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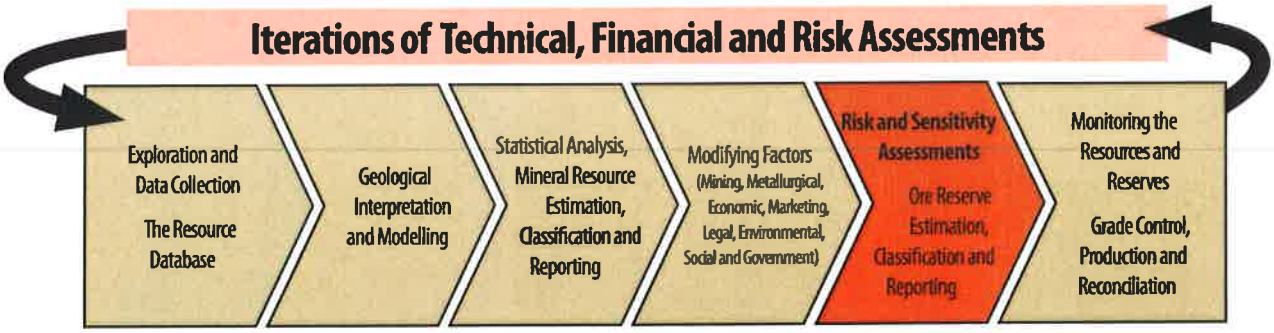
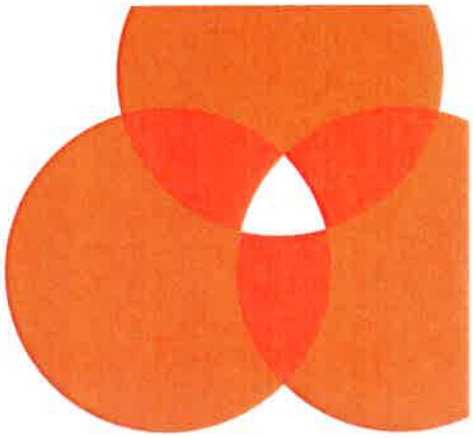


Chapter 7 | Risk in Resource and Reserve Estimation



Back to Basics – Geological and Mining Risks and Financial Issues on Resource and Reserve Evaluation in Coal Projects

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ABSTRACT

Despite all the effort and cost that goes into producing a Competent Person report (also known as mineral expert report), it is disheartening to realise that most recipients concentrate on very few pages in the final offering (the finance section) and usually just two figures: total Reserves and the valuation. Often, it's only the last figure. This is disappointing since there is usually much of value in every section, whether it is on geological risks, recommendations for productivity and processing improvements, underlying control factors on improvements, possible environmental and social issues impacting on the performance of the operations and any other issue highlighted in the main body of the expert report. As the underlying evaluation is generally based on internationally accepted codes such as JORC, Competent Persons almost always put additional caveats or, more importantly, warnings of potential pitfalls for deposits they evaluate.

Recent write-downs of assets by mining companies have indicated, yet again, the need for attention to all details in these reports. A regular independent review of performance and key figures relating to an ore deposit can be vital in preventing such financial disasters. International Financial Reporting Standards (IFRS) – a framework that enables company accounts to be comparable across international boundaries – requires that the evaluation of assets is undertaken annually. Few companies complete an independent evaluation every year and many never at all, using internal staff to complete evaluations. Yet this simple analysis can usually be independently completed quickly and at low cost, especially if the same individuals outside the organisation who become familiar with operations are used each time.

At the same time, there is a need for the industry in general to understand why and how financial analysis is carried out. This paper tries to address some of the fundamentals in current thinking on geological and mining risks and the consequent financial analysis of Resources and Reserves and their reporting internationally.

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INTRODUCTION

Globalisation of economies and technological advancements around the world have made many mining projects more easily accessible to international companies from both a production and financing point of view. As the financial rewards can be lucrative especially in the frontier areas, there are many incentives to bring these projects into production and transfer the products from the ground to end users in a timely manner. For this reason, all parties with a vested interest in a project want to know the quality and the quantity of the Resources and Reserves available for the project so that cash flows and profit and loss can be determined for future years.

At this point, standardised reporting for Resources and Reserves becomes an important issue for all interested parties since the mining projects, like any other, will have underlying risks associated with them. There are several international codes setting out the minimum standards, recommendations and guidelines for Public Reporting of Exploration Results, Mineral Resources and Ore Reserves. Considerable progress has been made towards the widespread adoption of consistent reporting standards throughout the world as a result of the work of the Combined Reserves International Reporting Standards Committee (CRIRSCO). These are embodied in the standards published and adopted by the relevant professional bodies in Australia, Canada, South Africa, United States (USA), United Kingdom (UK), Ireland and many European countries. Those countries around the world that do not have an internationally recognised reporting standard look to CRIRSCO to supply the guidelines.

Reports prepared by a Competent Person as defined by these codes aim to bring Transparency, Materiality and competency into the reporting process. In addition, significant responsibility is placed on the Competent Persons as they need to address certain criteria to reach the Mineral Resource and Ore Reserve estimate as defined by the Codes. Competent Person's reports (CPR) are comprehensive public documents defined by the JORC Code for any given deposit and can highlight underlying geological, mining and process-related issues in detail. It is disheartening, however, that despite all the cost and effort that goes into producing a Competent Person's report, recipients sometimes only concentrate on a few pages (the finance section) and two figures in the final offering: total reserves and the valuation; often it's just the last figure. In the following sections, the

underlying risks and their importance in any Resource and Reserve evaluation will be revisited, looking at the evaluation process from a holistic view based on the authors' experience undertaking different assignments in various countries worldwide.

GEOLOGICAL AND MINING RISKS

Anyone who is interested in investing in a mining project should ask three fundamental questions:

1. Is the quantity and quality/grade of the raw commodity in the ground?
2. Can it be extracted?
3. Is it worth extracting?

When all these questions are answered positively, the fundamentals of the project are, in principle, said to be in place; however, risks associated in winning the raw commodity can be influential in determining the final outcome.

Project risk can be defined as the chance of something happening that will have an impact upon objectives. In other words, risk is the possibility of something occurring that will negatively impact the viability of the project. In any mining operation whether underground or surface mining there are multiple risks that may cause significant loss of life, loss of equipment or damage to machinery (potentially costing tens of millions of dollars to replace or repair), loss of production and income, as well as serious damage to the environment.

Like any other risk assessment process, it is important to know all parts of the project site to ensure that all parties involved both at a technical and economic level understand the potential risks and there is a reasonable level of control to avoid unpleasant consequences. For this reason, CPRs aim to relay these risks perceived by either the Competent Person or the project owner to third parties. Once the risks are identified and relayed in a narrative format, they can be measured in terms of likelihood and consequence by the project evaluators internally. Risk assessment may range from a simple matrix (Table 1) to complex calculations that may be specific to the internal rules and experience of the company undertaking the risk assessment for the specific project; however, one aspect will be sought by all risk assessors: mitigating factors against any perceived risks determined. Risk control or mitigation often involves limiting the exposure of risks or hazards. It is important that control measures are considered in the order providing the greatest effect.

TABLE 1
Evaluation of risks.

Risk rank = consequence × likelihood					
	Likelihood				
Consequence	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost certain (5)
Insignificant	1	2	3	4	5
Minor	2	4	6	8	10
Moderate	3	6	9	12	15
Major	4	8	12	16	20
Catastrophic	5	10	15	20	25

Low risk Medium risk High risk

In practice, it may be necessary to use a combination of approaches to control a risk. A CPR may address these risks and mitigating factors at the same time to highlight potential issues challenging project operators. Mitigation usually involves eliminating the risk altogether; substituting the risk with something less risky; isolating the risk; engineering to reduce the risk and managing risk to lessen the exposure. Still, safety and all forms of risk mitigation must be the priority for all concerned.

The typical CPR is usually compiled by a number of experts from different disciplines and includes several headings on geological, mining and other risks associated with the project; further, it should endorse and reflect the transparency principle as described in international codes such as JORC. These risk analyses may also include discussion on risk strategies to mitigate their negative impact on the project. When converting Resources into Reserves, the so-called Modifying Factors – which include mining, processing, metallurgical, infrastructure, environmental, social, marketing, economic, legal and governmental considerations – also need to be taken into account.

Information may not be easily apparent or obvious to the untrained reader of a CPR, or its impact may not be comprehended immediately; however, what's important is that such risks are openly disclosed wherever possible so that decision-makers can understand them and make an informed decision regarding the project in question. For example, the 'Table 1 Checklist of Assessment and Reporting Criteria' (checklist table) in the 2012 JORC Code is a great help for the Competent Person to approach all these risk issues in a methodical way.

In order to give a clear understanding of what the possible geological and mining risks are in Resource and Reserve assessments, the following list has been chosen from coal mining operations. This is due to the combustible nature of the raw material associated with naturally occurring explosive methane content, but the underlying principles are also applicable to other mining commodities.

Reliability of data

Competent Persons must inspect all available data presented for their assessment of the deposit and satisfy themselves that the data generation and management process used in estimation of Resources and Reserves is acceptable to international standards. The checklist table of the JORC Code gives a list of documents and processes to be checked by the Competent Person. Although this list is quite comprehensive, the Competent Person still needs to check any for other relevant documentation not in the list. In many instances, data generated from past studies may not be traceable, reliable, repeatable or reproducible. In such circumstances, data can be dismissed and declared unreliable and/or in need of confirmation by additional studies.

Structural or tectonic issues

Deposits that have undergone intensive structural folding and faulting could have a profound effect in mining operations. The obvious challenge is seam continuity as some coal deposits can be subject to unexpected faults of any size. These faults can delay operations and change the overall mine plans including scheduling and equipment selection, which can be extremely costly to implement in the end. Therefore it is important to know the structural framework in advance of

any mining operation so that the proper equipment and mine design can be put into practice.

Furthermore, jointing and fracturing may pose additional challenges in underground workings where roof stability can be an issue. In some operations, heavily fractured zones can easily cave in unexpectedly and threaten the health and safety of personnel as well as jeopardising the machinery performance.

Seam continuity

In coal deposits, it is very common to see coal seams thinning or splitting due to their plastic nature. Therefore it is important to characterise seam geometry in a deposit so that mine scheduling will take into account thick and thin portions of the coal where coal seams can be extracted in an optimum way. If the seam continuity is not well defined in the deposit, delays in machine operation and loss of volumes are inevitable.

It is also possible to encounter seams being regularly eroded and replaced by sandstone channels, called wash-outs. When this happens and it is not determined earlier, coal seam volumes may no longer sustain the operations and the mine machinery will cut a tremendous amount of rock, which will cause wear and tear in the equipment and shorten the life of the machinery. During these delays, no production will come from operations. This can skew cash flow projections for that period and put pressure on operations trying to perform financially in a manageable manner. The CPR will highlight whether the deposit in question has any association with wash-outs and seam splitting/thinning through documented evidence.

Seam continuity can also be disrupted by the presence of igneous dykes or sills in the coal deposits. When this happens, coal quality usually deteriorates and the coal loses its saleable character. Some deposits around the world can be heavily dissected by these igneous intrusions; therefore it is important to delineate the extent of dykes in the field by geophysical methods and other exploration tools. The Competent Person's report should highlight the presence and extent of these igneous bodies and their impact on the surrounding coal seams.

Coal quality

This is one of the most important aspects of any CPR as the requirements for coal quality in thermal or metallurgical applications by end users will be different for each coal grade and the coal price will be determined accordingly. The Competent Person's report should highlight any areas in operations where coal quality deteriorates and whether its extent is known by the project management team. Deleterious elements should also be well defined for the product coal. Discussion on any of the deleterious elements, if present, should be encouraged since related environmental and technological concerns can cause the product to be downgraded. Coal quality improvement and deterioration will also be reflected in the price, which can seriously affect cash flow projections.

In some deposits, significant rank variation in coal can be encountered. In addition to the natural rank increase with depth, this also happens when both dykes/sills and burial and uplifting of faulted blocks are present. Prime coking coals with vitrinite reflectance values (a type of rank indicator for coals) between 1.2 per cent and 1.4 per cent and with desirable coking characteristics generally fetch premium prices in the market. Coking coals with reflectance values above 1.5 per cent are generally less desirable for coking coal markets and can only be used as a blend improver in coal charges at the coke batteries. Otherwise, high pressures generated in the coke-making process may damage the coke oven walls and these can be extremely expensive to repair. If significant variations in coal rank are encountered at the deposit but this has not been anticipated initially, quantities produced from high rank areas may experience some market resistance in the future.

Hydrogeological issues

The obvious risk from the hydrogeological issues in any deposit is the occurrence of flooding. Underground and surface mining operations can experience ingress of groundwater or uncontrolled surface run-off, such as from flash flooding after heavy rains if protection measures in place cannot cope with the amount of water coming into the workings. Flooding can destabilise pit walls resulting in mine collapse and loss of life, assets and property. For example, the floods in Queensland, Australia a couple of years ago caused significant mining losses, which included an estimated loss of mining revenues of about two to 3.5 billion dollars.

A good measure to prevent water entering mines is initially to characterise the hydrological and hydrogeological conditions at the site and its surroundings, then to erect levee banks against flood and install a network of boreholes and pump stations at appropriate locations. These will be critical for the continuous dewatering of mining operations, eg at the working mine face. In the underground environment, water ingress through fault planes can also be a problem. Therefore, a good description of the hydrogeological characteristics and structural framework at the project site becomes a crucial step in mine operations.

Extreme atmospheric conditions (snow, frost, thaw, etc) particularly in cold locations can also cause intensive weathering. This leads to sloughing and collapse of slopes of the open pits, which can hinder production significantly.

The consequences of water ingress can be a very costly exercise for operations. Water must be pumped out of the flooded pits and workings, mud removed and levees rebuilt. Flooding of a longwall (a single, long coal production face) at underground coal mines can be particularly costly as the equipment cannot be salvaged in some circumstances.

Geotechnical issues

Tectonically complex deposits combined with incompetent lithology always pose challenges for operators in terms of geotechnical stability for ground and roof control, not only in the underground environment but also for bench and highwall control in surface mines. Therefore, it is important to delineate the structural and lithological framework where tectonic elements are appropriately characterised. Mitigating measures such as the use of roof and floor monitoring equipment and the use of roof bolting, anchoring, meshing/screening against any rock falls from the roof should be suitably implemented in underground workings.

At surface mines, slope stability of pit walls and in-pit and out-of-pit waste dump designs are one of the most important parameters for safe operations. For this reason, it

is paramount to undertake the necessary geotechnical studies in order to reach the optimum and safe pit design as well as appropriate pit slope profiles, with reference to bench separation heights and batter slopes. The CPR should ideally address any obvious geotechnical issue and identify potential risks that would hinder operations.

Spontaneous combustion

Spontaneous combustion is an oxidation process that occurs without an external heat source. Once the reaction reaches a critical temperature, it can eventually lead to open flame and burning of material. Due to its high carbon content, coal seams can be prone to spontaneous combustion in underground and surface operations.

Not all coals can be prone to spontaneous combustion. In underground mines, the primary cause of spontaneous combustion is crushed coal – either left in goaf[3] areas or in highly stressed pillars[4] – that is in contact with a sluggish airflow. On the surface, spontaneous combustion is usually associated with stockpiling of coal (or waste dumps containing rejected coal material) in unconsolidated heaps where oxygen can come into contact with the coal and heat cannot dissipate. Therefore, it is important to know whether the coal in the project is prone to spontaneous combustion through a vigorous testing program so that management can take the necessary precautions to prevent and reduce spontaneous combustion incidents. If such measures are not implemented, production loss or product loss where these incidents occur is inevitable.

Gas and coal dust issues

Gas occurs naturally in coal deposits and needs to be drained from workings through ventilation for health and safety reasons. The amount and type of gas present in coal is important to know so that appropriate design and equipment can be selected and implemented in projects. If inadequate ventilation is in place and coal dust is present, this becomes a dangerous cocktail. Coal dust and methane gas explosions can be a real threat to operations for this reason. Any large-scale explosions and consequent fires could result in fatalities not to mention financial losses as production would in all likelihood be halted for a considerable time. Damage to equipment/machinery would be very high.

Fire fighting in mines typically involves the general principles of control measures in fire fighting, namely reducing or eliminating oxygen from the process (control of ventilation, use of sealing agents, dozing over, buffer blasting, cladding of the highwall), reducing temperature and hence the reaction rate (use of water cannons onto the highwall and in front of the dragline and during coaling, nitrogen or carbon dioxide injection into workings including old workings) and removal of fuel from the environment (excavation of hot or burning material). The CPR should ideally address the issue of gas and comment how it is managed by the project owners.

Geothermal gradient

As some coal can be extracted at deeper horizons underground (eg 1400 m below the surface), the geothermal gradient may be an issue for operations at these depths. If adequate measures are not in place – such as a good ventilation system and/or air-conditioning units – the loss of lives and Reserves are inevitable as operating at these depths and under these hot conditions would be very difficult.

Seismicity

Earthquakes and mining-induced seismic events of sufficient magnitude can cause serious damage to mining excavations and supports and can be a constant risk to mining. In general, seismicity levels are higher at greater mining depths and consequently more damaging. This is also true for less elastic rocks. Even earthquakes with an epicentre far away from workings can cause roof collapse and damage mining machinery.

Seismic activity in mines can be monitored by using geophones, but these are largely a reactive measure to detect seismic activity; however, it is still a good practice to monitor such events and this matter should be mentioned in a CPR.

Subsidence

Subsidence can sometimes be an issue where mining operations take place in residential areas or under important surface infrastructure such as railways, bridges, monuments or public amenities (spas, creational parks, etc). Subsidence can be especially prominent in multiseam coal extractions where it can propagate in amalgamated format. Therefore, it is important to sterilise Reserves under such areas or, if it is permissible to operate under local rules and regulations, a good monitoring practice should be in place against any damage that might require compensation due to mining activity. Such cost allocations should be projected during project implementation.

Equipment breakdown or failure

Due to the nature of mining and the amounts of material moved, large and expensive equipment is commonly used. These include, for example, long-walls for underground coal operations, draglines for surface operations, large processing plants for cleaning coal, winders for shaft operations, ventilation fans, refrigeration plants, shovels, crushers, large trucks, monorails, drilling rigs, pump stations, boiler houses, generators and substations.

It is inevitable that these machines will eventually break down and bottlenecks and loss of production will follow. Therefore, the CPR is expected to comment on the state of equipment and machinery including the age of the fleet, the general regular predictive and preventive maintenance practice and competency of the workforce in operating them. This should also mention the availability and supply of spare parts and the non-destructive testing of machinery to detect and prevent future mechanical/electrical failures.

Infrastructure issues

As the demand for raw materials in the last several years drove many lower quality and remotely located projects to become viable, infrastructure issues are increasingly becoming an important topic for these deposits. As the finance for such projects is under scrutiny from national governments who are desperately in need of cash due to their budgetary constraints and from shareholders of large mining companies who demand financial discipline for the capital

3. A longwall area behind the supports that has collapsed as planned.
4. Blocks of coal left intact to act as support for shafts or other underground workings.

expenditure, the lack of sufficient infrastructure is becoming the primary obstacle to the development of these Resources.

The CPR should ensure that all necessary infrastructure issues have been properly addressed in projects. This may include infrastructure deficits impacting on enterprise value, the return on all capital expenditure including infrastructure and consideration for appropriate financing. The latest 2012 version of the JORC Code also, appropriately, accommodates the inclusion of infrastructural matters in the Modifying Factors list. It appears that the development of infrastructure worldwide will continue to be slower and more complicated due to commercial risks involved in projects.

Skills shortages

As the image of mining in the public eye still has a long way to go and uncertainties associated with the nature of short business cycles are still governing factors, skills shortages are a major issue globally. The risk is that this could create a generation of workers and professionals without any proper mentorship in place. Slow growth in this area can increase costs in the long term and significant risks associated with skills shortage can impact on production, cause project delays and increase labour costs.

A competent workforce would make a huge difference to successful project implementation and delivery of product extracted from the ground to costumers. Projects that value and develop workplace training and sustainable skills development programs to fill gaps and develop strategic alliances with academic institutions and local communities will be regarded highly in the near future.

Environmental issues

Public awareness of mining activities impacting on the immediate environment has been on the rise for the last couple of decades. Mining companies have also been trying hard to change the industry's image and clean up its act since then. Unfortunate incidents still capture public attention and these issues are increasingly picked up by international audiences due to increased global communication through the international media and social networking sites on the internet.

It is a well-known fact that pollution to water streams, acid rock drainage, air pollution, heavy metal concentration in run-off and groundwater, land clearing and deforestation for mine site, mountain top removal, failures of tailing dams and spoil heaps are only a few of the issues faced if protective and preventive measures are not undertaken at mine sites.

Consequences for damage to the environment by project owners can be extremely costly: the loss of reputation, the loss of right to mine due to cancellation of the license and remediation costs for environmental damage are examples of potential negative impacts.

It is a comforting fact that many companies are increasingly subscribing to the Equator Principles, a voluntary code of standards for determining, assessing and managing social and environmental risk in project financing where total capital costs exceed US$10 million. The CPR can highlight the environmental issues for third parties and give an understanding of potential environmental impacts consequent to mining activities.

FINANCIAL MATTERS

Within the JORC Code, one of the Modifying Factors that can decide whether an orebody is a Resource or a Reserve and whether the mineral occurrence is worth pursuing is 'economic'. Yet 'economic' is not actually defined. There are some clues for cost and revenue factors for assessment in Table 1 of the Code but no clear definition. Does 'economic' mean that the project or asset is profitable? Or maybe cash positive? Is this to include money already spent or only looking forward? Over what term should the calculation be carried out? All these questions are somewhat glossed over and we, the practitioners, all tend to shirk away from whether the calculation should include taxation and what would be acceptable depreciation. If we are considering profit, should we allow for an element of return to lenders/investors as an acceptable cost and should lending considerations also figure? What it comes down to is whether an orebody should be sustainable financially or merely show a cash return. To be sustainable financially, we would expect to see a profitable return, enough to cover the costs and pay for all associated equipment and restoration. Showing a cash return depends on the timescale and we can be selective about the period, hence missing some costs.

Thus, a sustainable scheme should be able to bear all costs associated with it; however, if we apply cash flow calculations going forward, monies already paid out are ignored. Profit calculations will allow for this through the depreciation charge but, of course, different companies have different depreciation policies that will cause different results in terms of valuation. When considering profit and loss, it sometimes means that one should apply taxation. This can additionally complicate matters. It is no coincidence that taxation is a specialised branch of finance that has its own institute. Taxation regimes differ from country to country and from company to company, which further hinders any attempt to compare projects. Moreover, if stakeholders are located outside the project country, there is a potential transfer of profits to kinder taxation regimes.

The upshot is that it is almost impossible to compare different projects unless they are brought to a similar standard. It might be said that there is no need to bring projects to the same basis since each investment opportunity is part of a separate exercise and report; however, the authors believe that investors deserve the chance to compare investments even though they may not be looking at them side by side. Thus, some form of consistency is needed.

In this section, some of the terms and methodologies used by the finance expert of the team in Reserve assessments will be explained or demystified.

Valuation methodologies

At the simplest level, one measure would be whether a project returns in income the cash expended to develop the project and the associated costs – the cash flow scenario. Yet we immediately encounter a problem: what expenditure and incomes will be counted in the calculation? Is the total company looked at (which might include many mines or projects) the individual mine project or merely the future of the project?

Usually a Competent Person would look at a company as a whole or at least indicate which projects are included in the assessment. In some cases, there are liabilities from certain

operations to other parts of the same company. Care must be taken that these are not missed or at least, that the reader/investor is made aware of their existence. This can be clarified with further consultation, but will not necessarily indicate whether the company will have the necessary funds to make repayments of investment within the overall structure. Extending this latter point, it is also worth noting that at no time in a cash flow calculation does the CPR give an indication as to whether the company can fund all activities completely. Specifically, years of negative cash flow can and will be cancelled out by positive flows in later years; however, there is no facility to report what the maximum negative value will be and whether that level of outflow can be funded by an overdraft, loan or other means.

These days, the tendency to more vertical integration means that some mining operations while being reviewed as stand-alone are actually selling their entire product within the company. In such cases, some form of internal pricing or transfer mechanism is used that may not well reflect market prices. There may also be some form of barter between companies involving one product being exchanged at agreed ratios of volumes. These potentially distorted income calculations could well lead to a false valuation. Again, the CPR should highlight this issue.

Generally, 'cash flow' is based upon the cash flow going forward, because the valuation is set at a particular date and values the Resources/Reserves that remain. This is no doubt useful for potential investors but ignores the inputs and expectations of current investors who have brought the project to that stage. As part of a previous funding round, investors may already have made loans or provided support in expectation of a repayment or return. Indeed, the company may have already spent significant amounts of money to create the mine.

When looking at simple cash flow, as long as Resources exist it may take many years but still result in a positive valuation. Thus, it is important to know how long it might take to return the investment. This is the payback time, measured in years. Generally speaking, experts usually expect a six or seven year payback. This is not a bad measure but, using this norm, many good projects are going to be missed. Some projects, especially gold mines, have a longer payback period due to the higher initial cost, longer construction periods and slower ramp-up of outputs. Yet they can last much longer and produce very high incomes in later years.

One final issue that is worth emphasising: all these cash flow valuations work on the basis of a summation of annual cash flows. As mentioned earlier, none of the results take account of any cash deficit that occurs over the duration of the project. If there is a deficit of funds that exceeds bank loan limits or finance raised or contingency on equipment breakdown/replacement, there is no marker that flags it. This 'trapdoor test' fails. While other issues might be totally acceptable and open to interpretation, this is a pass or fail matter. Exceeding overdraft limits results in administration, yet no-one bothers to highlight how close a project comes to the limit during any stress tests.

Discounted cash flow

One of the most common methods used in project evaluations is the discounted cash flow (DCF). This method at least takes note of the fact that early money is worth more than later money. Cash flow and return of investment are included as well as the rate at which money is returned. Results are expressed as a net present value (NPV), which is a totalling of all the future cash flows but with higher value given to earlier incomes. There is still the problem of where the valuation point is set and how the earlier investment is dealt with, not to mention how the project can be compared to similar projects around the world. Although these questions are important to answer individually, they will be left to the reader to deal with as the valuation and comparison basis may fundamentally differ from one institution to another.

One of the most important factors in DCF calculations is at what rate future cash is reduced as the years go by – the discounting rate (DR). This is the subject of ongoing research, interest and argument. Traditionally, practitioners use the weighted average cost of capital (the ubiquitous WACC) – a relatively complex calculation that involves quite a few subjective decisions. Obviously, the company involved will wish to see as low a discounting factor as possible since this will increase the valuation calculated. This can lead to long discussions between project owners and the CPR team based upon differing perceptions. Yet, having raised new finance, the company WACC will almost certainly have changed. Again, is it appropriate to apply a company-wide discount factor to an individual project within a portfolio? Is it appropriate to discount the project at a rate for the company when the funding raised to implement the project may have a much different cost? One of the solutions to this conundrum is to agree to some figure with the project owners but include a table with results over a range of discount rates in any valuation exercise.

Another significant debate is how to calculate future costs and income. There are two options: calculate all figures valued at a specific date such as Quarter 4, 2012 (the so-called real model) or inflate all future costs and income using a specific annual inflation rate (the nominal model). In order to arrive at a comparable valuation using the different methods, the theory tells us that the discount rate applied should then be increased by the value of the inflation rate applied. The option selected is based on personal choice and experience: some prefer the year-on-year direct comparison of the real model, while others prefer to see how the variable costs and incomes change year on year as in the nominal model.

A pragmatic approach would be to use the real model, which avoids the use of deliberately introduced and uncontrollable variables that must be subjectively estimated and then adjusted. Who can propose what the inflation rate will be next year let alone how it will behave over the lifetime of a model or mine? Furthermore, it is most likely that different costs and selling prices will inflate at different rates, so which rate to apply? Not many years ago (2008), a target for Russian inflation by the state authorities was determined to be six per cent by 2012, which accordingly adopted by the companies around the country in their cash flow projections. This was used extensively in nominal models but the reality (12 per cent) was remarkably different in 2012. So, what was the use of the nominal model in these cases?

Similarly is the issue of currency transactions. These can affect both costs and selling prices and sometimes become very important when dealing with international sales of product. Since the view about inflation is already outlined above, it can be guessed that the preferred methodology for the financial expert of this paper would be at fixed exchange rates without indulging in predictions. Intuitively, one might

prefer the real model when inflation and exchange rates are relatively stable, but it is difficult to have faith in the nominal model where there is instability. In the latter case (such as Zimbabwe), many prefer to convert all costs, incomes and capex (capital expenditure) into a stable currency such as US dollars and then provide the valuation in US$.

Terminal values

It has become popular to value a project based upon a relatively long time span and then add a terminal value (TV), which values all subsequent years of mining. This can sometimes significantly inflate the valuation but also the related Reserves. Often, this is done to satisfy some macho approach on the part of the company to maximise the valuation or the Reserves started. (At this point, it is worth pointing out that the authors have experienced a company insisting on adding less profitable blocks of product to a valuation that has reduced the value of the overall Reserve but maximised the total Reserve tonnage.) This over-enthusiasm for stated Reserves seems to have its origin in a belief in some quarters that having huge Reserves shows stability and a long-term future.

In theory, the approach of using terminal values is financially acceptable. It is worth noting though that such an approach was developed for circumstances where a stable situation had been achieved in mining terms and significant ongoing change was unlikely, yet it was not possible to make a definite detailed mining plan with specific outputs. The example quoted is diamond mining where large volumes of rock are moved but there is no predictable rate at which diamonds might be found – simply an overall average based upon historic results. This stability includes no change in volumes and capital expenditure. This 'stable' year is then assumed to be repeated on an ongoing basis and no attempt is made to predict variations. A financial calculation then mirrors this situation with the operation either assuming to last forever or for the calculation to be terminated in some distant year.

It has become popular to apply terminal values to almost any situation. Often, 20-year models are extended using a terminal value. The authors favour a specific period for the evaluation and a business plan encompassing this period. Such a period should be reasonable in terms of the ability to predict and not last for centuries as has recently been experienced in Russia. In any case, the Resources that can convert into Reserves at some stage should be stated and this gives an indication of future longevity. Finally, on this point, it should be realised that with a discount factor of about ten per cent the amount of valuation increase after 20 years is minimal.

Many experts will state that it is already stretching a point to be making predictions of output, cost and selling price over a 20-year period without assuming that the situation will pertain for a much longer period. One can add that, in mining, it is very rare for the situation to become stable. Capital expenditure can often be extremely variable in nature and mining becomes more expensive as stripping ratios and tramming distances increase. Thus, extreme care should be used when terminal values are being applied. Interestingly, most valuation exercises will not indicate whether some terminal value has been used in valuation calculations. The only indicator might be the time over which the Reserves valued will last, given a specific rate of production.

International Financial Reporting Standards, annual assessment of Resources/Reserves and role of Competent Persons

With the advent of international reporting, the application of International Financial Reporting Standards (IFRS) has become important. Many organisations are obliged by this accounting standard to value their assets every year. This is to ensure that the assets shown in their balance sheet are worth what they have cost. Few companies annually complete an independent evaluation and many never at all – using only internal staff to complete evaluations. For example, Figure 1 clearly indicates the high percentage of internal staff versus external sources used in compiling Reserves and Resource tables in annual reports from some major mining companies in 2012. There have been a number of recent, highly publicised write-downs by companies due, presumably, to such exercises. Most companies carry out their own assessments of new and existing projects as well as carrying out their own regular valuations of assets. Is it no wonder that such valuations are self-fulfilling? And is it also no wonder that such asset revaluations result in write-downs of assets.

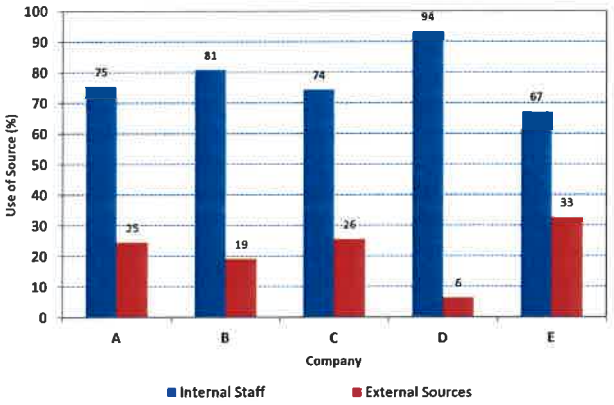

FIG 1 - Use of internal staff and external sources in preparation of Resource and Reserve tables in annual reports from major companies in 2012 (except for Company D, which is 2011).

One of the common industry practices is to conduct a peer review process for new projects so as to ensure that the consistency of standards has been maintained at exploration, Pre-Feasibility and bankable Feasibility Study levels. In many cases, the work undertaken by different organisations at these stages are scrutinised by independent third-party organisations so that expensive mistakes can be avoided at the mine construction and later stages.

Similarly, there seems to be a strong case for a regular independent valuation of assets and of projects in a wider realm. The JORC Code recommends that persons being called upon to act as Competent Persons should be clearly satisfied in their own minds that they could face their peers and demonstrate Competence in the commodity, type of deposit and situation under consideration. If doubt exists, the person should either seek opinions from appropriately experienced colleagues or decline to act as a Competent Person. As companies sometimes develop their projects through in-house capabilities, emotional involvement in projects and corporate culture may play a crucial role in underestimating some of the important aspects of the projects. An independent

third-party assessment of the project can bring a fresh eye to the assets under review.

Yet, this simple analysis can be independently completed quickly and at low cost especially if the same individuals outside the organisation, who become familiar with operations, are used each time to prepare a Competent Person report. One might be tempted to say that an independent consultant would say this in self-interest. Yet, investors in a new company listed under most stock exchanges or subject to new investment calls or bond issues are provided some level of comfort by an independent review.

Why should existing stakeholders not be given some reassurance for existing projects and assets too? However, it is not the intention of the authors to advocate annual checks or even a legal requirement that all new projects are reviewed on behalf of investors by independent third-party organisations. Merely that occasional but regular reviews should be carried out independently from internal production staff. These need not be in-depth nor result in major cost.

One interesting issue in particular has been raised by this IFRS asset valuation requirement in Russia. There, the Reserves are valued along with various physical assets such as buildings and processing plants. Based upon a DCF analysis, one might suggest that these buildings are all part of the system that produces an ore and processes it into a saleable product to generate income. As such, these assets are already valued and cannot be assessed for worth again or we should be double-counting the value. Only as a used asset at the end of mine life might they have a value, but surely by this time they are, at best, obsolete and more probably a liability.

Sensitivities

An important element of any valuation is the sensitivity analysis. This can be a very useful section in the Competent Person's report, giving the reader a range of 'what-if' scenarios. Often ignored, it actually gives the reader some idea of how risky the project might be and what lesser performance in the future might mean in terms of value and potential return on any investment. This is necessary for one very good reason.

Confucius apparently said:

> [a man] *who aims for the stars might reach the ceiling, but the man who aims for the ceiling will not get off the floor.*

Thus, we might expect some level of optimism on the part of project proposers. One of the most difficult issues for reviewers is to remove this 'optimism bias' without being unduly pessimistic. One way of doing this is to demonstrate where a project is likely to be weaker and prone to sensitivities.

CONCLUSIONS

Competent Person reports on Resources and Reserves are comprehensive documents for any given deposits and can highlight many underlying geological, mining and process-related issues in detail. It is important that work undertaken by Competent Persons will be truly independent and professional and that the quality of work can be scrutinised by peers.

A Competent Person will judge the appropriate category of Mineral Resource depending upon quantity, distribution and quality of data available and the level of confidence, taking into account those issues cited in various internationally accepted Codes.

Similarly, Ore Reserves will be categorised after the application of all mining factors for a viable project after taking into account all relevant Modifying Factors, risks and issues cited in the preceding sections.

It should be remembered that the estimation of Mineral Resources and Ore Reserves is mostly a team effort involving several technical disciplines. The entire procedure is an iterative consultation process between team members, and decisions and conclusions are generally reached in a collective manner.

In this consultative process, all factors and risks related to geology, mining, ore processing, infrastructure, environment, social aspects and economics are considered. Like any other risk assessment process, it is important to know all areas of the project site to ensure that risks are understood by all parties – both at a technical and economic level – and controlled to a reasonable level to avoid unpleasant consequences. One of the important functions of the Competent Person's report is to relay these perceived risks and mitigating factors to third parties independently and simultaneously.

Geological and mining factors can typically include tectonic issues, seam or ore continuity, ore grade or coal quality, hydrogeological issues, geotechnical issues, spontaneous combustion, gas and coal dust issues, geothermal gradient, seismicity, subsidence, equipment breakdown/failure, overall infrastructure issues, skills shortages and environmental issues.

Once the deposit is characterised in terms of quantity and quality and all the above factors are identified, the project or asset is then reviewed to see whether it is economic or not. Although there are a number of methods that can be employed for this purpose, any chosen methodology will have its own advantages and disadvantages due to the nature of the mining projects; these generally involve a high cost of initial investments and prolonged payback periods and uncertainties in the international commodity markets. Some of the important economic topics that need to be investigated in detail encompass questions such as whether the:

- project is profitable or cash positive
- project includes money already spent or is only forward-looking
- term the calculation based on is considered
- calculations include taxation
- acceptable depreciation amount is considered
- element of return for lenders/investors is accepted as cost
- deposit is sustainable financially or showing only cash returns
- payback period is acceptable for the investment considered
- discounted cash flow considers the real model or nominal model
- chosen inflation and currency exchange rates reflect the reality
- terminal value would be realistic in real terms.

As stated, it is disheartening that despite all the cost and effort that goes into producing a Competent Person report or mineral expert report, most recipients concentrate on very few pages (usually the financial section) and just two figures in the final offering: total Reserves and the valuation.

Often it's just the last figure. This is disappointing since there is usually much of value in every section, whether it is on geological risks, recommendations for productivity and processing improvements, underlying control factors on improvements, possible environmental and social issues impacting on the performance of the operations and any other reason highlighted in the main body of the expert report. As the underlying evaluation is based on internationally accepted codes such as JORC, the Competent Person always puts additional caveats or, more importantly, warnings of potential pitfalls for the deposits they evaluate.

Recent events have indicated yet again the need for attention to all details in these reports as well as a regular, independent review of performance and key figures relating to an ore deposit, as it can be vital in preventing such financial disasters.

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