Technology Review

MINING RESEARCH AND EDUCATION

BY

JACK A. CALDWELL
# Table of Contents

**Technology Review** .................................................................................................................. 1

**Mining Research and Education** .............................................................................................. 1

**Table of Contents** ....................................................................................................................... 2

**Introduction** ................................................................................................................................. 4

**R&D in Mining** ............................................................................................................................. 4

*What are the best steps to take to promote the essential need for R&D in the Mining Industry?********** 4

**Mining R&D People** .................................................................................................................... 8

**Recruiting** ................................................................................................................................... 8

*Who should be recruited or engaged in R&D activities?* ............................................................ 8

**Intellectual Elite** .......................................................................................................................... 8

*Is R&D only for an intellectual elite?* ............................................................................................ 8

**Who Undertakes R&D?** ............................................................................................................. 10

*Should R&D be undertaken by industry, government, or academia?* ........................................... 10

**Undergraduates in R&D** ........................................................................................................... 11

*What is the role of R&D in the undergraduate curriculum?* ....................................................... 11

*Should research be separate from education?* ............................................................................ 12

**R&D in Developing Countries** .................................................................................................. 13

*What is the role of R&D in developing countries?* ............................................................... 13

**Social Issues** ............................................................................................................................... 14

*How should important societal and political issues today and in the future be incorporated into Mining R&D?* .............................................................. 14

**Innovation vs Evolution** ............................................................................................................. 17

*Should R&D in Mining look exclusively for innovation (revolutionary) or is there a need to include traditional knowledge (evolutionary and appropriate) in the work?* ................................................... 17

**Interdisciplinary R&D** ............................................................................................................... 20
How should interdisciplinary and collaborative R&D be encouraged in Mining? ............................. 20

EDUCATION FOR PROFESSIONALS FOR MINING ........................................................................... 23

How do we attract the “best” people into our industry through our academic programs? ............. 23

PROFESSIONAL SKILLS? .................................................................................................................. 27

What are the set of skills needed by a Mining Professional in the 21st century? .............................. 27

LIFE-LONG LEARNING .................................................................................................................. 30

What approaches should be used for life-long learning programs and needs—both continuing education for our graduates and opportunities to provide early education to high-school and primary school students? ................................................................. 30

OUTREACH ...................................................................................................................................... 32

How should the industry and our educational institutions out-reach to remote communities and indigenous populations? .................................................................................................................. 32

What opportunities exist to develop collaborative teaching and learning approaches by industry and academic institutions? .................................................................................................................. 32

CLOSURE ........................................................................................................................................ 33
INTRODUCTION

A conference was planned, people were writing and organizing, and then thing went awry. Here is what I wrote on the topic of Mining Research and Education in anticipation of the now postponed conference. I post these writings now, rather than hide them for a year or more, in the hope that controversial as they are, they may contribute to argument and discussion—hence the formulation of answers by those more knowledgeable than I am.

The sections of this “paper” reflect the questions that were posed by the conference organizers. They gave these questions to me to prepare these writings. They have not responded to them: maybe the answers will be forthcoming at the time of the conference.

R&D IN MINING

What are the best steps to take to promote the essential need for R&D in the Mining Industry?

I believe all research, and specifically research directed to the world-wide mining industry should be based on this paradigm or algorithm: establish a system that generates more ideas than can be researched or implemented; scrutinize all ideas for worth and merit; discard bad idea; develop good ideas; disseminate the results of the good ideas to those who can implement them; and generate more new ideas on the
basis of the successful, implemented ideas. You may think of this as simply research evolution.

On the basis of this paradigm, I conclude that there is no exclusivity on the generation of new ideas—everybody, regardless of education or training is a potential source of new ideas and my system would seek to capture all these ideas—very much as is done in the Brainstorming Session for a comprehensive Value Engineering Workshop.

Scrutinizing ideas for R&D related to mining must involve judgment and opinions, and here my system would place the judgment function onto as many juries of peers as can be assembled. Groups from all segments of industry should contribute at one point or the other: I would include manufacturers, sellers, users, salesmen, consultants, magazine writers, miners, academics, and pestilential critics of all stripes. The group providing the funding for further work would have the right to choose the committee to scrutinize the work they fund. This could be a group of lecturers associated with a consortium of universities, the board of directors of a think tank, the R&D VP and staff of a manufacturing company, the technology development division of an international mining company. There is no end to the diversity of peer groups that could and should sift through new ideas for mining-related R&D. I would not allow the task to become the exclusive preserve of a self-selecting group closely allied to the industry. That will only breed stasis like so many other august bodies convened to promote national objectives.
Money is required to develop good ideas. So the more well-funded R&D institutions and groups in a country and industry, the better. I cannot support the notion that the taxpayer benefits in the long-run, and so should pay in the short term. I distrust any government funded and controlled initiative. I believe that every research group should compete in the free market for the research monies made available as a matter of national policy by governments, in the interests of industry by the mines, and as a matter of personal glory by rich persons. I know it is easy to point to Darwin and Einstein and the advances they made in the absence of well-funded research programs. Some fundamental work can indeed be done on inherited fortunes and poorly paid postal salaries, but most of the topics we need to R&D in the mining industry involve teams and money to collect and evaluate data. So we need to encourage as many independent sources of funding as we possible can to keep the free-market part of my algorithm functioning. And if society does not do it then I submit the only proper sources of such funds is the mining industry.

A good example of the free market at work in the mining-related R&D field is the conference as the most powerful disseminator of research results. Incidentally, breakout groups at conference also provide an ideal peer jury to evaluate and recommend on research directions and funding. Personally I avoid conferences, but I recognize the fun they can be and I grant the ready and manifest benefits of conferences as a way to share knowledge and disseminate good ideas, useful practices, and research results. Many conferences these days are organized by
commercial entities that make large sums of money from their labors—and in my mind good luck to them, may they continue to do more in this regard.

There are other dissemination avenues. The magazine of peer reviewed papers is the oldest. This website, InfoMine and TechnoMine are the newest. This very piece is an attempt to disseminate ideas about the ICREME conference to be held in one of the most salubrious settings in all the world. Maybe via this piece and similar pieces during and immediately after the conference, we can disseminate the good, new ideas fast and get them into the brains and hands of the widest possible audience world-wide within hours if not days of their generation; no need to wait for written versions to appear in print. This is now and we have tools not hitherto available to generate and disseminate R&D results. Join with me as I proceed with this pre-conference piece. I hope I can update it as the conference evolves and my ideas are tested, accepted and/or rejected: I make no apology for putting down my own ideas here even if they be erroneous. I try to say why I conclude as I do—for I am sure there are many who will delight in correcting me if I am wrong. To those who do so, I say thank you in advance: that is the very essence of science and advancement of civilization.
MINING R&D PEOPLE

Recruiting

Who should be recruited or engaged in R&D activities?

In posing this question, UBC also asks five subsidiary questions, and I tackle each in turn.

Intellectual Elite

Is R&D only for an intellectual elite?

This question scares me with its implications of, yes, elitism. The problem is what constitutes an intellectual elite? At first blush this would imply that only people with a PhD should be allowed to touch R&D. But in my experience some of the best new ideas and advances have come from ordinary, hardworking men and women faced with a problem they have had to solve. Would this success be banned if only the intellectual elite were allowed to engage in R&D? Clearly there are different levels of education in all walks of life. We cannot shy away from the fact that some are educated as practitioners, some as consultants, some as managers, some as leaders, some as teachers, some as academics, and some as researchers. We must face the fact that a degree from a community college will not put you at the top of the opportunity ladder in the mining industry and will hardly equip you for a career in research.
We must face the fact that a simple undergraduate degree from an ordinary university (anywhere in the world) will get you a job in the mining industry and the opportunity to excel; but the degree will not guarantee success in research, unless you have those elusive qualities that make a good researcher: ninety-nine percent perspiration and one percent inspiration. I submit that a basic degree in a topic relevant to the research topic will make you a good researcher if that is your instinct and application. But of course, if you have those skills, you might as well go ahead and get a masters degree in addition.

The masters degree in no way befits you, \textit{ex post facto}, to be a good researcher—my daughter has a masters in engineering from one of the best universities in Southern California, and she is a great consultant, but would certainly need more to do research in her chosen field: dynamic soil-structure interaction and the design of foundations for those new high-rises going up in Los Angeles. Hence we are led inexorably to the PhD as the working degree for research leadership. But I confess unease with this conclusion. I can accept it if we are setting up a system, an industry, to produce researchers, but then we are talking only of the most intellectual cutting-edge research. I suspect there are many problems on individual mines, in individual industries, in specific consulting organizations, where those with a bachelors or masters degree could most successfully undertake fundamental research.

I fear that any society, system, or industry, and I include the mining industry, that limits research to a specific degree or to a specific level
of intellectual elitism is doomed. I am a firm believer in the equality of opportunity for all to undertake that which interests them, to do that which is in accord with innate ability, and to solve those problems that come enter their ken that need solving. In my opinion, the only people who should be allowed to undertake research are those who want to and who need to and there should be no restrictions by virtue of academic history or paper degrees.

**Who Undertakes R&D?**

**Should R&D be undertaken by industry, government, or academia?**

Of course R&D should be undertaken by industry, government, and academia. In the rubric of industry I include the mining houses, the mines, consultants, and those who design and build equipment for mining. We cannot possibly restrict R&D to one branch of society. To do so infringes on societal freedom and the right of every society and group therein to do what it deems best for itself and hence for its society. To restrict R&D to one group will impoverish society and the reliant industries. Academics by their very nature, interests, and resources have only a limited scope for undertaking R&D. If they were the only group undertaking R&D I suspect we would still be debating this question, and similar, when the real world is screaming for practical answers.
Think of the development of new computer codes that enable us to undertake analyses that could only be dreamt of when I was at university. For example, consider the DEM software that now enables us to examine the interaction of individual particles in almost any setting we can imagine. This code is the product of R&D by a single committed individual seeking his best opportunities. I think of the work we did on the UMTRA program as consultants working with regulators in Washington to advance the practice of closure of uranium mill tailings piles for a 1,000-year design life. The stuff on the topic coming out of universities was to all intents and purposes useless—too academic and too unfocussed to provide real answers. I think of the superb work being done by those in the mines regarding the application of geomorphic principles to reclamation of the oil sands in Alberta.

There are simply too many advances in mining that have resulted from the application of intellect by industry and government to further debate this issue. All sectors of the industry must undertake R&D in those areas of technology relevant to their operations and to their interests, and we will all benefit thereby.

**Undergraduates in R&D**

**What is the role of R&D in the undergraduate curriculum?**

Personally I think R&D should be kept out of the undergraduate curriculum. There is enough to do, enough to learn in the
undergraduate curriculum without imposing yet one more requirement. Now of course there is no harm in a class focusing on activities that replicate the R&D process, and that may even yield R&D results. For nine years, I was a judge at the WERC contest held annually in Las Cruces, New Mexico. This competition is sponsored by the U.S. Department of Energy and other interested organizations worldwide as a way of encouraging R&D type activities by students at universities world-wide. One of the best solutions to the question: what is the best mix of sources for energy for a given state (in the competition, New Mexico) came from a group of maths students at a university in Ontario. Their mathematical research and application was adopted and is now used by the power industry in New Mexico as a standard tool. I recall too the kiln designed by a student from Mexico to fire mud bricks using waste in the poorer areas of Mexico. What Canadian university would have touched this lowly research topic?

My simple answer to this question is that the mining industry should get involved in the WERC program and use it as an opportunity to undertake undergraduate research. Contact Abbas Gassimi New Mexico State in Las Cruces for more details. And for the rest I would avoid burdening the undergraduate curriculum with R&D ideals.

**Should research be separate from education?**

I am not sure how this question differs in focus from the preceding one. There is a methodology to research and presumably this
methodology can be taught. In that sense research can be taught. Maybe we need a course in research techniques and methodologies. But to infuse R&D into all of education is too elitist for my taste.

**R&D In Developing Countries**

**What is the role of R&D in developing countries?**

The answer is immediately obvious: find ways to improve conditions in such countries. Who undertakes such R&D? In Canada, the instinct will no doubt be to say that Canadian researchers should do such R&D. In the United States, the answer would probably be, let them get on with it, for we have sufficient R&D issues that relate to our nation without getting too wrapped up in developing countries—at any rate they probably do not like Americans and will not facilitate advances. Maybe we conclude that the mining companies operating in third world countries should undertake or at least pay for the R&D relevant to the issues of those countries. Sadly only those few enlightened mining houses that already do this will do this.

The question of how to advance R&D related to mining in developing countries raises all those difficult issue of national right and pride. For example, what right have we as North Americans to impose R&D requirements on free (and not so free) nations not as “developed” as ours? There is no harm in academics, industry, and governments in many countries cooperating to support R&D re mining worldwide. And indeed this is to be encouraged. I recall the superb activities of the
Chamber of Mines in South Africa in advancing mining R&D. But who is going to spend money on mining-related R&D in Zimbabwe, at least until Mugabe dies and a more enlightened dictator takes over. I suspect that we cannot ask mining R&D to solve the intractable social problems of countries that choose or fall into pathological paths.

I take what is probably an elitist perspective: if mining R&D is undertaken in the developed nations, the advances will be applied in mining in developing countries as a result of the exercise of free economic advance by the mines themselves. If the governments and organizations of those developing countries can find it in their systems to support and/or undertake mining R&D, let us encourage and support and interact with them; but we cannot impose it on them as a matter of civilized behavior and fiat.

Social Issues

How should important societal and political issues today and in the future be incorporated into Mining R&D?

I submit that Steven D’Esposito of Earthworks is the best example I know of somebody who is incorporating important societal and political issues into mining R&D. We may not all agree with his lines of research and we may not all agree with the conclusions and recommendations of the research he supports and reports on. But at least he and his group are trying to look afresh at societal and political issues free of the constraints that are too real in universities and
industry and government sponsored R&D organizations. For example, I believe the honesty with which Earthworks moved on to the concept of Responsible Mining and left behind the stale field of Sustainable Mining as the guiding light of decent action is admirable and could not have been done by those whose careers are invested in a useful but somewhat mining-inappropriate concept.

You cannot by dictate “incorporate” any R&D finding into mining. So even if important societal and political issues are resolved by appropriate research, there is no ubermench to dictate the incorporation of these findings into mining. Position papers can argue causes and promote ideas and courses of action, but it is for the governments of the mining nations to make the laws and for the mining companies to choose to implement new ways that may be shown by R&D to be better. It is a free world, and should remain so. We cannot have the international R&D czar dictate new ways of doing things come from the field of mining-related R&D. If an idea is good, it will be picked up, provided there is sufficient dissemination of the idea in readable publications.

Now maybe I have got the wrong end of this rather ambiguous question, and what was really intended was this question: what societal and political issues should be researched by mining-related researchers in order to improve mining practice world-wide? The answer to that depends on your perspective. Personally I would love to see research on these societal and political issues as they relate to mining:
The history of mining and what it tells us of the rise and fall of societies that mined as compared to those that did not mine.

The role of mining in territorial expansion and the subsequent rise and fall of societies and countries.

Mining in the development of cities (start with Johannesburg, Vancouver, and San Francisco.)

Post-mining development of regions (start with Montana, Idaho, the California foothills, and the Witwatersrand.)

Colorado Rockies: from mining mecca to playground of the rich.

Africa versus South America as mining locale: a dispassionate comparison of Chile and Zimbabwe, Peru and Zambia, and any other A versus B you choose.

The role of mining in the development/demise of political freedom in South America.

The role of Canadian Provincial policies in promoting/inhibiting provincial mining.

California still has one of the biggest mining industries in the USA—namely aggregate mining. For the rest, is the state correct in relying on other places to provide basic metals?

International law as the basis of reasonable mining practice world-wide.
I could go on forever, but who will pay to research these fascinating but esoteric topics? As a taxpayer I have no desire to pay for answers to my own questions.

**INNOVATION VS EVOLUTION**

Should R&D in Mining look exclusively for innovation (revolutionary) or is there a need to include traditional knowledge (evolutionary and appropriate) in the work?

To better understand this question, let us look at the subsidiary issue raised in the prospective program for the conference. They are: (1) designing appropriate technologies; (2) looking for breakthroughs; (3) short-term versus long-term R&D—the right balance; (4) matching the past with the future; (5) integrating myths into mining R&D. Let us deal with them seriatim.

**Appropriate technologies.** I return to my basic theme: there is no one right line of research related to mining. In the broadest context R&D needs to be done by any society and by any industry that seeks to find more cost-effective, more socially productive ways of doing things to the benefit of all mankind. Of course there are appropriate and inappropriate mining technologies; there are “breakthroughs” out there waiting to be found; we must balance short-term and long-term R&D; we must match the past with the future; and we must dispel the myths that accrue to mining and any other human activity.
I await with eager anticipation the breakthrough that leads to appropriate, non-environmentally intrusive artesianal mining. It cannot be as simple as stopping the locals from splashing mercury around the local streams, can it? But maybe it is the tragedy of the commons that has to be ended? Or is this just another of those totally unsustainable practices that litter the South American landscape? And should it be left to take its course so in a hundred years we can enjoy retrospective coffee books on the glory of past freedoms lost and environments forever changed? Should the United Nations sponsor social, economic, and technical research programs to curtail, eliminate, or improve such mining practices? I cannot believe that anything short of a social revolution is going to put and end to the instinct for locals seeking to feed their families seeking to exploit their local resources; or should Canadian mining companies be given the right to displace this messy practice and do it according to modern practices, paying the workers a livable wage?

**Breakthroughs.** I am baffled by the notion of “looking for breakthroughs”. Is this not ultimately the goal of all R&D? Is there some philosophical methodology, some technical approach out there that I am not aware of that is the basis for action that is specifically directed to “looking for breakthroughs” as compared to good old fashioned slogging the details and adding a dash of inspiration?

**Short-term vs. long-term R&D.** I reject the notion that there is such a thing as short-term versus long-term research. A research project should be only as long as it needs to be to define the issues,
explore the options, make recommendations, and shut down the enterprise before it becomes a self-serving organization. I do not like the idea of research programs, i.e., those with no beginning, no middle, and worst of all, no end. They devolve into self-serving redundancy. I recognize that some research programs may have to go on for a long time: what is the successional vegetation development on a commingled tailings and waste rock cover; does mercury poisoning of the children of artesianal miners lead to metal retardation; what is the cumulative impact of selenium on downstream receiving biota; and so on. But these hard questions hardly justify long long-term research per se.

**Matching the past and the future.** Those who ignore the past are doomed to repeat it—or so a popular saying. Teach history and politics as required undergraduate mining courses, is my solution to this issue. Another is to support think tanks that write readable papers on the history of mining and its social implications. Another is to make students read and debate the websites of the NGOs and other groups that oppose mining. There are many such websites out there and while of variable quality, they are all entertaining and challenging. The battle between evolution, creation, and intelligent design is as good an example as any to study to see the value of websites and well written books in formulating opinions and debating contentious issues. I see no reason why mining should be exempt from the vigorous debate that swirls around supposedly settled issues like evolution.
Maybe we need a Civil Liberties Union of mining to go to court and fight for the fundamental rights of mines, mining, and miners.

**Integrating Myths into mining R&D.** I hope this is not a plea to integrate myths into what should be scientific undertaking. Coming from Canada, this is probably one of those interminable pleas to take into account aboriginal rights. As a believer in Responsible Mining I do not have to defend or explain my position of this one: of course it is sensible and necessary to consider aboriginal rights, period. But do we have to go through that again? Just because a hilltop is sacred, it is not ipso facto exempt from mining. Creation myths are wonderful; I love them; but they do not provide a basis for economic or political action. We cannot exempt all of Canada from mining just because the Europeans and Asians got here later than others. It is the overall benefit of current multi-everything Canada as it is now that must be considered. I await this conference discussion with interest.

**INTERDISCIPLINARY R&D**

*How should interdisciplinary and collaborative R&D be encouraged in Mining?*

Does the answer to this question lie in the subheadings compiled by the conference organizers, namely: borrowing ideas from other disciplines; providing cross-over employment opportunities;
maintaining the balance of the image of mining; multi-objective R&D projects; and incentives for interdisciplinary studies?

I have already touched on ideas for potential mining-related studies that derive from history, sociology, and the other life sciences. All of these, if ever undertaken, would constitute interdisciplinary R&D focused on mining. We have noted the difficulty of defining just what “pure” mining research is. At first blush it would be research focused on getting ore out of the ground, recovering the valuable constituents from the less valuable, and cost-effectively and safely disposing of the wastes. Every other activity related to mining is a subset of another “pure” discipline, whether civil engineering, environmental engineering, biology, history, or economics. Clearly there is need and room for application of research advances in these disciplines to the field of mining. For example, advances in biology regarding the interaction of viruses and bacteria holds promise of solving that most intractable of mining-related issues: acid rock drainage. Advances in the manufacture of geosynthetics and understanding of their long-term performance holds promise for reducing the cost of mining and enhancing environmental protection at mining sites. Software developments in many fields from hydraulics to systems analysis and decision making provides tools that may be used to solve many an hitherto unquantifiable mining-related problem.

I once worked on a U.S. Department of Energy cleanup site where the only PhD on our team was assigned full-time responsibility for monitoring technical advances and screening them for applicability to
every aspect of the cleanup operations. Can you imagine a similar position on every mine? This is unlikely to occur, although similar positions do exist in some mining houses. Maybe this is where a national or international research institute could play a valuable role. I know the fellow at Sandia National Laboratories in Albuquerque who is charged with just this task: monitor technology and scientific developments and seek applications for them at the lab. I even try to do this in a small way on TechnoMine: keep abreast of technology and scientific developments and report on them in our pages in the hopes that the mining industry will pick up the ideas and turn them into advances.

There would be no harm done if the diverse departments of our national and local universities collaborated on interdisciplinary mining-related research. Thus the geology department working with the mining reclamationists could formulate the rules of quantitative geomorphology and their application to the long-term performance of mine waste disposal facilities. Or the geology department could work with the miners to locate ore deposits in areas where there is nobody’s backyard. Or the economists could prepare a model for remuneration of locals affected by new mine development. Of the law department could formulate and propose a viable system of international mining law. Maybe the political scientists could tell us how to implement international mining law in an enforceable way—I have heard one proposal that Canada should lead the way and pass a national law that requires mining companies to implement a set of quasi-international
laws in their mining activities in other countries. How would this apply to rogue countries like Cuba where Canadians are even now happily mining at former U.S. holdings or at least lands that once belonged to the refugees now in Florida who used to own those lands? Maybe once the softwood timber deal is reached those same politicians can undertake research on compensation of the U.S. for Canadian fortunes made in Cuba.

**EDUCATION FOR PROFESSIONALS FOR MINING**

How do we attract the “best” people into our industry through our academic programs?

I find this question elitist and narrow. What does it mean? Is the questioner trying to establish a procedure for attracting more bright students to the mining faculty of the University of British Columbia? Is the implication that if the faculty provides better academic programs, then brighter students will come? If they succeed in offering the best possible academic program [whatever that is] and hence in attracting the best students [whatever that means] then so what? How does the industry and the nation and the world, for that matter, benefit if very bright kids get educated in mining in British Columbia? I suppose the stock answer is that mining needs bright kids to become successful leaders of the industry lest it wither and die or simply blunder along inefficiently and the world suffer a decline in life style as a result of
operations run by second-rate student-graduates from American universities.

Let us start by examining the premise that the brightest kids will benefit the mining industry. Perhaps we should start with the question what is “bright” in the context of a student entering the mining faculty of a university? Clearly the higher the SAT score of the student the brighter they are in the conventional meaning of the word. Of do we mean the best rounded student: the one who was the class leader at school, the all-round balanced academic and sports jock and social activist? Are we looking for future leaders, future managers, future researchers, future engineers, and future technicians? Probably all, although the technicians can be ignored for the purposes of the conference as we are focusing on university education.

No offence intended, but in my many years in the mining industry I have observed that there is seldom a one-to-one correlation between SAT-score potential (book learning intelligence) and the ability to make a mine successful. I intuit that the most successful miners are those with a dogged perseverance, with an innate optimism, and with the natural ability to get things done. And this is true from the exploration geologist to the landman to the financier to the community relations consultant to the regulator to the design engineer to the fellow in charge of the equipment that sinks the shaft and crushes the rock and adds the cyanide to free the gold to the environmentalist who finally closes the mine and reclaims the site to the lawyer who argues
that it is all done in accordance with laws, regulations, and the best principles of sustainable development.

What is most interesting about this list of people who find a mine, make a mine, and close a mine, is that most won’t have studied mining engineering in the first place. They studied philosophy, political science, natural science, social science, mathematics, economics, civil engineering, chemistry, physics, or they did time at the community college and in the field completing an honorable apprenticeship.

Maybe then the question, how do we attract the best through academic programs, is irrelevant to the mining industry. All that need be done is provide for the best education of all in whatever topic they choose and then let them free in the world to pursue their best opportunities, and if that happens to be mining, good, and if not then society will benefit regardless from their activities in their chosen fields. All the mining industry needs to do is support community colleges, technical colleges, training institutions, and universities in a neutral way and focus their energy on making the mining industry attractive to graduates regardless of their academic potential, success, or background.

This support can be as simple as paying taxes diligently. It may involve providing financial support to local educational institutions. It may involve scholarships to promising or even otherwise deprived students. It may involve sending mining staff to the educational
institutions to lecture and help with education. It may involve summer internships and job programs—although from my experience, one summer in a mining internship on a mine is enough to chase even the most enthusiastic away.

I am nervous about supporting a proposal to select one university, one faculty, one program, on discipline and to shower mining-derived or taxpayer-derived money on it. Who needs a stream of like-minded persons inculcated with one set of ideas? I believe the future of society and the success of mining depends on the give and take of many disciplines; on the infusion of new ideas from all parts of the academic and skills spectrum; on the freshness of people from different walks of live, from different societies, and from irritating perspectives that challenge the given and move us to the new.

I hope that the discussions of the conference do not come up with a set of platitudes. You know the sort: more money for UBC mining; more money for research in mining; higher salaries for mining academics; greater job security for graduates who enter the mining industry; and so on. Rather I hope we see agreement that the mining industry pay its fair share of educating the whole population in the widest possible spectrum of disciplines and skills and then rely on good old-fashioned market forces to attract and keep those who are worthy and needed and have a contribution to make, regardless of prevailing opinions and prejudices.
PROFESSIONAL SKILLS?

What are the set of skills needed by a Mining Professional in the 21st century?

To answer this question, we first need to know what a mining professional is. It cannot be simply someone who works in the mining industry. As I note above the diversity of people who work in the mining industry is so great that there is not one set of skills that suffice to keep the industry vital and productive.

The easy answer to the question of who is a mining professional is that it is somebody who graduates from a prestigious university with a degree in mining engineering and who proceeds to get a job with a big international mining company. Let us first, therefore focus on this one type of professional. My answer of course is ultimately irrelevant, for the question is then best answered by the large mining company that is seeking to employ mining professionals. What do they want? What skills are in demand in the lucrative halls and offices of mining head offices? I guess they seek somebody who has basic training in: (1) hard science including mathematics, chemistry, physics, and geology; (2) social science including law, politics, management, human and community relations; (3) economics including finance, accounting, and money management; (4) the humanities including philosophy, languages, and history; and (5) engineering including mining, civil, process, mechanical, and electrical. That is a tall order to cram into an undergraduate degree. But if you can find such graduates, and
they do exist, give them a big salary and move them to Switzerland or Brazil, Toronto, Denver, Reno, or Vancouver.

Given that all the skills I enumerate in the paragraph above cannot be taught in a few short years, we wonder if there should be a focus on hard engineering skills or on soft social skills when educating those who will lead the mining industry deep into the 21\textsuperscript{st} century. Maybe we should have multiple streams: one producing mining engineers; one producing mining managers; one producing mining developers; one producing mining philosophers; and so on according to your tastes.

Perhaps that degree of specialization is best deferred to post-graduate years. It is then we can train the specialist in mining history and philosophy. And he/she can proceed to formulate and answer the hard questions including: do we need mines or can we recycle to meet our needs; where should new mines be located; what is the international law of mining; why do some societies benefit from mines and some get destroyed; is the pre-eminent tenet of mining sustainability or responsible conduct; of what should a mining Environmental Impact Statement consist; international migration of labor to meet the needs of mine development [fence design]; and so on?

In the post-doctorate programs we can have teams working on nanotechnology in mining, bacteria to kill viruses, robotic mining to free folk to work in social programs, broadband communication for remote
mine operation and management, and the many other great advances we envisage.

Then we should establish Think-Tanks, those great institutions so beloved of United States right-wing politicians and supporters. The success of Republicans since 1994 in US politics is attributed by many to the proliferation of Think-Tanks to address conservative issues. I read the other day that 24 new Think-Tanks have been established in Ottawa since the Harper government came to minority, and the aim of these Canadian Think-Tanks is to replicate conservative success in the US. I am told Simon Fraser has a Think-Tank that does some mining-related work (I read their summary of the best jurisdictions in which to mine.) Maybe each mining house should be required, as a matter of public policy and industry largesse, to finance a Mining Think-Tank and to pay learned researchers large salaries to write erudite but readable papers on mining issues.

I can easily formulate many a paper to be produced by the first UBC Mining Think-Tank (UBC-MTT): Canadian national policy for third-world-country mines; Oil Sands and how to overtake [take over?] OPEC; Canadian territorial fragmentation, First Nation rights, and the implications for mine development; mine reclamation standards based on geomorphic principles. The list is endless, and I volunteer to continue formulating ideas and write the first few papers for a rewarding sum.
The point of all this is that there is no one right route to the education of a 21st century mining professional. It is an ongoing voyage, a journey, and process of self-development, of societal development, and of national and international self interest.

**LIFE-LONG LEARNING**

What approaches should be used for life-long learning programs and needs—both continuing education for our graduates and opportunities to provide early education to high-school and primary school students?

This is so broad a question that I divide it into two before proffering an opinion. The two questions are:

- How does society provide for continuing education in mining if at all?

- Should the mining industry attempt to “educate” primary and high school students in mining?

Regarding the first question, I admit a conflict of interest. I work for InfoMine and we have EduMine. I believe that EduMine is the best and only way to provide for future post-graduation education and life-long learning for mining professionals. EduMine has it all: free market responsiveness; ready accessibility; large choice; low cost. I cannot envisage that the same can be achieved by any university, nor do I believe that any university should strive to do so—that is neither their
mission nor purpose. Cobbler stick to your loom—or whatever the old saying is.

There is some room for those many organizations that wonder around the world providing real-time courses: this week in Pittsburg, next week in Perth, the following in Katmandu. We all love the visceral thrill of sitting in a class with others as ignorant as we and being entertained and educated by a charismatic teacher. It is fun and we are prepared to pay large sums to be thus entertained as compared to sitting alone at a still desk and blinking computer screen. But again this wondering pedagogue role is not for the university. Maybe the best university lecturers can be paid speakers, but he/she should never be the organizer and motivator. He/she should stick to home and teach the students the taxpayers subsidize.

As to the question of the mining industry going to the schools to promote their cause. I am dead set against this. Nobody under the age of 18 should be subject to propaganda, however well intentioned. The mining industry should stay away. If the mining industry claims the right to inculcate values in the young, why then so do the NGOs and the environmental groups and the creationist and there is no end in sight. Teach our children the fundamentals. Equip them to learn. Equip them to read and calculate, and to discriminate and to make choices and to act. But do not try to teach them to think like you. Your time is past; the future is theirs; they do not need to hobbled by your outdated prejudices.
OUTREACH

How should the industry and our educational institutions outreach to remote communities and indigenous populations?

Only somebody from a rich and privileged city could ask such a question. I dismiss this arrogant question by referring again to EduMine and my opinion about spreading propaganda amongst the young and innocent. If an individual in a remote community, regardless of their ethnicity or race or whatever, is interested and able, they should have access to the educational opportunities as the average Canadian aristocrat from a private school: money and the chance to attend a decent learning institution. This is easily done by scholarships, student loans, and open enrollment. If an older person in same remote community wants more education, they should be able to go to the local library, access a free internet computer, and log onto EduMine. I do that in Belle Plaine, Iowa. These issues are settled in so many parts of the world, they hardly need delay us at a conference.

What opportunities exist to develop collaborative teaching and learning approaches by industry and academic institutions?

When I was a lecturer in the mid 1970s in South Africa, these same questions were asked. The answers are simple; their implementation hard. The university professor has to get out of the tower, go down to the grubby halls of industry, and persuade the practitioner to come to the University to give a lecture, to run a course, to lead a design class. Neither the average consultant nor the average mine operator has the
time, the energy, or the skills to teach. So the university professor
has to seek out that small group of people in industry who can teach
and he has to persuade and induce them to come. The most
successful person I know in this regard is Bruce Thompson at the
University of New Mexico. I still have the Hartman brief case I bought
with the $500 I earned giving lectures on Civil Engineering,
Environmental Considerations, and Mine Reclamation to his off-campus
classes in Albuquerque, Grants, and Gallup via video. Invite him to
come tell you how it is done.

CLOSURE

I look forward to comment, negative and positive on this piece. After
all this is too important a topic to take nicely and lightly. Let us
discuss every aspect and hopefully bring about some changes and
improvements. But do not let this become a choir practice where all
sing out of tune in the same way. Let us rather seek a complex opera
where all is integrated into a satisfying unity of theme and purpose.