figure 1 is a supplemental figure provided in the on-line version of this paper, which can be downloaded for free by all IMWA members). In the context of globalization, mining can be an opportunity to change things for the better, and thereby provide a better life to our descendants.

However, mining, globally, has a pejorative connotation, and is still considered in many circles as a polluting industrial activity, with strongly undesirable social impacts. There are strong anti-mining movements that consider the industry as evil, unaware that activities such as

To the friends I've gained in this long walk, and all who will be responsible for mining in the future, please remember that every new challenge provides us with new opportunities to achieve.

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intensive agriculture and grazing cause much more environmental damage and are a greater threat to biodiversity. To overcome such bias, mining is obliged to rational exploitation of mineral resources, in the context of a global village, in accordance with all laws, and to benefit the public good and regional development. To make this possible, all laws, standards, and regulations must include guarantees for the concepts of ownership, production, consumption, and environmental and social liability, and should guarantee that mining investments will be supported by social and institutional foundations (MMSD 2002).

Mineral resources are located where the Supreme Creator placed them and a mining operation is inextricably linked to its location. Furthermore, it is an axiom that economically viable mineral deposits occur relatively rarely. Mining operations require, not just acceptance, but increasingly, a high level of approval by communities located near the mines (Thomson and Boutilier 2001). To achieve this, the people who live in the area must benefit from the mutual synergies. Moreover, the non-renewable nature of mineral resources and their depletion by mining implies that the social and environmental costs of mining, to be acceptable, must be offset by economic benefits for those disadvantaged by the process.

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Technical Challenges

We can be confident that the increased value of the world's mineral resources will allow the mining industry to perform in ever more challenging territories with increasingly inhospitable conditions, in deeper mines (Fig. 1) with lower rates of mineralization, and more complex ore treatment processes. This is against a background of growing world populations, heightened environmental concerns, and increased energy requirements, all of which will put pressure on the world's natural resources. Mining is also increasingly taking place in extreme climates, including arctic and hyper-arid environments, where the challenges include working with frozen soil and water scarcity. While we know that technologies have been and can be developed to make this possible, it is expensive, and the environmental impact can be profound. We should also remain aware of issues related to mining of the ocean floor (i.e. the recovery of manganese and nickel nodules), which will likely be extended to areas where the oceanic crust is expanding. All of these challenges mean that mining will become increasingly complex as the industry continues to develop new methods of exploitation.

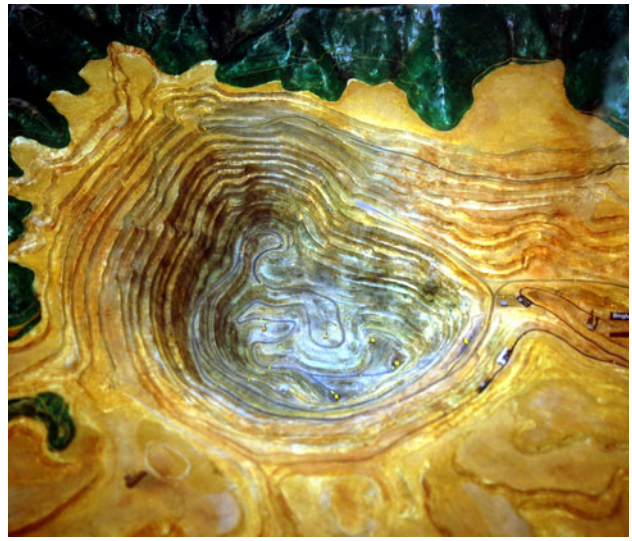

Fig. 1 A scale model of the Bingham Canyon Mine, UT, USA, as it is expected to look in 2015

The technical challenges of the near-future must be met by a change in academic strategies from within the universities, to prepare students to be future super-mine managers capable of addressing operations in an environment with fundamentally more stringent standards with respect to safety, health, environment, socio-economy, water, waste, etc. Technological development will require the training of a well-prepared, professional workforce with the skills to work with new processes of manipulation and control, based on advanced computer and electronic systems. Future mining professionals will rely on modern software and specialized applications geared towards exploration, mine design, mineral processing, control equipment, circuits, and processes, as well as administering valuable human resources in the best possible way. And all of this technological development will require appropriate geo-referencing of information, an essential tool when working with a lot of information covering varied subject areas. So, the training of mining engineering must evolve, incorporating all of these new disciplines and skills without losing the virtues of prudence, solid know-how, and adventurous character.

These future professionals will also need a deep knowledge of languages, because multinational mining companies will continue to be active in many countries and because scientific and technological activities are published in different languages. Proficiency in English alone is insufficient; Anglo-Saxons also need to learn foreign languages to enrich their knowledge and their possibilities for action.

The easy-to-exploit mineral deposits are depleted and the mineral deposits that are now being discovered are ever more difficult to exploit because of their depth, location, or concentration. This depletion of the more superficial mineral reserves, together with more stringent environmental requirements, has led to increased underground mining, with gradual access to reserves at depths of several kilometres. Rock mechanics and mining hydrogeology will play key roles in the opening of large cavities deep underground, including preventing major problems, such as subsidence and the risk of adversely affecting the quality and quantity of potable groundwater.

Future mining will benefit by harvesting virtually all of the potential mining resources as by-products and by more compact production; this will surely be the case with polymetallic mining. We will mine with multiple goals, taking advantage of all the mineral resources available in each mining operation, thus minimizing waste production. This will include the exploitation of "new" resources, such as the rare earth minerals demanded by the electronics industry, and minerals that until now have been regarded as almost worthless (e.g. thorium to replace uranium). The future will also likely see increased recovery of minerals dissolved in effluents from abandoned mines and waste piles (Fig. 2). Thus, mine water that contains high concentrations of metals will become a resource!

Activities are also already underway to exploit coal deep underground through in situ coal gasification, which has some operational similarities with hydrometallurgical in situ biological leaching, and to capture CO_2 gas emissions and store them deep underground. Another technological field that is already developing, with great potential, is the exploitation of geothermal energy employing heat pump equipment; flooded abandoned mine shafts and mine pools are becoming increasingly valuable as energy sources due to the increased temperatures provided by the geothermal gradient.

All of these advances will increasingly be subject to the objective of minimal environmental impact, which will require increasingly detailed feasibility plans and parallel environmental impact studies. We can also expect to see increased emphasis on eliminating the illegal informal (artisanal) mining that takes place in many developing countries. The technologies used at such sites are obsolete, unsafe, and environmentally destructive, and obviously damage the image and perception of mining.

Fig. 2 The author sampling an ore stockpile effluent with a high copper content (at the Sossego Copper Mine, Para, Brazil)

Finally, mine planning has to incorporate sustainable mine closure. The cessation of mining has to be considered from the beginning of the operation and factored into the mine design. Moreover, closure and post-closure plans have to be reviewed and updated during the life of the mine, both to offset the impacts inherent in mine closure and to create new infrastructure and business opportunities.

Social and Community Challenges

Sustainable mining must integrate the surrounding communities, from the beginning of the process of exploration through the development and exploitation phases, and during closure and post-closure, in order to create a living environment that facilitates the long-term economic development of its inhabitants. In this sense, efforts should be aimed at integrating the mining project with its environment, so that neighbouring communities are also actors and beneficiaries of its implementation.

Just as society requires mining to supply the minerals and metals that enable them to meet their needs and general welfare, mining requires a Social License, which has its roots in the beliefs, perceptions, and opinions of the local population and other stakeholders in the area of mine operation. Such opinions and perceptions are subject to change, as new information is acquired, so that a Social License has to be earned and maintained. Achieving these commitments requires what the International Finance Corporation has defined as FPIC; 'Free' (free of intimidation and/or coercion), 'Prior' (timely disclosure of information before any decision is made), and 'Informed Consultation' (relevant, understandable, and accessible information; IFC 2006).

This social challenge may require that, within the framework of proper planning, industry underwrite all or part of the costs in relocating those who will be displaced by mining or who will lose their income when the mineral resources lie close to urban centres or agricultural or forestry. It is desirable that the surrounding communities all see the benefits and the positive economic impact of mining, and therefore see no benefit in supporting anti-mining activities. Thus, socio-economic empowerment, based on the benefits of mining, is essential for further development in the region over the medium and long term. Embracing advanced corporate social responsibility as an uncompromising commitment is essential to a friendly and close interaction between mining and society.

But this only happens when the affected communities agree to share their land in exchange for receiving fair compensation and when the mining company successfully minimizes the short and long-term impacts of the mining operation. Coexistence of community, business, and society is possible with application of Agreement 169 of the International Labour Organization (ILO 1989) for indigenous peoples.

By obtaining a social license to exploit natural resources, ensuring the proper distribution of benefits from mining, and being sure not to violate legal regulations, a company should be able to avoid violence, which is often promoted by external agents. In this context, the company can develop their business and carry the heavy investments and risks involved in mining, while avoiding lengthy and costly disputes. And the various state, regional, and local authorities must ensure that a company that complies with these regulations can implement a mining project, regardless of political vicissitudes. Simple, understandable, and applicable laws that meet the objectives of minimizing environmental impacts and protecting future generations, while encouraging and safeguarding the investments of the mining community, are essential. This does not exempt, but reinforces the need to consistently communicate the policies and relevant details of the mining activity to the local and regional media and community organizations. Pressure groups may use misinformation or distorted information and fallacious and misleading arguments, impregnated with a populist message, to generate resentment against mining companies. The only way to combat this is to make sure that the public is kept fully aware of all of the benefits that mining brings to the area. To achieve this goal, mining will integrate professionals from the branches of sociology, anthropology, archaeology and other fields as well as appropriate local personnel, and should, whenever possible, attempt to train unskilled labour (MMSD 2002).

Economic and Environmental Challenges

Mining, like all industrial activities, is subject to economic imperatives. The recent turmoil and vagaries of the global economy, and the resulting economic chaos, has ironically been good for some types of mining, especially gold. The most responsible companies are taking advantage of the rising prices of commodities to invest a portion of the profits in improved environmental performance. In the coming years, tens of billions of euros (or dollars) will be invested in mining, and these resources must be managed to produce the greatest overall benefits, not just for the mining companies, but also to respond to the social, environmental, and economic needs of the countries and communities involved.

Mining can be an engine for development in emerging countries that are rich in mineral resources, especially if mining contributes to sustainable development at the local level by ensuring that a substantial portion of the profits are invested in training and infrastructure. The challenge becomes how to optimize the trade-off between environmental damage and the potential developmental benefits to local and national economies. Steps should be taken to use the best technologies and management techniques, supported by accelerated research and technological innovation, to produce the smallest environmental impact possible, without excessive costs (MMSD 2002). Following this path, it is expected that primary and secondary energy consumption, relative to total production, will decrease, helped in part by increased use of renewable energy sources at mining operations worldwide.

It is crucial that society stops seeing mining as synonymous with destruction and irreversible damage. Mining must be designed and implemented with imagination, using the best technological resources to make efficient and rational use of natural resources. Along the way, mining must make a strong commitment to care for the environment, reducing its impact on water and air quality, land pollution, and water consumption through operational improvements and comprehensive management. The recovery of former mining environmental liabilities will be important, together with the recoverability of mining infrastructure and mining heritage. The fundamentals of sustainable development must become embedded in the culture of mining companies. Mining should not leave unacceptable environmental or other negative legacies. The closure of the mine and the post-closure phase should be planned to ensure that the land and infrastructure can be rehabilitated for other uses by the resident population.

Mining is booming now, but experience has taught us that boom cycles do not last forever. The goal, therefore, should be to properly reconcile all interests in mining and the environment (including the underground environment), while avoiding conflict situations.

Hydrological Challenges

Water, the most important renewable natural resource of the planet, is a basic and necessary component of mining and metallurgical processes (wet treatments and leaching), pipeline transportation of waste and concentrates, dust reduction, hygiene requirements, rehabilitation of mining areas, and so on. The significance of this will only increase in the future, given the impact that climate change may have on the hydrological cycle and the availability of water

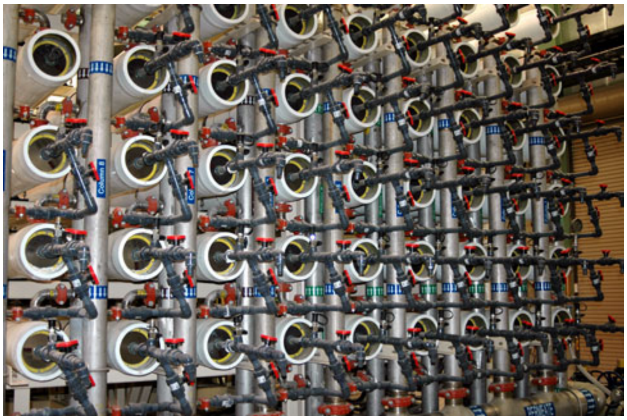

Fig. 3 Reverse osmosis water treatment plant at Bingham Canyon, UT, USA

resources. Reuse, reduced consumption, use of wastewater, and desalination will all become more important and hydrologists will be expected to institute efficient and sustainable management of water resources. This will involve:

- Excellent water management to reduce water consumption, with the goal of zero discharge.
- Reconciling water scarcity with the needs of mining operations and competing needs, such as the demands of farming communities.
- Reusing water, so as not to impact an increasingly water-hungry society.
- Using surplus treated water for reforestation or other uses, not forgetting that mining is the only industry that can be a net producer of water.
- Minimising the amount of water retained, given the ever-decreasing ore grade, increased waste production and ratio of water used/tonne mined, with solutions such as water recovery filtering waste treatment (paste tailings).
- Reducing the costs of water supply for mining operations, when planning desalination of sea water or pumping large volumes over long distances and with high heads (as occurs in Peru and Chile).
- Collaborating on the supply of water to neighbouring people, especially in countries where groundwater plays a strategic role and mining can bring knowledge of the subsurface and hydrogeological characterization.
- Better use of treated mine water, especially with desalination processes or reverse osmosis (Fig. 3).
- Avoiding negative impacts on groundwater systems from in situ coal gasification and coal seam gas extraction.
- Considering the effects of climate change on pit lakes, and;
- Developing new methods of exploitation, such as deep bioleaching through holes.

Thus, the sustainable use of water goes beyond technical issues and becomes a political, social, economic, and cultural challenge that engages the mining industry and society as a whole.

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