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Mining Economics

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Introduction

The economics of mining at an inflection point.

For the last decade or so our focus has been on developing mines and bringing them into production. Demand has outstripped supply, and commodity prices have reflected this. In this world, the winners have been the ones who moved into production early; benefitting from uninflated construction costs and high margins.

Now supply is coming into balance with demand, and will probably overshoot. Competition will drive commodity prices lower. It is not *production* on its own that is important, it is how efficiently we can produce.

In this changed world the winners will be the ones who understand the economics of their mine and can adapt and change to maintain and improve these economics.

My objective with this presentation is to map out the economics of mining and the implications of this change.

The presentation is in two parts:

1. What is different about mining, and mining investments, *and*
2. What we will have to do differently in this new economic environment.

My message is definitely a challenging one. Inefficiencies that can go unaddressed in an environment of rising prices become all too evident in an environment of declining prices. Profits can no longer be taken for granted. However it doesn't mean that we can't achieve healthy returns.

What is Different About Mining?

Mining has been undertaken around the world for thousands of years. Everything in existence, at least initially, has to be either grown or mined. Our high standard of living today is totally underpinned by the products of mining. But the success of mining from a production perspective has not always been matched by success from an economic perspective.

Indeed, poor economic success was a characteristic of mining more than 230 years ago when Adam Smith penned this description in his famous work *The Wealth of Nations*

> *Of all those expensive and uncertain projects, however, which bring bankruptcy upon the greater part of the people who engage in them, there is none perhaps more perfectly ruinous than the search after new … mines. …. Projects of mining, instead of replacing the capital employed in them, …. commonly absorb both capital and profit. (Smith 1976 [1776], p. 562)*

The high returns that many companies in our industry have enjoyed over the last decade suggest that there may be a permanent break from this historical trend. Alternatively, perhaps the biggest, most sustained boom in a century will be followed by the biggest bust in a century? My view is that neither outcome is set in stone. My view is that if we understand the industry economics and how this fits in the environment we operate within – and make decisions accordingly – we can expect a healthy future for our industry.

What is different about the mining industry compared to other industries?

I highlight 5 characteristics of large scale mining that are different to most or all other industries:

1. Every mine is different, because every orebody is different.

2. Mining is a Capital Intensive Industry, with High Sunk Costs
3. Large scale mining requires continual injections of capital, even to maintain production
4. Knowledge is High Cost. Decisions are made on imperfect information.
5. As a primary industry, returns are very sensitive to Booms and Busts

Unique Factor of Production – the Orebody

The economics of every mine are set in place by the orebody.

Very few industries are in this situation. For example, in manufacturing a small scale supplier cannot hope to compete with a global supplier of the same product, because the global supplier enjoys economies of scale.

In mining, this relationship is a much weaker one. Even small scale mines can compete in the world market for supply of minerals if the orebody is sufficiently rich. There may be several, quite different ways to exploit an orebody. The best way to exploit an orebody may change dramatically when the selling price of the commodity changes.

High Sunk Costs

Many industries are capital intensive. Where mining differs markedly from most other capital intensive industries is in the proportion of this capital that is "sunk."

The airline industry, for example, is also quite capital intensive, with high fixed costs and low variable costs. However in the circumstance of overinvestment and overcapacity, corrections to industry structure can readily occur. The aircraft can be sold and flown off to enter service somewhere else in the world.

In the circumstance of overinvestment and overcapacity, the owners of a mining investment cannot do the same. If you have invested $250 million in a shaft to access the orebody, the second-hand value of this shaft is not very much. The proportion of capital that is "at risk" is much higher. This "high sunk cost" characteristic means that we have to be particularly careful in our investments.

In the event of over-investment or badly understood investments ill-informed operators will certainly lose money. However, more importantly, everyone else in the industry will also suffer, due to the impact [of these bad investments] on industry structure.

If too much production is brought on-stream and the demand doesn't materialize, commodity prices will fall dramatically. All operators in the industry will lose money. Of course, as with other industries, the least competitive producer will go out of business. But here the difference between mining and other industries is stark: industry structure will not be restored because the assets of the company that goes out of business fall into the hands of a new owner who continues to produce. Supply is not reduced. Commodity prices will remain low until industry structure is finally restored through equipment wearing out, mines getting deeper, and demand growth.

The seeds of the next bust in the mining industry are sown through unwarranted investment in the final stages of the boom part of the cycle. This is the phase of the cycle that we are now in.

Continual Injections of Capital?

One reason often cited why investors dislike investments in mining is the need for continual injections of capital. In this section I will explain why this is so.

Consider a simple open pit coal mine:

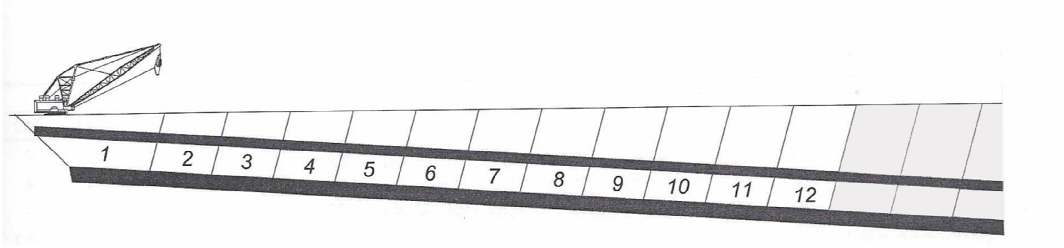

Figure 1 – Mine Designed to Exploit Economically Viable Reserves

In this deposit, as in most deposits, mine planning engineers could easily design the mine to be constant, year-in-year-out. But we normally don't design this way because a schedule such as this would be sub-optimal from an economic perspective. It is more economical to start at the shallow end and mine towards the deep end. Not only does this provide faster earlier cash flows, but it also leaves open the option to extend the mine deeper over time as better, more cost efficient technologies are developed.

An alternate schedule is to hold the amount of overburden removal equipment constant. However such a schedule will result in declining coal production rates and lower utilization of all downstream capital (capital that is associated with [coal] output). This too is sub-optimal from an economic perspective.

In practice the mine scheduling for even fairly simple mines is a complex process, balancing technical requirements (production rates, blending constraints, and inventories) with equipment utilization and capital requirements over time. Mine scheduling incorporating mining economics is one of the key technologies that *Runge Limited* has developed and is known for through our 35 years in this business.

"Delayed capital" requirements should not be any drawback to mining investment.

However in the face of declining commodity prices, a strategy to delay some capital investment until later in mine life – with the view to funding part or all of it out of cash flow – can rapidly unravel.

With declining commodity prices, initial mining is still likely to be profitable – it just will not generate the high cash flows expected. Thus the ability of the mine to finance a high proportion of the delayed capital requirements is severely impaired. Yet additional investment is still warranted and needed, because if it is not proceeded with the return on the initial investment will become even worse! This is not a good environment to find oneself in!

Maximizing return on investment in an environment of declining commodity prices, and correctly anticipating the actions and reactions of all participants is a non-trivial task. Addressing these issues only when commodity prices are low, and the need for additional capital is urgent, is not a recipe for achieving the best returns from a mining investment. The time for examination of these scenarios is now when most mining companies have healthy cash flows (or, at least, healthy *planned* cash flows) and reasonable access to capital.

High Cost of Knowledge

[this section not included in presentation due to time constraints] This issue was already touched upon in the previous section, where I noted that one objective of mine planning is to schedule production from the deeper, more complex parts of the mine for later in the mine life. In that section I showed how this made economic sense: if the deeper, more complex parts of the mine are better understood – which they will be after the mine has been in operation for some time – then the risk is lower and the cost of capital commensurably lower. I now expand on this further to illustrate why from this perspective mining operations and mining investments are different to other kinds of production operations and investments.

Every industry, including mining, has to face uncertainty prior to the investment decision; it is the *nature of the uncertainty* that sets mining apart. A tourism investment, like a mining development, for example, might be subject to the vagaries of the weather, but no amount of study beforehand will necessarily resolve the uncertainty.

What sets mining investments apart from most other investments is that the economics of resolving the uncertainty are both significant, and endogenous to the investment process.

Except in rare circumstances, it is not possible to optimize a mine plan in advance.

The problem lies in obtaining reliable input data. Drilling out an orebody is expensive. Optimizing something at the feasibility stage requires comprehensive knowledge of the whole orebody – even parts of the orebody that may not be mined 10 or 20 years into the mine life or perhaps never mined at all. The present value (cost) of obtaining such information, perhaps decades before the ore will be mined, can make the whole mine unviable.

In practice the decision-making process is an iterative one. A small investment in knowledge (drilling, sampling, testing) can be sufficient to justify an investment in additional knowledge. The initial focus for this investment in knowledge is on parts of the orebody likely to be mined in the early years of mine life. Nevertheless, these costs mean that at some point, prior to commitment, planning engineers have to make a judgment that the reduction in risk associated with additional work doesn't yield benefits to offset the additional cost.

In times of high commodity prices mines may be economical to start at production rates substantially less than their optimum rate. This allows the mine to be started at lower rates and lower capital requirements, with uncertainty resolution delayed until after the mine is in production. When the mine is in production uncertainty resolution can be addressed at much lower cost.

Sensitivity to Booms and Busts

[this section not included in presentation due to time constraints] Mining is at the very start of the production chain. The products of mining find their way into both consumer goods and as an input to capital investments needed to make other capital goods and other consumer goods. When *retail* sales reduce by 5%, the next level down in the production chain also suffers a 5% reduction in demand as well as a short term additional reduction in demand due to inventory draw-down.

At the bottom of the production chain is mining – multiple levels down, and supplying commodities to the widest cross-section of the economy, but suffering the largest reduction in demand in any down-turn.

Where are we at in this cycle? This is a topic too broad to cover in a short paper, however I am cautiously optimistic that we in the mining industry are substantially through the worst impacts of the recent cycle. I mention this here because many commentators see the further risk of commodity price falls being due primarily to further weakness in demand due to the global business cycle. I do not share this view. My view is that, yes, we are at risk of further commodity price declines, but the cause will be supply growth outpacing demand growth, not any significant unanticipated drop in demand.

What we have to do differently

For the last decade or so our focus has been on developing new mines and bringing them into production. Now, with deteriorating commodity prices our focus has to change. What should our priorities be, and how should we be conducting our affairs to maximize our returns as we make this transition?

This is also too big a topic to cover in just a short paper, so I will focus on just two aspects:

1. Understanding Orebody Characteristics, and
2. The priorities for Long Term Mine Planning

Understanding Orebody Characteristics

Earlier I said that the economics of every mine are set in place by the orebody. Orebody characteristics can be understood in two dimensions:

1 What is *physically* in the ground (Quantity, Shape of Reserves, Grade Characteristics etc.), and

2 The *value* of the orebody.

When mining companies quote reserve estimates, they are largely quoting how much ore is physically in the ground. To quote ore as "reserves" (rather than as "resources" or "mineralization") the geologist has to be satisfied that extraction could reasonably be justified, but apart from this, published reserve estimates say little about economics. "Ore reserve" definitions are standardized to some degree, with the Australian "JORC" code and Canadian "43-101" definitions (quite similar) being commonly used.

Understanding the *value* of the orebody is a much more complex task requiring synthesis of technical skills (mining engineering, metallurgy etc.) as well as economic skills.

In the balance of this section I provide an example of how "real" reserve estimates – that is, what is economically viable – can change dramatically with changing economic conditions.

Consider for example the two-seam coal mine previously shown in Figure 1. Assume that at (say) $120/tonne almost the entire reserve shown is economically viable (i.e. excluding the shaded areas). An optimized reserve will draw the pit limits at the deep end where the marginal cost equates to the marginal revenue. When calculating these marginal costs a certain type and size of mining equipment will be assumed. For example, larger equipment will generally move material at a lower cost than smaller equipment. Perhaps under this scenario the reserves are sufficient to support a mine life of 15 years using the bigger equipment.

Now, using the same *cost* structure, consider the new case where the coal selling price falls to (say) $80/tonne. The reserves will reduce.

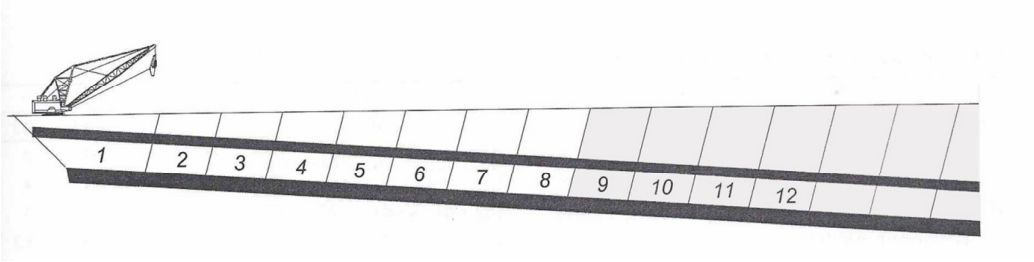

Figure 2 –Economically Viable Reserves reduced with Decline in Commodity Price

However a mine developed to exploit this reserve might have to be mined at a lower production rate to maximize return on the fixed capital. At lower production rates, smaller mining equipment must be used. Smaller equipment has higher operating costs. So the "economic" reserves shown in Figure 2 (unshaded parts) are not valid reserves. The estimate must be re-calculated applying the operating costs appropriate to the mining method – that is, smaller equipment. Figure 3 shows the additional reduction in mineable reserves consistent with this smaller rate of production. In this scenario, only the unshaded parts are economically viable – a dramatic reduction from the original assessment.

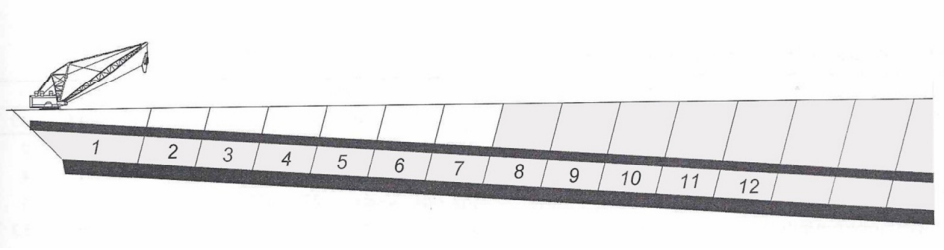

Figure 3 –The Vicious Circle on Reserves with Decline in Commodity Price

In this example, the decline in commodity prices results in a vicious circle of challenging economic viability – the economics of the mine suffers not only from the declining commodity price, but also from the reduced mine life and increased mining cost resulting from the smaller reserves. Not all deposits are like this however.

I stated at the introduction to this presentation that "the winners will be the ones who understand the economics of their mine and can adapt and change to maintain and improve these economics". A key element in change and adaptation comes from the orebody. If it can be mined in some totally different way without sacrificing efficiency then this might be the key to surviving and prospering in a different economic environment.

Priorities for Long Term Mine Planning

For the last decade or so, economics has taken a back seat in prioritizing inputs to new mine development. If even an inefficient mine is very viable because of high commodity prices, it is hard to prioritize efficiency. This is true provided planned production outputs are achieved, thus "Production" has been the economic imperative. An entire generation of operators has gained their formative professional experience in the production battlefield not the efficiency battlefield.

Now the industry faces the efficiency battlefield. How can we best make the transition?

If history is a guide, serious action to address efficiency issues only comes about when the operator is losing money. Frequently "efficiency" indicators are not in place to guide decisions. "Tonnes produced" is easy to measure. "Opportunity Costs" *cannot* be measured. "Marginal Costs" are a planning tool to help us make

better choices, and although they can often be calculated they too cannot be measured. If you belong to the school of thought that says "if you can't measure it, you can't manage it" then the transition into this new era is going to be a difficult one.

My recommendation for prioritizing resources in this new era is to start with a [new] long term plan focussed on economics, and developed on the basis of lower commodity prices (much lower than today). Such a plan serves two valuable purposes:

1 It immediately prioritizes short term plans towards better long term outcomes in the event of unexpected commodity price declines. Management focus remains on importance rather than urgency, and

2 It highlights in advance essential capital requirements for needed change and adaptation. It allows necessary financial resources to be addressed now when more options are available, rather than when the commodity price decline happens and capital markets freeze up.

Conclusion

I warned at the start that the message in my presentation would be a challenging one. However my message also defines my mission: if, at this stage in the commodities cycle we are alert to the economic issues, and we condition our decision-making accordingly, then the worst effects of down-turns that have harmed us in past cycles can be avoided. Specifically I am referring to avoiding overcapacity and excess supply, and ensuring that when change occurs we are best equipped to adapt. Over the last 35 years *Runge Limited* has worked closely with many of the major mining houses to help them understand the key economic drivers of their operations and to help them increase efficiency in their mines, and this remains our primary mission.

The time for planning for change is *now* when our cash flows are sufficiently strong and our options numerous. If we embrace this new economic environment before we are forced into a reactive response we will emerge as a stronger, more efficient, and still-profitable industry.

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