Physics and Mining are Connected Through the Millennia

by Daniel L. Cluff

The oldest recorded use of stone tools is estimated, using paleomagnetic dating or the characterisation of reversals in Earth's magnetic field over time, to be about 3.3 million years [1]. A chert mining site was discovered at the Nazlet Khater 4, estimated by radiocarbon dating to be 33,000 years old [2]. Chert is a sedimentary rock of mythical hardness that was used by early humans for tool-making and also to strike sparks to start a fire. The oldest known proper mine, that being a traceable activity to extract certain minerals in an organised fashion, is currently held by the Lions Cavern at the Bomvu Ridge in the Ngwenya mountains of Swaziland (now eSwatini). The hematite and specularite were extracted for cosmetics or rituals and is estimated, by radiocarbon dating, to have been active about 43,000 B.C. to 41,000 B.C. and may have been mined until at least 23,000 B.C [3]. Perhaps this honour will be bestowed to an as yet discovered operation because it is presently accepted that the use of cosmetics dates back at least 500,000 years [4]. Mining has been part of the human experience for millennia as determined by the use of dating methodologies based on physical principles.

In the present day, mining is a complex industry. The five basic elements of the mining cycle are: exploration, from a lone prospector in the wilderness to large scale geophysical surveys using seismic, gravitational, magnetic, electrical and electromagnetic methodologies; discovery, the stage where the deposits found by exploration are confirmed to a higher level of accuracy and the permits or environmental surveys needed to further the project are sought; development, is the point where feasibility, geoscience and engineering studies are advanced to the point where financing decisions are able to be made; production, is the culmination of the previous activities that have led to an operating mine where the primary activities are extraction, milling and processing of minerals and finally closure, the environmental renovation and ongoing land reclamation, which often starts at the onset of the project and may continue long after the completion of mining activities. This brief description of the mining cycle demonstrates the need for high quality science and engineering from beginning to end of a mining project; a mining project can typically take about seven to ten years from discovery to an operating mine and cost from hundreds of millions to billions of dollars to build. Taking into account the risk factor it is estimated that about 500 to 1,000 exploration projects are undertaken to produce 100 possible advanced exploration projects leading to 10 development projects capable of attracting financing, but of these typically one delivers a profitable mine [5]. The amount of time and expenditure required to create a producing mine is substantial; thus, opportunities abound.

Summary

Mining, as a human activity, is connected with the first demand for a stone of a special type that would have to have been "found" by searching the surface. In the present day, mining is a complex industry with advancements enabling it to be a part of our clean future.

The intent of this issue is to inform everybody of the connection between modern mining and physics already illustrated to some extent in the introductory paragraphs. The typical impression that comes to mind of a mining operation is a dirty place with a crew of ragged workers carrying picks and shovels, but today that is no longer the case, mines are getting cleaner due to ongoing changes in health and safety legislation and the increased presence of advanced technology such as autonomous or remotely operated equipment. Another impression is that mines are built and operated by mining engineers, which is still true for the most part, but the engineers' teams are increasingly comprised of multidisciplinary groups of scientists, specialised engineers and technologists. A wide array of mining engineering consultancy firms have long been in existence and are growing, but over the last few decades increasing numbers of specialist consultancies and mine service companies have successfully launched. In this climate physicists are becoming progressively more sought after especially as the mines get deeper, the thermodynamics and seismic susceptibility, two of the most intractable problems associated with deep mining, are both strongly connected to physicists and the technology needed to meet the demands is becoming increasingly more complex.

Mining corporations have been increasingly closing their research departments in favour of contracting out

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these services. In response to this challenge small companies have assembled the expertise to supply these services. In the 2017 budget, the federal government announced an Innovation Supercluster Initiative (ISI) to provide $950 million for business led consortia. The purpose of the ISI is to accelerate the growth and development of business-led innovation superclusters in Canada. The CLEER supercluster (**C**lean, **L**ow-energy, **E**ffective, **E**ngaged and **R**emediated) cultivated a consortium commitment upwards of $700 million, cash plus in-kind from 162 members across Canada, with a full 70% coming from Small and Medium-sized Enterprises (SME) and although the request from the federal government was only about $200 to move forward with a $900 million program the supercluster did not make the final cut. This pan-Canadian "cluster of clusters" would have created an estimated 140,000 new direct and indirect jobs and contributed $26 billion to Canada's GDP after five years [6]. The failure of the federal government to approve the mining supercluster demonstrates their lack of understanding of the vast support industry that has grown across Canada to provide research and support services to the mining industry and the impact that this support network has had on the Canadian industry and on the mining industry globally.

The recent Carbon tax introduced by the Federal budget brings to mind the connection between mining and environmental stewardship. Although mining corporations have made great progress and continue to strive to extract minerals in cleaner operations the connection between mining and climate change is not often at the forefront of public awareness. The simple equation expresses as follows: carbon reduction requires an increase in metals. The increase in electric vehicles and new advanced technologies not only requires much more of the basic metals such as copper and nickel, but also more of the exotic minerals such as the rare earth elements. So the mining activity is not just itself getting cleaner, but is a significant part of our clean future.

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