

The Application of Modifying Factors

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Demonstration of the feasibility of economic extraction is not required before Exploration Results or Mineral Resources are reported. However, the use of Modifying Factors is fundamental in demonstrating feasibility and thus in converting a Mineral Resource to a Mineral Reserves. Understanding the application of these Modifying Factors is important to ensure the correct declaration of a Mineral Reserve. Failure to properly investigate all relevant Modifying Factors can lead to the incorrect conversion of Mineral Resources to Reserves, adding unnecessary risk to a project or even leading to premature closure of a mine. The importance of correctly applying Modifying Factors to Mineral Resources is discussed and examples provided to demonstrate the negative outcomes when Modifying Factors are incorrectly applied.

Traditionally, mining engineers have looked to the more conventional Modifying Factors; such as mining, metallurgical, legal, and economic factors. However, other factors, for example, governmental, social and labour, environmental, and infrastructure factors, previously thought by some engineers to be less significant, are now recognized as key factors. The paper discusses the application of Modifying Factors and their importance in establishing the feasibility of a mining project.

INTRODUCTION

Establishing a Mineral Reserve demonstrates the financial viability of a mine or project. Having sufficient Proved Reserves to cover the payback period of a project is viewed by most lenders as an essential requirement; one which limits risk to the investor. For the Competent Person (CP) it is important that all Modifying Factors are considered when declaring a Mineral Reserve. Failure to properly investigate all relevant Modifying Factors can lead to the incorrect conversion of Mineral Resources to Mineral Reserves, adding unnecessary risk to a project or even leading to premature closure of a mine. The author has been involved with a number of recent projects that have closed due to project teams failing to fully understand the effect of Modifying Factors.

The SAMREC Code 2016 states that:

A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource.

It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.

The reference point at which Mineral Reserves are defined, usually the point where the ore is delivered to the processing plant, must be stated. It is important that, in all situations where the reference point is different, such as for a saleable product, a clarifying statement is included to ensure that the reader is fully informed as to what is being reported.

Based on the above statement, it is clear that in order to declare a Mineral Reserve a Pre-Feasibility or Feasibility Study must have been completed and all Modifying Factors included to demonstrate, at the time of reporting, that extraction could be realistically and reasonably justified. In terms of Proved and Probable Mineral Reserves the Code also allows for a life-of-mine (LOM) plan to be suitable for an operating mine. Until 2016, Pre-Feasibility or Feasibility Study were not adequately defined. However, in order to improve transparency the 2016 SAMREC Code now defines Pre-Feasibility and Feasibility Study and LOM Plan.

A Pre-Feasibility Study is a comprehensive study of the viability of a range of options for a mineral project that has advanced to a stage at which the preferred mining method in the case of underground mining or the pit configuration in the case of an open pit has been established and an effective method of mineral processing has been determined. It includes a financial analysis based on realistic assumptions of technical, engineering, operating, economic factors and the evaluation of other relevant factors that are sufficient for a Competent Person, acting reasonably, to determine if all or part of the Mineral Resource may be classified as a Mineral Reserve. The overall confidence of the study should be stated. A Prefeasibility Study is at a lower confidence level than a Feasibility Study.

A Feasibility Study is a comprehensive design and costing study of the selected option for the development of a mineral project in which appropriate assessments have been made of realistically assumed geological, mining, metallurgical, economic, marketing, legal, environmental, social, governmental, engineering, operational and all other modifying factors, which are considered in sufficient detail to demonstrate at the time of reporting that extraction is reasonably justified (economically mineable) and the factors reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or finance, the development of the project. The overall confidence of the study should be stated.

A LOM Plan is a design and costing study of an existing operation in which appropriate assessments have been made of realistically assumed geological, mining, metallurgical, economic, marketing, legal, environmental, social, governmental, engineering, operational and all other Modifying Factors, which are considered in sufficient detail to demonstrate at the time of reporting that extraction is reasonably justified. The level of study should at least be equivalent to a Prefeasibility.

The above sets out the minimum expectations for the various technical studies. Table 2 of the 2016 SAMREC Code also provides recommendations in terms of the confidence levels associated with capital expenditure and operating costs for the types of technical studies. The CP is expected to understand the level of work required to declare a Pre-Feasibility Study or Feasibility Study; however, the Code provides additional guidance in order to improve transparency. In the past, some CPs have

stretched the definition of Scoping Studies to attempt to justify the declaration of a Mineral Reserve when the study is in fact not conducted to a Pre-Feasibility Study level.

When converting a Mineral Resource to a Mineral Reserve the two most significant Modifying Factors are dilution and mining loss. Mining dilution is defined as waste material, either barren material or waste containing some mineral content below the cut-off grade, and which is extracted during the course of mining operations and thereby forms part of the Mineral Reserve. Mining loss is defined as ore left behind in the mining operation due either to practical mining considerations such as the application of a maximum mining cut in deep Witwatersrand gold deposits, designed stability pillars, *etc.* Unplanned ore loss results from ore being left behind due to poor cleaning practices, poor sampling, estimation errors, or misdirected (tipped) trucks or hoppers resulting in ore being tipped into waste passes.

Underestimating dilution can lead to the overstating of the head grade, and the understatement of mining losses can lead to the overstatement of tonnage. An accurate estimation of the head grade is the more critical of the two, and the author has seen a number of new mines fail due to the overestimation of the head grade. The CP must ensure that appropriate factors are applied when converting Mineral Resources to Mineral Reserves. The author has observed a number of mines' head grades negatively affected due to underestimation of mining dilution.

MODIFYING FACTORS

In order to convert a Resource to a Reserve one must consider the application of all the Modifying Factors. It is not uncommon to view reports that inadequately cover some of the Modifying Factors when demonstrating the viability of a project. Key factors identified are:

- Mining
- Metallurgical
- Economic
- Marketing
- Legal
- Environmental
- Infrastructural
- Social and governmental.

Mining

The application of mining losses and dilution is probably one of the more contentious elements of applying Modifying Factors to mineral resources. Project owners tend to be optimistic in estimating mining dilution and mining losses. For operating mines the CP should make use of historical results to benchmark the mining factors. For Mineral Reserves estimated from technical studies the CP must use their experience to select the appropriate factors.

An example of the important role of mining factors in the Reserve estimation process is the following. In 2006 a Feasibility Study was conducted on a platinum project which estimated dilution at 14.5% at a grade of 1.5 g/t (4E). Based on the assumed dilution a run-of-mine (ROM) head grade of 3.16 g/t was used for the project evaluation. At the mine's start-up the actual ROM head grade ranged from 2.1 to 2.4 g/t (4E). During this period the Mineral Reserve grade was reviewed and re-adjusted from 3.16 g/t to 2.65 g/t (4E), based on planned improvements in stoping width and other in-stope dilution controls. In 2012, the project was placed on care and maintenance with the actual ROM grade never consistently achieving the estimated 2.65 g/t. In the author's opinion, the failure to achieve the planned ROM head grade was one of the main reasons why the mine was placed on care and maintenance.

Additional considerations include the mining method, mine plans and production schedules. The CP should provide a description and justification of the mining method(s), as well as discussion of the mining rate, mine equipment selection, grade control measures, geotechnical and geohydrological consideration, human resource requirements, health and safety, dilution, mining losses, and operating costs. For open pit mines additional inputs for pit slopes, slope stability, and strip ratio are required. For underground mining, the mining method, rock engineering considerations, ventilation and cooling, mine drainage, as well as the impact on surface and groundwater require discussion.

Metallurgical or Beneficiation

The metallurgical characterization of any ore is critical in terms of describing or identifying any factors that may have a negative impact on product quality and recovery. Frequently, metallurgical recoveries are based on historical data or test work based on limited sample sites that do not always reflect the natural variability in most orebodies. If the metallurgical inputs are not properly considered, inaccurate recoveries may be used resulting in either lower or higher plant recoveries, thus potentially impacting on the accuracy of the reporting of Mineral Reserves (Pienaar and Freese, 2016).

Metallurgical considerations include the metallurgical process or method, equipment, plant capacity, efficiencies, and personnel requirements. The CP should discuss the nature, scope, and representativeness of metallurgical test work undertaken and the recovery factors used, and comment on the appropriateness of the selected methodology, *e.g.* whether it is well established or new technology. A detailed flow sheet and a mass balance should exist, especially for multi-product operations from which the saleable products are priced according to different chemical and physical characteristics.

The CP should state what assumptions or allowances have been made for deleterious elements, the results of any bulk-sample or pilot-scale test work, and the degree to which such samples are representative of the orebody as a whole. Stated recoveries must be related to full-scale operations, taking into account laboratory scale test results as well as the geological domain in which the ore is sourced. The CP must consider environmental, community, and health and safety issues associated with the metallurgical process, with those sections dealing with hazardous materials or operations incorporating more detail. Issues like acid water drainage and other hazardous seepages into the groundwater from tailings and waste storage facilities should be carefully considered as the cost of lining such facilities is enormous.

Economics Parameters

The financial viability of a project is a critical factor – in order for a Mineral Reserve to be declared, the project must be economically feasible, proving the deposit is mineable. The CP should ensure that the commodity prices are relevant to the product quality and volume being sold and related to the market. For example, in the case of Coal Reserves the coal quality must be reported in order to support the proposed market and selling price. Without such details it is inappropriate for the CP to declare a Reserve. For projects/mines selling commodities under a current contract the CP should consider whether the full Reserve is covered by the contract or establish the likelihood of the contract being extended, including commentary on future commodity prices and volumes.

When considering economic parameters the CP should provide a description of the product to be sold and the market conditions for the product, its impact on that market, and whether contracts for the sale of the product are in place or expected to be obtained. The CP should state and justify all economic criteria that have been used for the study, such as capital and operating costs, exchange rates, revenue inputs, royalties, and cut-off grades. The method used to estimate the commodity price profiles used for cut-off grade calculation, economic analysis and project valuation, including applicable taxes, inflation indices, and exchange rates should be described. The CP should demonstrate that the product price assumptions are reasonable and supportable, and justify assumptions concerning production cost and value of the product. Consideration should be given to transportation, treatment, penalties, exchange rates, marketing, and other costs.

A detailed cash flow analysis for the life of the project, including a summary of taxes, royalties, and other government levies must be completed. Sensitivity and risk analyses related to grade, prices, capital costs, operating costs, and any additional significant variables should be conducted. The date of the financial report and the base date of the financial analysis must be stated.

CPs must also ensure that the point of sale is clearly defined and that on- and off-mine costs are accurately accounted to the point of sale. The documentation supporting commodity prices and sales volumes should include a comparison of prices with historical, current, and future price forecasts as well as a consideration of contracts, market conditions, exchange rates, and any other material information. In special cases, commodity prices may be confidential and it may be necessary for the CP to withhold price-sensitive information. In such cases, for transparency the CP needs to justify why such information is not disclosed.

Marketing

The SAMREC Code requires the consideration of the supply, demand, and stock situation for the particular commodity, consumption trends, and factors likely to affect supply and demand into the future. A customer and competitor analysis along with likely market windows for the product should be discussed and a description of the product to be sold, customer specifications, testing, and acceptance requirements included in the analysis. The CP should discuss whether there exists a ready market for the product and whether offtake agreements are in place or are expected to be readily obtained.

A realistic commodity price is important. The market assessment may indicate that minerals are not saleable in the proportions in which they are to be produced, and as a result the Reserves estimates may need to be adjusted.

Legal

A statement in the study is required to the effect that no legal issues exist that could negatively affect the project. Although the CP may not be qualified to conduct a legal due diligence, he/she should conduct basic checks to verify that the prospecting permit or mining right, or other rights, are valid or reasonably expected to be granted. CPs should be careful when actual tenure is not secured, as more than one example can be provided where a client believed that the prospecting or mining right would be granted only to find that the right had already been granted to another party. No tenure means no Mineral Reserve.

Environmental

The CP should provide information on the status of studies of potential environmental impacts of the mining and processing operation, as well as a statement on the status of the approval processes for all necessary permits (tailings and waste). The CP should describe future yearly environmental liabilities, compliance methods and costs, including rehabilitation and closure funding. Reference to the Environmental Impact Study should be recorded and the CP must recognize that environment permitting may change over time, which could impact on the Mineral Reserve estimation. If problems arise or are solved, the Mineral Reserve estimates must be adjusted accordingly.

Some permits cannot be obtained until after a detailed mine study has been conducted, *i.e.* a Mineral Reserve has been declared. The CP should recognize that there may be reasons why obtaining some permits could be postponed. Furthermore, as the regulatory process may be time-consuming it is recognized that material information should be released to the investors in a timely fashion, and therefore it is acceptable that material is disclosed prior to granting of permits, as deemed appropriate by the CP. To reflect the above, the Table 5.5 in the 2016 SAMREC Code has been modified so as to enable a Mineral Reserve to be declared on anticipation of the approval of various environmental permits.

Recent discussions around the updating of the Code have included the introduction of material input to the environmental section of the Code, as well as Table 1. This approach has been largely rejected

since the Working Group was of the opinion that sufficient guidance is already present in the Code. While many environmental issues need to be considered when developing a mineral project, it is not the place for the Code to provide guidance on all of these issues. Sufficient requirements are made in terms of Environmental Impact Assessments, water use, and other aspects. Rather, the Code is there to ensure that the CP has satisfied himself/herself that full environmental compliance has taken place. The declaration of a Mineral Reserve must fully comprehend environmental factors that may impact on the project.

Infrastructure

The CP should report in sufficient detail to demonstrate that the necessary facilities have been allowed for, which may include, but are not limited to, processing plant, tailings dam, leaching facilities, waste dumps, road, rail or port facilities/allocations, power supply, potable water, wastewater treatment, stormwater handling, communications, fuel storage, offices, housing, security, resource sterilization testing *etc.* Detailed maps showing locations of facilities should exist. Project milestones and completion dates should be stated. In South Africa, the availability of power, water, and material handling (off-mine logistics) are critical. The author has reviewed a number of projects where infrastructure requirements have been critically underestimated, in some case to the extent that realistic infrastructure requirements have led to the failure of the project. In South Africa, the cost of self-generated power has a significant impact on the operating costs. Therefore, the delivery date of power sourced from the local grid must be carefully considered. The allocation of water rights and delivery is equally critical.

Social and Governmental

One of the significant changes included in the 2016 SAMREC Code is the relaxation of the clause dealing with obtaining the necessary government approvals. *'A statement [deleted] (to) the effect that mandatory social and labour management programmes, if any, have been approved or there is reasonable basis to believe that approval can be obtained. Costs of such programmes should be considered in Techno economic studies.'* This clause has replaced the 2009 clause that *'A statement should be provided to the effect that all necessary permits have been approved.'* The above has brought the SAMREC Code in line with other international codes, as well as account for the fact that investors may require Mineral Reserve status while awaiting the various governmental permits to be approved – a task that often may take over two years to accomplish. The critical aspect of the new clause is the 'reasonable basis', which the CP must consider.

Local environmental laws and processes must be taken into account. To demonstrate reasonable expectation that all permits, ancillary rights, and authorizations can be obtained, the reporting entity must show understanding of the procedures to be followed to obtain such permits, ancillary rights, and authorizations.

Information that materially increases or decreases the risk that the necessary legal rights or permits will be obtained must be publicly disclosed. It is recognized that the legal and permitting environment may change over time and that such changes could have an impact on the Mineral Reserve estimate. If obstacles arise or are eliminated, the Mineral Reserve estimates must be adjusted accordingly.

It is recognized that some permits cannot be obtained until after a Mineral Reserve has been declared. There might be sound business reasons why obtaining some permits should be postponed. It is also recognized that waiting for all permits to be on hand could result in critical information not being released to the investors in a timely fashion, and therefore it is recommended that disclosure of material information occur prior to obtaining permits as appropriate

Documentation should include a brief description of the title, claim, lease, or option under which the reporting entity has the right to hold or operate the property, indicating any conditions that the registrant must meet in order to obtain or retain the property. Royalty terms and clawback rights of former claimholders also must be disclosed. If held by leases or options, the expiration dates of such

leases or options should be stated. If extension of leases or options will be needed to mine the Mineral Reserves, there should be reasonable expectation that such extension will be granted.

A statement should be provided to the effect that mandatory social management programmes (social and labour plan), if any, have been approved. A statement should also be provided to the effect that such governmental requirements have been approved. A number of statutory requirements relevant to project development should be considered. The following lists a few South African government requirements that should be considered by the CP (Rupprecht, 2014):

- Mineral and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002)
- MPRDA Act of 49 of 2008
- MPRDA Amendment Bill 2013
- Broad-based Socio-Economic Charter
- Mineral and Petroleum Resources Royalty Act (Act 28 of 2008)
- National Environmental Management Act (NEMA) (Act 107 of 1998)
- National Environmental Management Air Quality (Act 39 of 2004)
- National Environmental Management Waste Act (Act 59 of 2008)
- National Environmental Management Protected Areas Act (Act 57 of 2003)
- Environmental Conservation Act (Act 73 of 1998)
- National Forests Act (Act 30 of 1998)
- National Water Act (Act 36 of 1998)
- Mine Health and Safety Act (Act 29 of 1996) and amendments (MHSA).

Risk Analysis

Project technical, social, environmental, and economic risk should be highlighted in order to inform the reader of the likelihood of the identified risk, mitigating considerations, and the impact the risk may have on the Mineral Reserve declaration. Depending upon the identified risk, the Mineral Reserve declaration could result in a Measured Resource being converted to Probable Reserves or even removed from the reserve category altogether. Similarly, an Indicated Resource could be found unsuitable for Reserve declaration. The author has observed several Mineral Reserve declarations that are only 'going through the motions'. A risk analysis should be viewed as a powerful tool to help management mitigate potential problems before they become significant.

CONCLUSION

As commonly understood, the application of the Modifying Factors constitutes an integral part of the Mineral Reserve estimation process. It is the responsibility of the Competent Person to ensure that all, not just some, of the Modifying Factors are adequately considered during the estimation and reporting of Mineral Reserves. This paper provided an analysis of the Modifying Factors provided in the 2016 SAMREC Code as a mechanism to improve reporting standards, reporting transparency, and provide assurance that all technical inputs have been considered. The 2016 SAMREC Code provides a comprehensive checklist (Table 1) for the Competent Person to consider and comment.

REFERENCES

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