Managing Technology Development in a Changing Business Environment

2004 SME Annual Conference

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ABSTRACT

Major societal and industry changes over the last four decades have influenced the management of technology in the minerals industry. From the authors' experience in both private and public sector R&D, the paper analyses the range of strategic and structural changes and provides examples of some key technology delivery responses.

For those charged with managing technology, the two key challenges facing them over the next decade are (1) moving technology development from a cost focus to a value focus (that is from "how much long term research can we afford?" to "identifying and capturing the value created from R&D") and (2) the recruitment and retention of key talent

THE NEED TO ADAPT

"Change is slow and gradual. It requires hard work, a bit of luck, a fair amount of self-sacrifice, and a lot of patience (Greene, 1998)." Since the 1960's the world has changed and the minerals industry has had to adapt to the changing circumstances. In the 60's, minerals were there to be discovered and fortunes to be made; in Australia, the World War II embargo on exporting iron ore was lifted and the Western Australian iron-ore boom commenced, to be followed by the exploitation of the Darling Range bauxites; copper, lead, zinc and nickel were discovered and mines developed. The Australian dollar was worth US$1.11 whereas to-day it is around US$0.65.

The oil crisis of 1976 sharpened focus on the sensitivity of the minerals industry on energy costs. By the late 1970's The Club of Rome was predicting the imminent demise of certain key metals - a prediction that has not been fulfilled - though the signs of the shift were there. The minerals industry was losing its shine. More recently "triple", then "triple plus one", bottom line accountability - a desirable goal - has required the industry to further modify its approach.

These changes have been accompanied by significant shifts in the management of technology. To standstill is to go backwards. This paper reflects on the changes in the minerals industry, on the different responses adopted for managing technology and postulates the next major issues for technology managers.

SO WHAT'S CHANGED?

Industry Structure

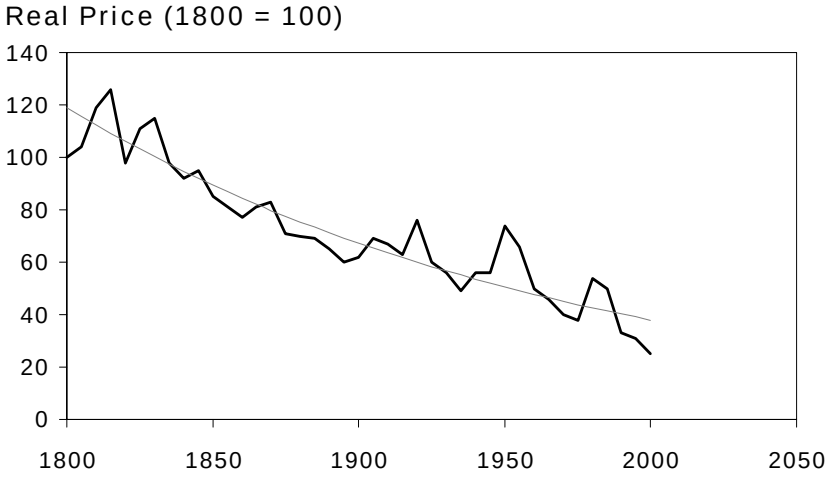
During the 1960's, Mt Isa Mines Ltd was, for a brief period, Australia's largest company. Last year, it was taken over by Xstrata for a mere A$4.93 billion (about US$3b). During the equivalent period, General Electric's market capitalisation went from US$6.3 to US$330 billion, to become more than the combined market capitalization of the top 150 minerals companies.

The decline in relative importance of the mining and primary metal production sector to western economies has resulted in relentless change in the structure of our industry. Classical bifurcation of the market into a handful of large companies and a long tail of smaller companies has changed the nature and capabilities for technological delivery. We have witnessed the dual listing of CRA and Rio Tinto, the merging of BHP with Billiton and no doubt further rationalisation to come. The emergence of the traders, Glencore and Xstrata, will initiate a new interesting dynamic. Outokumpu is moving away from mining towards downstream, higher value-added parts of the metal production chain. … and so on.

Based on surveys by the Raw Materials Group (1990, 2002) in Stockholm, of the top 50 mining companies in the western world that existed in 1990, only 33 of these survived to see the new millennium, with the other 17 being taken over or broken up. The authors estimate (September 2003) that a further 5 of the original 50 companies have since been acquired and 5 of the original companies have significantly slipped in their rankings – meaning that presently only 23 of the original 50 companies in 1990 are still in the top 50 list today. Of these 23 companies, 9 are state-owned enterprises.

Whilst metals have an assured place in the future, the high attrition rate clearly shows that within the present industry structure, companies are struggling to survive. As a result, the focus is on short-term profit objectives, that adversely impact on how companies treat long-term high-risk investments in R&D and exploration.

Figure 1 : Long Term Trends in Real Metal Prices : 1800-2000



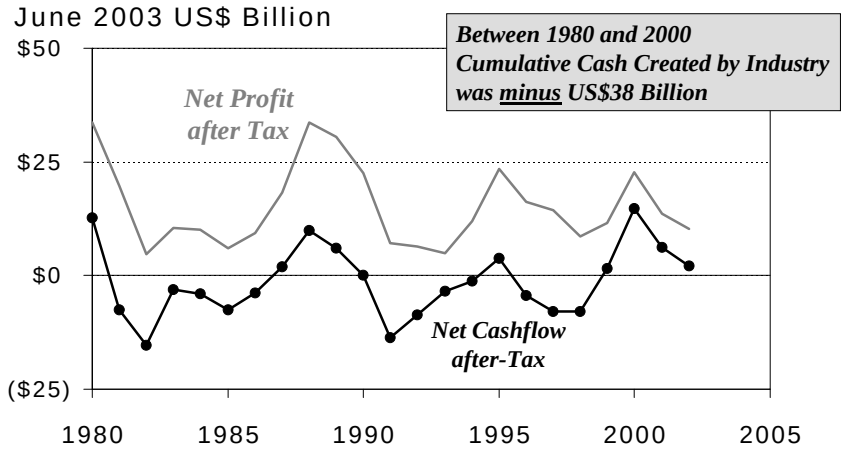
Source : JB Were 2001

Declining Value and the Economic Cycle

Over the last two hundred years, commodity prices have fallen in real terms on average by 0.6% pa, Figure 1 (J B Were 2001). Superimposed on this downward trend are shorter cyclically movements – the boom/bust of the industry.

One is forced to wonder whether this can be maintained in the longer term. An evaluation (MICA-CRU, 2003) of the financial performance of 262 major non-ferrous and precious metal mining companies over the last two decades, Figure 2, shows that the industry only generated surplus cash in seven out of the last twenty years, and that over the period 1980 to 2000 the industry had a cumulative cash deficit of US$38 billion.

Figure 2 : Trends in Profits and Cashflows for Western world non-Ferrous and Precious Metals Mining Industries : 1980-2002



Source : MICA-CRU 2003

The fundamental problem is that the industry is capital-intensive and has long lead-times to find mines and build new capacity. It is also reluctant to shutdown marginal operations. The lack of supply-side flexibility, coupled with rapid changes in demand leads to large swings in commodity prices. The industry has tended to over-build, resulting in extended periods of mediocre prices and low profitability. The challenge for technologists is to develop ways of lowering costs (both capital and operating) and improving the industry's flexibility to break out of the traditional boom-bust cycle.

Societal Expectations

Not only has the economic landscape changed but society's expectations with respect to the exploitation of the earth's riches has also changed. Despite the boom-bust cycle of the minerals industry, which might otherwise hinder the development of technologies leading to environmental significant performance improvements, the industry has not been tardy in responding with responsible practices and auditable

reporting of environmental performance (La Nauze and Temos, 2002). As the industry has been generally a price taker not a price maker, it has passed on the benefits of lower costs to any customer as lower prices. Whether this was caused by market indiscipline or not, it has meant that consumers do not impugn the full "environmental" cost in their purchase and the potential for improvements beyond those which give high internal rates of returns through cost savings or increased revenue have been difficult to justify.

THE CHALLENGES TO MANAGING TECHNOLOGY

The Chief Technology Officer (CTO) must operate within this challenging and changing milieux. This section outlines some of the challenges and the responses being exhibited throughout the industry.

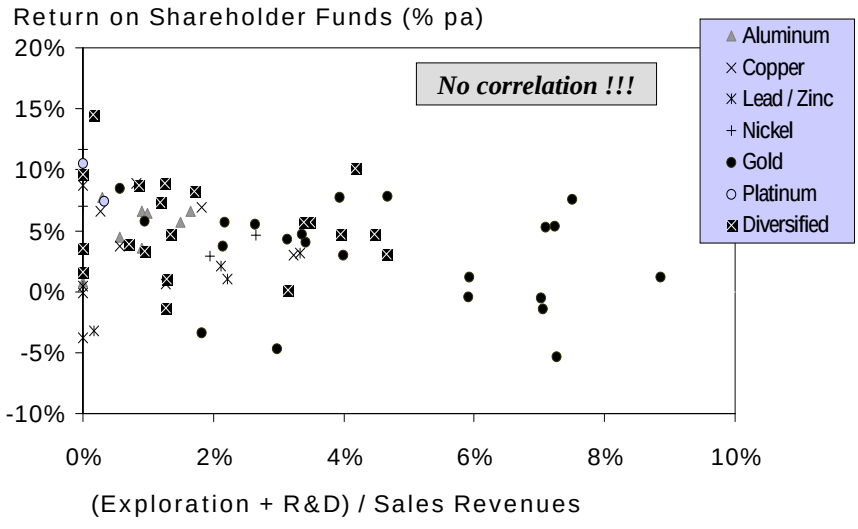
CTO's biggest challenges

The annual survey of Industrial Research Institute members asks Chief Technology Officers what are the "biggest problems" facing technology leaders. The IRI membership is representative of a wide cross-section of US industry although it has only small representation from miners and primary metal producers. Despite tightened economic circumstances, the 2003 IRI survey had "growing the business through innovation" as the CTO's top priority. At the same time, the data also suggests that IRI membership have aligned their technology planning with their business strategy.

For the IRI membership growing the business through innovation is consistently a long way ahead of balancing long-term/short-term R&D objectives which some would say was the mineral industry's current concern. In the mining industry, where the absolute industry sector size is stagnant and products are not significantly differentiated, the CTO does not have such a clear mandate.

Such a mandate would be clear if there was a demonstrable link between profitability and spending on R&D. Unfortunately definitive proof of this relationship is elusive. Recent data, Figure 3, (MICA-CRU 2002) of the average combined level of expenditures on exploration and R&D as a proportion of sales revenue of 88 large mining companies showed no correlation with return on shareholders funds.

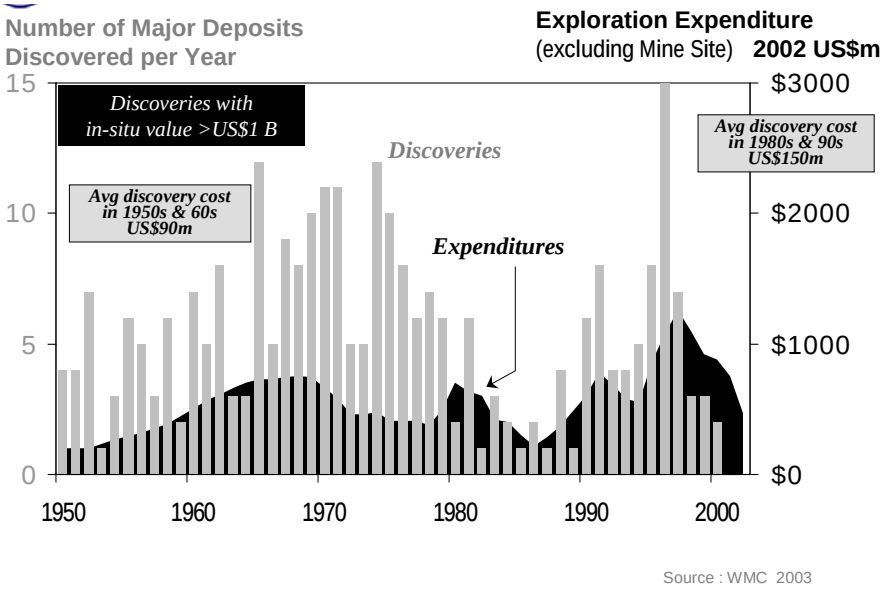
Figure 3 : Relationship between the level of Expenditure on Exploration and R&D versus Return on Shareholders Funds for Various Sectors of the Western World Mining Industry : 1995-2000



Source : MICA-CRU 2001

Recent studies (Schodde 2003) on the exploration expenditure and discovery rates of the mining industry indicate that that the industry has performed poorly in recent years, Figure 4. While the rate of discovery of major deposits (with an in-situ value greater than US$1 billion) has remained fairly constant over the last 30 years, the amount of spent (in constant 2002 dollars) on finding them has risen significantly. In the 1950s and 60s the average cost per major gold or base metals discovery was U$90 million. By the 1990s this had risen to around US$150 million for a major base metals discovery and US$290 million for a major gold discovery.

Figure 4 : Expenditure and Discovery History for Major Base Metal Deposits found in the Western World : 1950-2000



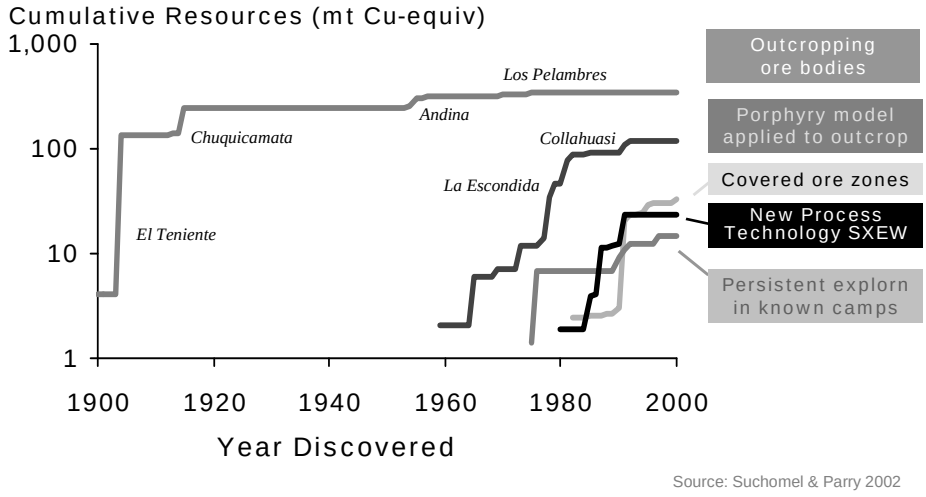
The factors behind the decline in exploration performance are complex. Even so, there is a widespread view that "all the easy, out-cropping, deposits have been found" and that the next generation of discoveries will require searching for them under deep cover. This is expensive and difficult. It is argued that it is the mediocre discovery performance of the industry that has led to the recent decline in western world exploration expenditures of 72% in real terms between 1997 and 2002 (MEG 2002). The best way to turn this situation around is to be much smarter at how and where we explore. Technology has a key role to play in making this happen.

This phenomenon is not restricted to the minerals industry. Fewer new drugs are reaching the market each year. This is in spite of a 12-fold increase in spending (in real-terms) on R&D by the US Pharmaceutical Companies. According to the head of the biotechnology consulting arm of Ernst & Young (Crocker 2003), the problem with the pharmaceutical industry is that "it is simply more difficult to produce new drugs. All the low hanging fruit has been picked and a treatment found for many of the simple illnesses." These concerns echo the same challenges faced by the mining industry.

We speculate that the minerals industry CTO's biggest problem is convincing and continuing to convince, the CEO that investment in technology stacks up well against other demands on company resources. Unfortunately, major new discoveries and projects are scarce and take time to come to fruition and the industry is facing increased mineralogical complexity requiring technical advancements for their discovery and exploitation.

Notwithstanding this, new exploration concepts and technologies can re-invigorate a mature exploration district, such as Chile (Suchomel and Parry 2002). For instance, the development in the 1980s of the solvent extraction electro-winning (SX/EW) process for copper oxide ore, Figure 5, made it possible for the industry to economically mine a new class of copper ore bodies. More recently, major advances in block caving has seen a 70% reduction in the capital cost/tonne mined, further pushing the boundary of exploitable copper ores.

Figure 5 : Cumulative Number of Tonnes of Copper Metal Found in Chile using different Technologies and Exploration concepts : 1900-2000



Source: Suchomel & Parry 2002

Witherly (1994) suggested that there is an early mover advantage for those companies who adopted various new types of airborne electro-magnetic systems. He speculated that introduction of a new system typically leads to significant discoveries within a few years. However, such related technologies are often competing for the same family of targets and consequently the individual technologies quickly become obsolete as better systems are developed. It will be interesting to see how many discoveries can be attributed to the recently launched Falcon airborne gravity gradiometer and whether it can adapt to compete with the next generation of airborne systems already emerging into the market place. Experience indicates that the mining industry is very quick to pick up on such innovations. Indeed a strategy of not being a developer but rather a rapid and innovative user is often adopted.

Dry et al (2002) have analysed why so few iron direct smelting technologies have become commercially viable. They conclude that:

1. The time-scale for developing this type of technology is more like 20 years than the 3-5 years typically assigned for the initial campaign and patience runs out
2. For successful development there is no way of avoiding a large expensive pilot plant phase
3. If the underlying motivation is not both strategic and strong enough to counterbalance the risk and cost of the exercise, don't do it.

R& D Strategy

The A D Little book, *Third generation R&D* (Roussel et al 1991) had a major influence on large company approaches to the management of technology. At that time most research and development undertaken by minerals companies either internally or by contract was short term and *ad hoc*. It was rarely undertaken within the context of a technology strategy, which, in turn, ought to have been part of the company's business strategy. During the mid 1990s, as attention switched to developing a portfolio of projects closely aligned to the business, large mining houses went about major downsizing of their technological and exploration efforts. For example, BHP and Rio Tinto both closed major in-house laboratories; Alcoa reduced staff in its Pittsburgh complex. Exploration groups in BHP, Rio Tinto, WMC and many others were significantly cut back.

But smaller may mean smarter. At least now there is significant alignment of exploration and technology strategies with the company business strategy. Companies, facing rising costs, are shifting to improvements addressing short-term needs and brownfields expansions at the expense of greenfields exploration or development. In today's environment, most minerals companies have a clear strategy for technology, even if this is to focus on the short-term. Such a technology strategy requires a clear understanding of the company's core competencies and core technologies, an objective assessment of the company's competitive position in those competencies and technologies, and strategies for maintaining and enhancing these capabilities preferably under a portfolio management approach. The risk is that a short-term approach does not create opportunities to develop major new businesses for the company.

Most importantly, indeed probably the single most important factor for successful technology management is the commitment from the senior management of the company.

Three horizons for R&D

Three horizons of company growth can be defined (Baghai et al, 1999): Horizon 1, extending and defending core businesses, Horizon 2, building emerging businesses and Horizon 3, creating viable options. The authors argue that all three horizons must be managed and that each requires a different focus and performance measure. How minerals companies do this in a market of stagnant size is a matter of conjecture.

Companies will range across these three horizons in terms of emphasis/expenditure, strategy and structure. In 2001, WMC undertook a survey of technology development within a peer group of mining companies. Some companies indicated a prime focus on incremental improvement (Horizon 1) and were unlikely to sink large capital into speculative projects. However, others were willing to make significant commitments to step change projects (Horizon 3) on the basis of achieving significant competitive advantage. For example, BHPBilliton has invested heavily in airborne gravity gradiometry (Falcon) and biotechnology (BioNIC, BioCOP, etc). Rio Tinto, in addition to significant investment in direct iron making (HIsmelt), saw their competitive advantage in the rapid identification and adoption of emerging technologies and the effective transfer across the operations.

It is not necessarily only the big players who are making breakthroughs, for example, Phelps Dodge in heap leaching of low grade copper ores, Inco in nickel carbonyl technology and WMC in the application of automated underground vehicles.

There have been many changes in how companies structure their technical effort over the last thirty years. Rubenstein suggests that these are "not always in the direction of improving effectiveness of the R&D/innovation and not always to the benefit of the firm" and may be more influenced by the boom-bust economic cycles. However, a rational approach based on the three horizons for growth would be to

structure and manage technical developments according to the strategic emphasis placed by the company management on each horizon, its size and available resources and the 'life' of their deposits.

In addition to the strategic positioning taken by the company in their markets, the key determinants for internal technical delivery ought to be (i) the size and extent of the operational activities and whether these cover one or several commodities, (ii) the nature of each commodity market and the extent of vertical integration within the company and (iii) technological complexity associated with the commodities.

The pressures created by the operational structure of the business can have important influences on the technology function. For example:

- Operational unit task orientation towards "return on capital" and simple "cost reduction" targets unduly discourages spending on technology support and development.
- Short-term time horizons in business plans and excessive focus on current year budgets can impact on the long-term creation potential of technology development.
- The tendency for business unit structures to inhibit "share support" and cross-unit technical transfer.
- The remoteness of some operational sites and efficacy of internal career path development will affect the ability to retain and motivate technologists

More important than structure is the processes by which the technology function is driven by the company's strategic plan and business imperatives and how it is efficiently managed to maximise potential gains across the three horizons.

GETTING AND RETAINING TALENT

In Australia, the Minerals Tertiary Educational Council has expressed concerns over the declining numbers entering tertiary institutions in traditional mining/minerals industry related disciplines. Whilst numbers entering the profession have a stochastic character and company operational efficiencies have reduced demand, the Council predicts that significantly reduced numbers of mining and metallurgy graduates and post-graduates will be available to enter the workforce over the next few years.

In Australia, competition for funds within the University system has placed great strains on small departments whose student numbers fail to reach funding quotas. If the industry is not careful, we will wake up some day and find that all university departments of metallurgy and mining are gone.

However, of potentially greater concern to the minerals industry as well as most other technology-based industries, is the significant decline in the quality of science education and learning within the secondary schools system in Australia. This is a worrying trend, as Australia with South Africa, USA and Canada represent a significant proportion of the graduate base entering the minerals industry.

If recruitment trends continue and the market forces do not reverse the availability of supply, most companies will need to grapple with recruiting and retaining key technical talent. In 1997, Woodall (1997) in his keynote address to the AMIRA Conference outlined the common links in the chain of intelligent management, which are fundamental to remaining profitable.

> *"The links in the chain are effective interdisciplinary communication, knowledge, vigilance, motivation, trust, perseverance, professional leadership, teamwork, vision, freedom, delegation and a caring management."*

With the predicted tightening of the supply of new talent, a company's ability to successfully undertake these linkages will be severely tested.

CONCLUDING REMARKS

Looking back more some forty years one can see nothing but change; changes mostly for the better. Solutions to challenges arising from such change have required greater ingenuity with time. These challenges have been met by adaptation.

Technologists and their managers have a better understanding of the company's needs, they are better prepared with the management and technical tools to develop different solutions; knowledge management tools and the computer has connected them to a plethora of resources.

But the industry is lagging in the competition for talent. It is not engaging sufficiently in the debate which channels key government resources into education and research institutions, it is too willing to sit back. When the crisis caused by the lack of capability emerges, recovering the situation will be long and painful as high-class educational institutions, which give birth to such talent, take years to develop.

If the industry addresses this issue, it will have the talent to continue, maybe accelerate innovation in the mining and minerals industry to the benefit of our shareholders and the community.

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ACKNOWLEDGEMENT

The authors are grateful to WMC Resources Ltd for permission to publish the paper. The views expressed are those of the authors alone.