RUPPRECHT, S. Establishing the feasibility of your proposed mining venture. *International Platinum Conference 'Platinum Adding Value'*, The South African Institute of Mining and Metallurgy, 2004.

Establishing the feasibility of your proposed mining venture

S. RUPPRECHT
RSG Global, Helderkruin, Republic of South Africa

Project evaluations of mineral deposits are necessary for mineral rights, owners and investors alike. A feasibility study provides a definitive technical, environmental and commercial base and is the key element leading to a decision to invest or not to invest. For example, the study may be used to justify further exploration and development expenditure or to provide a basis for a major underwriting to raise the required capital.

There are three distinct phases in the development of a project and the type of study will differ depending on the quality of information available or the level of decision to be made. This paper looks at these three phases in the development of a mineral project and the type of study required; namely, a scoping study, prefeasibility, and a full feasibility study.

Keywords: scoping studies, feasibility studies, mining projects.

Introduction

Determining the feasibility of a mineral property may be simple or sophisticated but has one primary goal. This is to demonstrate that the project is economically viable if it is designed, constructed and operated appropriately. The feasibility study will define the ore reserves, the mining methods, the mineral processing concepts and the scale of the project.

Mining is more prone to risk than most businesses and often projects initiated fail to achieve their expectations in terms of cost and timing of project or operational performance such as the size of reserves or grade recovery. The average feasibility study is a lot less accurate than one would like to think and in many cases there is a strong likelihood that a new project could run into problems. It must be recognized that, as engineers we need to improve and develop our skills in feasibility study preparation throughout the mining value chain. This paper looks at three phases in the development of a mineral project and the type of study required: namely a scoping study, prefeasibility, and a full feasibility study.

Project evaluation

The concept of a 'feasibility study' is a widely used term which includes a whole range of activities from a scoping study to a full feasibility study. Thus, it is critical that the purpose of a study be defined upfront i.e. clear terms of reference are required to manage expectations associated with the level of available information and the cost of the study.

The mine evaluation process is an important tool in the decision process, which allows mining executives, senior consultants and financiers to understand the inherent value of a project. Depending upon the level of information, a project or property will be examined under different conditions or phases. The following sections discuss the various phases of the evaluation process and the level of detail expected.

Scoping studies

Scoping studies are an initial financial appraisal carried out very early in the project life and are often included in an elementary mine plan. Scoping studies are often used to evaluate whether to acquire exploration areas, or initiate/proceed further with a mineral project and are accurate to 30–50%. The evaluation is conducted by using mine layouts and factoring known costs and capacities of similar projects completed elsewhere. Care must be taken with scoping studies, as a viable mining project may be relinquished due to an inadequate assessment. Therefore, it is essential that experienced people are involved in the scoping study.

In order to conduct a scoping study, one must first estimate the mineral resources in the ground, i.e. grade and quantity of mineralization that has been identified. Applying current metal prices allows one to determine an *in situ* gross value, to which a factor can be applied to obtain the net value of the potential ore. It should be emphasized that a scoping study is based around grade and recovery. It does not provide assessment of whether sufficient reserves exist to be economical. This is a point raised by McCarthy[1], 'It is acceptable for scoping studies to be based on very limited information or speculative assumptions in the absence of hard data. The study is directed at the potential of the property rather than a conservative view based on limited information.'

Prefeasibility studies

Prefeasibility studies are usually undertaken once a mineral resource has been identified and it is at this stage that one should ensure that the project is indeed feasible and/or identify areas requiring further detailed studies.

There are four common reasons for conducting a prefeasibility study:

- As a base to justify a major exploration programme, for example an exploration shaft or decline
- As part of due diligence work by a potential purchaser

- To determine whether to proceed with a full feasibility study
- As a means to determine issues requiring further attention.

Preliminary studies are accurate to 15 to 30% and are typically obtained by factoring known unit costs and estimated gross quantities once conceptual or preliminary engineering has been completed. At this stage, the level of engineering (10 to 30%) should match the level of accuracy required, i.e. no greater than required to reliably compare concepts and assess the overall economics.

These studies are usually completed by a small multi-disciplined group of experienced technical people. Assumptions should be realistic rather than optimistic and conclusions qualified wherever necessary. Main features of a prefeasibility study (after P.L. McCarthy, AMC) are as follows:

- Location and description of the project
- Regional and local geology
- Mineral resource estimate and model
- Reserve conversion
- Preliminary studies completed on geotechnical, environmental and infrastructure requirements
- Mine design based on a resource model, best alternatives selected from a range of alternatives
- Mine sections and level plans
- Mining method(s) and extraction sequence
- Ore handling
- Bench scale metallurgical tests and preliminary process design completed
- Process plant
- Mill flow sheet
- Pre-production construction schedule
- Production schedule
- Capital and operating cost estimate
- Preliminary financial evaluation and risk analysis.

Full feasibility study

The objective of a full feasibility study is to remove all significant doubt and to present relevant information about referenced material. A full feasibility study should demonstrate within a reasonable confidence that the project can be constructed and operated in a technically sound and economically viable manner. The study should support the raising of finances for the project from banks or other sources, and provide a basis for detailed designs and construction. Typically, a full feasibility study is the basis for capital appropriation and provides the budget figures for the project. Capital and operating costs are estimated to an accuracy of 10–15%, including realistic contingencies, based on the level of engineering completed.

The full feasibility study should determine:

- Ore reserves as per standard definition (i.e. SAMREC, JORC, etc.)
- Scale of the project
- Construction budget and schedule for the project
- Cost estimate for operating and capital
- Contingency; there are many approaches to the inclusion of a contingency. The contingency may be an estimate of costs that will arise subsequent to the study or it may be a hedge against improper or incomplete estimates
- Market estimates; the most significant variable in a feasibility study is often commodity price and currency exchange rate
- Cash flow study; an appropriate discount rate should be agreed by all concerned and used to calculate the NPV
- Risk and sensitivity analysis; risk and sensitivity analysis are commonly used to assess the upside and downside potential of the project.

Cost of studies

The cost of studies varies substantially, depending on the size and nature of the project, the type of study being undertaken, the number of alternatives to be investigated and numerous other factors. The indicative costs displayed below do not include owner's costs such as exploration drilling, metallurgical tests, environmental studies or other support studies. These indicative costs are commonly expressed as a percentage of the capital cost of the project.

- Scoping study 0.1 to 0.3 per cent
- Prefeasibility study 0.2 to 0.8 per cent
- Full feasibility study 0.5 to 1.5 per cent.

Accuracy of cost estimates

The accuracy of capital and operating cost estimates increases as the project advances from conceptual to preliminary to feasibility phase. Normally acceptable ranges of accuracy are considered to be:

- Scoping study 30 to 50 per cent
- Prefeasibility study 15 to 30 per cent
- Full feasibility study 10 to 15 per cent.

Higher levels of estimate accuracy are a reflection of the extent of analysis undertaken to quantify risk elements and therein establish cost to the prescribed level of accuracy. As the project advances, the level of detail of engineering studies increases, as does the cost to undertake the higher level studies. Therefore it is common for detailed engineering to be conducted in the full feasibility study after the project concepts have been fully optimized.

All studies factor in a level of contingency. This is an allowance to cover costs, which, based on historical experience, are expected to be encountered but which are not possible to identify at the time an estimate is prepared. It is the amount of money provided for the uncertainties in quantity, pricing, productivity and timing, which lie within the defined scope of the project. The key is the manner in which the contingency is derived. There should be degrees of contingency for differing circumstances and the various components of the project. These can be then summed up to show the overall contingency allowance.

Mine feasibility sequence

The following discussion reviews each discipline in the evaluation process. The scope of work for each phase of the study is essentially the same for any phase of the evaluation process (i.e. scoping, preliminary feasibility, or full feasibility study). However, the detail and quantity of work required for the appropriate level of accuracy will vary considerably. In addition, the process is integrated and iterative, requiring several detailed studies before committing to a full feasibility study.

Geology

Geological data and interpretations form the basis of the entire evaluation process by delineating the mineralization, estimating the resource, and providing essential information for the mine and processing design. When done correctly, it improves the confidence level; if done incorrectly, it can have disastrous effects on the mine design and ultimately on the investment decision.

Many types of detailed geological data are required to begin evaluation of a mineral deposit and the data must be accurate, detailed, complete and consistent. Many minor geological features, such as trace minerals, fracture patterns or subtle alteration and rock textural changes, can significantly affect the geological understanding, mine plans, or metallurgical characteristics of the mineral deposit.

Resource estimate

The resource estimation is conducted by the geologist, sampling consultant and geostatistician who will build the geological model, quantify the accuracy of the data collected and develop the resource estimate. Along with the resource estimation, the acceptability of the drilling method should be discussed along with the sample preparation, analytical procedures and check assay results. This data should be statistically analysed to determine the variance and level of confidence of the resource estimate. The resource estimate is the critical fundamental foundation of all mining projects. All work done must be compliant with the relevant code i.e. SAMREC or JORC etc.

Reserve estimates

The reserve estimate gives an indication of the viability of the mineral resource. Calculation of the reserves will depend on the mining method, including an estimate on dilution and extraction, mineral processing concepts, including cut off grade, overall recovery and expected capital and operating costs.

Geotechnical

Geotechnical studies require the same basic data for both underground and opencast mining; however, some data is more critical to one mining method than it may be to the other. The amount of data required is a function of the accuracy required for the type of study and for the geological complexity of the geology. The basic parameters required are interpreted geological sections and level maps, joint set characteristics of the ore zone, hangingwall and footwall, intact rock, fracture and fault shear strengths of the different rock types, and the hydrologic conditions.

Basic geological interpretation is of major importance. Interpreted geological sections and level maps, which show major rock types, alteration zones, and major structures such as faults, veins, and fold axes, should be prepared to the same scale that will be used for the mining plan, and the area investigated should extend horizontally beyond the limit of the orebody in all directions, approximately twice the depth of the deposit.

The structural geology of the deposit is reviewed in regard to major structures and rock fabric. Major structures such as faults, folds, dykes, etc. which have lengths in the order of the size of the deposit, are usually considered individually in the mine design and are part of the geological map. Rock fabric is predominantly joints and faults that have a high frequency of occurrence. Detailed mapping (where the rock is exposed) measures the fracture characteristics for each fracture set within 10 to 15 m. In other cases, where the data can only be obtained from drilling, a few oriented core holes should be included in the exploration drilling programme. These core holes will provide the same information as the detailed mapping, with the exception of the joint length characteristics.

Rock strengths are required, such as: rock shear strength (uniaxial and triaxial compressive tests), fracture shear strength, and fault gouge shear strength. For slope stability, primary strengths are required for fracture and fault gouge. The number of specimens required for representative testing varies according to rock type; however three to six samples per rock type per test is recommended.

Hydrologic conditions can affect rock strength properties as groundwater in a slope induces pore pressure on potential failure surfaces, which serves to decrease the open pit slope stability. Information required includes the level of the water table, location of water sources, and location of water-bearing geological structures.

Based on the opencast geotechnical information, the slope angles of the pit can be defined.

In terms of surface infrastructure, the geotechnical studies include investigations into the appropriate positioning of tailings and water storage facilities, the plant site and construction inputs (foundation studies), and waste dumps. Additional duties could include assessments on road/rail stability and identifying the supply of construction material.

For the evaluation of underground mining, geotechnical inputs are required to assist in determining the appropriate mining method and to evaluate the required size of openings, types and amount of support, caving characteristics, and expected subsidence. For underground mining, rock shear strength, fracture shear strength, and fault gouge shear strength would be required to be determined. Typical geotechnical inputs would be tunnel and stope orientation, width of stopes, pillar sizes, and support strategy.

Mine design

The level of mine design will vary depending upon the level of the study. At the start of the study, it will be necessary for the mining engineers involved in the study to understand the nature and disposition of the orebody, and structure and content of the geological resource block model. The scale of the operation and the mining method will largely be influenced by the size of the resource. The shape and disposition of the resource will also influence the selection of the mining method, the per cent extraction and dilution and ultimately the economics of the mining method selected. The study should schedule the ore and waste movement throughout the mine life and assess its achievability, practicality and optimality in the light of any constraints such as mining fleet, resource configuration or mill throughput. In addition, the mining engineer will need to understand the mine infrastructure requirements. Waste disposal also needs to be considered and is becoming increasingly important as government and the public are exerting greater influence on the industry to minimize surface disturbances. Of importance is the ability to anticipate future trends or requirements so that ore is not sterilized.

New technology

A conscious decision must be made about new technology. There are always opportunities for new projects to incorporate prototype equipment or processes. However, one needs to understand the associated risk. New projects already incorporate risk; one should not add untested concepts and equipment unless it is essential to the viability of the project.

Process design and logistics

Processing engineers should become involved during the late stages of exploration as mineral processing will influence ore reserve estimations. Process engineers will indicate what drill samples are necessary for bench scale test work or if bulk samples are required for pilot plant work. Since it is both time consuming and expensive to obtain a representative bulk sample, it is ideal to identify the need for pilot plant work as soon as possible. The test work will establish a preliminary flow sheet, which will be used to estimate costs and recoveries. It is important that the treatment process be designed to handle maximum concentrations of minerals, peak material flows and ore hardness, not only average values.

Infrastructure

Infrastructure requirements will need to be assessed and designed to a level in keeping with the study accuracy, and usually addresses the following:

- Power supply
- Water supply
- Internal roads
- Plant infrastructure
- Permitting and authorities.

The design of on-site infrastructure is partially dependent upon the company's organizational philosophy. The degree to which the operation will rely on outsourcing certain operations (for example maintenance, surveying, assaying, security or mining), will influence the design, location and equipping of infrastructure requirements. Other external infrastructure requirements such as power, water, access and community will be required, regardless of the company's organizational philosophy.

Mining projects are normally very energy intensive and the availability and cost of electrical power is always a significant consideration. Water is also important: the identification, acquisition and construction of the necessary water supply and control systems will be a major consideration.

Access is obviously of critical importance, and includes construction of railways, roads, airstrips and shipping facilities. Although on the decrease, mining communities are still developed in emerging countries where the mine may be expected to introduce social and regional development.

Construction

The feasibility study should reflect the expected approach to project construction. The most common approach is to use contractors to provide engineering, procurement and construction management (EPCM). In any feasibility, one must account for the build-up period on commissioning of the project. The cost of operations and the production build-up period during this stage must be planned and budgeted. Finally, pre- and post-technical audits of the project need to be conducted. Post-audits are often neglected, yet can provide great insight when comparing anticipated results with actual results.

Land and legal

Land and legal issues should be dealt with at an early stage, i.e. once an exploration programme begins to show positive signs. During the early stages of the evaluation process, property issues (mineral and surface rights) should be addressed to identify any possible fractional areas that may exist within the project area, understand any title deficiencies and plan for remedial action. Additional property should be available for such issues as infrastructure requirements (such as offices and workshops), processing plants, waste and tailing disposal, housing and general site access.

Environmental

The development of any mine will require an environmental impact assessment (EIA). The EIA consists of mitigation, management, monitoring and institutional measures to be taken to eliminate adverse environmental and social impacts. The EIA and subsequent permitting will always be on the critical path and can be more expensive and time consuming than the feasibility itself. Due to the critical nature of the EIA and permitting, it is advisable to begin environmental studies during the late stages of exploration. Typical areas that should be reviewed include:

- Implementation of baseline studies, including routine sampling of active drainages to assess water quality before and after drilling
- Implementation of general flora and fauna baseline surveys
- Monitoring of local water wells, dams and other drill holes to determine seasonal variations in the water table
- Multi-element soil geochemistry and details of mineralogical work
- Establishment of a weather station capable of measuring rainfall, wind direction, wind velocity and temperature.

Capital and operational costs

Estimates of the project capital and operating costs are based on the level of the study. For instance, a scoping study would require only order of magnitude costs; a prefeasibility study may base operationing costs on similar operations in the region, whereas a full feasibility study would require definitive cost estimates.

Capital cost estimates for a prefeasibility study would consist of mechanical equipment, pipe work and electrical and instrumentation equipment costed by suppliers; steelwork, earthworks and civil work quoted on unit rates, and engineering and management costs based on man-hour estimates.

Full feasibility studies would require written budget quotations based on general arrangement and section drawings, duty specifications of equipment, bulk quantity items and P and ID drawings. Estimates would include all manpower costs-including contingencies.

Engineers and consultants will develop the operating cost estimate to an accuracy of 15 to 20% for a prefeasibility study and 10 to 15% for a full feasibility study. The operating cost estimates will be developed as follows:

- Manpower schedules and remuneration rates agreed
- Mining costs either for owner operated or contractor
- Power consumption estimates and power supply rates from the power suppliers
- Reagents and consumables from consumption estimates and supplier quotations
- Water consumption estimate and supply cost
- Maintenance costs from consumption estimates and supplier quotes
- Taxes, duties, levies etc, as supplied by GFG (define)
- Assay costs based on quantities and consumables costs
- Overhead cost estimates for telecommunications and office supplies.

Marketing and evaluation

One additional aspect of project evaluation that must be considered prior to making the final decision to proceed with the project is product marketing and the subsequent revenues received. The projected revenue or return of the mining venture is the ultimate criteria for determining the feasibility of any mining venture. If the return isn't high enough, then an extensive study is not justified. In addition to the financial evaluation, a risk assessment should be carried out on the major parameters, including metal price, working costs, capital costs and recoveries. The first level at which revenue becomes critical is the exploration phase. If the rate of return isn't sufficient at that point, there is no point in continuing on with the project.

Conclusion

Feasibility studies are required for the evaluation of a property, which leads to a high degree of confidence in the decision process. This paper reviews the work expected to be completed for the various types of feasibility studies i.e. a scoping, prefeasibility or full feasibility study. However, the reader should note that what has been presented is only a guideline and would vary depending on the actual details of the project and the amount of work done to date.

References

1. MCCARTHY, P.L. Objectives of feasibility studies. Internal paper for Australian Mining Consultants.