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FINANCIAL VALUATION OF MINERAL ASSETS

by

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MINOR DISSERTATION

Submitted in partial fulfilment of the requirement for the degree

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In

BUSINESS MANAGEMENT

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Supervisor: Mr FD Durand

2012
Abstract

All valuations of mineral assets in South Africa are guided by the South African Mineral Resources Committee (SAMREC) and South African Mineral Valuation (SAMVAL) codes. They have also been adopted by the Johannesburg Securities Exchange (JSE) in order to protect shareholders.

Different capital budgeting methods are used for mineral assets valuation in South Africa. These are the net present value (NPV), internal rate of return (IRR), payback period, cost, market and real options methods. It is not known which capital budgeting method is most often used for mining property valuations, as South African mining companies and associations are not required to share their capital budgeting processes with the public. In addition, the SAMVAL code does not recommend the use of the real options method and no reasons are provided.

The study was aimed at establishing the capital budgeting method most often used for mining property valuations in South Africa, as well as the reasons why the real options method is not recommended by the SAMVAL code. A judgement sample of expert valuators was utilised in the study and interviews were carried out using open ended questions.

The research revealed that NPV is the capital budgeting method most often used for mining property valuations followed by the IRR method. Outside South Africa, Bhappu & Guzman (1995) found that these preferences were reversed. Since the IRR method represents a notional rather than an actual return on investment, South African valuators were found to be more rational than their overseas counterparts in the application of these discounted cash flow (DCF) methods.

The findings also revealed that the cost, market and payback methods were less preferred to the NPV and IRR methods. The reasons given were all consistent with the theory. The cost method was avoided because it uses historical cost data which is not usually applicable, the market method was limited due to the lack of available information on truly comparable projects and the payback method was shunned for
undervaluing mining properties by ignoring cash flows that arrive after the payback period.

The respondents also indicated that the real options method is the least used. The method (which includes the value of embedded optionality) was regarded as complex and not widely understood and this was also thought to explain why it is not recommended by the SAMVAL code. This finding indicated that in South Africa the embedded optionality in mining projects may not be taken into account and as a result, opportunities for the exploitation of its mineral assets could be missed.
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Glossary of Terms

**Assay:** A quantitative determination of the amount of chemical substances, such as gold and silver, in a particular ore sample.

**Assets:** A resource controlled by the entity as a result of past events and from which future economic benefits are expected to flow to the entity.

**Competent Person:** A person who is registered with the South African Council for Natural Scientific Professionals (SACNASP), the Engineering Council of South Africa (ECSA) or the Professional Land Surveyors and Technical Surveyors (PLATO) or is a member or Fellow of the South African Institute of Mining and Metallurgy (SAIMM), the Geological Society of South Africa (GSSA) or a Recognised Overseas Professional Organisation (ROPO). A competent person must have a minimum of 5 (five) years experience relevant to the style of mineralisation and type of deposit under consideration and to the activity which that person is undertaking. Persons being called upon to sign as a competent person must be clearly satisfied in their own minds that they are able to face their peers and demonstrate competence in the commodity, type of the deposit and situation under consideration.

**Competent Valuator:** A person who is registered with SACNASP, ECSA or the PLATO or is a member or fellow of SAIMM, the GSSA or a ROPO. A competent valuator has to be in possession of the necessary qualifications, ability and sufficient relevant experience in valuing mineral asset and is clearly satisfied in his own mind that he is able to face his peers and demonstrate competence in the valuation undertaken.

**Cut-off Grade:** The lowest grade of ore that can be mined and processed profitably in a mining operation.

**Developmental Property:** A mineral asset that is being prepared for mineral production.

**Dormant Property:** A mineral asset which is not being actively explored.
Drilling: Poking a coordinated hole in the ground in order to collect rock samples.

Environmental Impact Assessment: A process of identifying and assessing the actual and potential environmental implications of a project before the project commences.

Exploration Property: A mineral asset that is being explored for mineral deposits.

Exploration Results: Includes data and information generated by exploration programmes that may be of use to investors.

Feasibility Study: 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.

Geoscience: The science that is concerned with the origin and evolution of the earth.

Hurdle Rate (Discount Rate): Represents the minimum return of a project below which the decision to invest (or develop a new project) will be negative, and above which the project may be developed.

Life of a Mine Plan: A design and costing study of an existing operation in which appropriate assessments have been made of realistically assumes 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.

**Mineral:** A naturally occurring, homogenous solid with a defined chemical composition and highly ordered atomic arrangement.

**Mineral Deposit:** A naturally occurring mineralized body that has been physically delineated by sufficient drilling, trenching and/or underground work. Such a deposit does not have enough information to warrant it to be a commercially mineable ore body.

**Mineral Asset:** Any right to explore or mine that has been granted or entity holding such property or the securities of such entity including but not limited to all corporeal and incorporeal property, mineral rights, mining titles, mining leases, intellectual property, personal property, mining and exploration tenure and titles or any other right held or acquired in connection with the finding and removing of minerals located in or near the earth’s crust.

**Mineral Exploration:** A process used to determine the presence of geological formations which may contain mineral deposits such as precious metals, or other minerals, as well as to determine the extent, geometry and grade of such deposits. Mapping, drilling, pitting, trenching and sampling are common activities undertaken during mineral exploration.

**Mineral Resource:** A concentration or occurrence of material of economic interest in or on the earth’s crust in such form, quality and quantity that there are reasonable and realistic prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a mineral resource are known, or estimated from specific geological evidence, sampling and knowledge interpreted from an appropriately constrained and portrayed geological model. Mineral resources are subdivided, and must be so reported, in order of increasing confidence in respect of geoscientific evidence, into inferred, indicated and measured categories.
**Mineral Reserve:** The economically mineable material derived from a measured or indicated mineral resource or both. It includes diluting materials and allows for losses that are expected to occur when the material is mined. Appropriate assessments to a minimum of a pre-feasibility study for a project, or a life of mine plan for an operation, must have been carried out, including consideration of, and modification by, realistically assumed mining, metallurgical, economic, marketing, legal environmental, social and governmental factors. Where the term ‘ore reserve’ is used; this is synonymous with the term ‘mineral reserve’.

**Ore:** A mineral-bearing rock that contains one or more minerals, at least one of which can be mined and treated profitably under current or immediately foreseeable economic conditions.

**Ore Body:** A well-defined and relatively continuous accumulation of minerals, distinct from the host rock, and in sufficient quantity to be worth commercial exploitation.

**Pre-feasibility Studies:** 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.

**Production (Mining) Property:** A mineral asset that is in mining and production.

**Prospecting:** A physical search of mineral deposits.
1. Chapter 1
1.1. Background
1.1.1. Introduction

Valuation of mineral assets is done by those who mine, fund, invest and audit mineral assets. The financial valuation of mineral assets is carried out under supervision of independent auditors known as competent persons that are guided by the SAMREC and SAMVAL codes that oversee the reporting and valuation of mineral assets. The codes are also adopted by the JSE. “Section 12 of the JSE listing requirements states that a competent person`s report on mineral assets must comply with the SAMREC and SAMVAL codes” (Deloitte & Touche, 2003:41).

Cawood (2004:36) explained that the codes were designed to maintain a common scientific standard across resource reporting systems with the priority of protecting investors from scandals such as that associated with Bre-X Minerals Limited (Bre-X). Bre-X was a Canadian company which claimed to have found a 200 million ounce gold deposit in Indonesia in March 1997. Investors bought shares and the company’s stock price increased. This was until an American company, Freeport, became interested in making a deal with Bre-X. Alden (1997) reported that Freeport carried out a due diligence and found that Bre-X has been cheating by adding gold to samples before sending it to the laboratory. The deal was cancelled, Bre-X `s stock price plunged, the company collapsed and investors lost money.

Investors require a return for investing in the minerals industry (mining and exploration companies). Companies raise money from investors in order to develop mineral assets for mining. Financial valuations are carried out in order to determine if the investment needed to develop and mine mineral assets will pay the required return. This helps to ensure the efficient use of capital.
1.1.2. The SAMREC Code

The SAMREC code (2007) was developed by a committee comprising representatives of all major stakeholders in the local minerals industry. It included the Southern African Institute of Mining and Metallurgy (SAIMM) and the Geological Society of South Africa (GSSA).

The SAMREC code (2007:9) “sets out minimum standards, recommendations and guidelines for the public reporting of exploration results, mineral resources and mineral reserves”. The value of mineral assets increases with an escalating level of geoscientific knowledge and confidence through exploration results to mineral resources as indicated in Figure 1.1.

![Figure 1.1. Exploration results, mineral resources and mineral reserves in the SAMREC code.](image)

Source: Adapted from SAMREC code (2007:8)

The value increases from mineral resource to mineral reserves by performing technical and economic evaluation (pre-feasibility and feasibility) studies, which
consider the mining, metallurgical, economic, marketing, legal, environmental and governmental factors (see Appendix 1, for a practical example). The SAMREC code (2007:6) stipulates the use of the terms “inferred”, “indicated” or “measured” to reflect increasing levels of geoscientific confidence in mineral resource estimates, and “probable” or “proved” for reporting of mineral reserves to reflect the degree of technical and economic evaluation applied. An inferred resource can only increase in value to an indicated resource. An indicated resource can increase in value to a measured resource (through escalating geoscientific knowledge) or to a probable reserve (by applying technical and economic evaluation). A measured resource usually increases in value to a proved reserve, but can be converted to a probable reserve if the technical and economic evaluation applied is of low confidence. “Exploration results, mineral resources and mineral reserves are documented within a report that is prepared and carried out under the direction of, and signed by, a competent person”.

The requirements stipulated in the SAMREC code (2007) are not prescriptive rules, but provide guidance to the competent person as to the transparency, relevance and materiality of the contents of the resulting competent person’s report. The SAMREC code (2007:6) stipulates that the following principles should be considered in the application of the code:

- **Materiality.** “A public report contains all the relevant information which investors and professional advisors would reasonably require, and expect to find, for the purpose of making a reasoned and balanced judgement regarding the exploration results, mineral resources and mineral reserves being reported on”.

- **Transparency.** “The reader of a public report must be provided with sufficient information, the presentation of which is clear and unambiguous, to understand the report and not mislead”; and

- **Competency.** “The public report is based on the work that is the responsibility of a suitable qualified and experienced person who is subject to an enforceable professional code of ethics. The code further stipulates that the author of the public report should be satisfied that the work has not been
unduly influenced by the organisation, company or person commissioning the report”.

1.1.3. The SAMVAL Code

“The SAMVAL code sets out minimum standards and guidelines for public reporting of mineral asset valuation in South Africa” (SAMVAL, 2008:68). The SAMVAL code (2008:65) defines mineral asset valuation as the valuation that has been completed according to the guidelines stated in the SAMVAL code and signed off by a competent valuator.

The SAMVAL code (2008) reported that a mineral asset can be classified as being dormant, exploratory, developmental, productive (mining) and defunct. A mineral asset that is:-

- not currently being explored is considered to be a dormant property,
- being explored for mineral deposits is considered to be an exploratory property,
- being prepared for mineral production is considered to be a developmental property; and
- being mined is considered to be a productive or mining property.

Each classification represents a stage in the life of a mineral asset.

1.1.4. Capital Budgeting

Firer, Ross, Westerfield & Jordan (2008:268), describe capital budgeting as a process concerned with planning and management of a firm’s long term investments. There are several capital budgeting methods that are used to value mineral assets, namely the cash flow, cost and market approaches. Ellis (2001) describes the cash flow and cost approaches as follows:-

- the cash flow approach includes all methods that are used to estimate the value of an asset based on its ability to generate cash flow. Included in this approach are the net present value (NPV), real options, internal rate of return (IRR), and payback period methods.
- The cost approach to mineral valuation is based on the principle of contribution to value.

“The market approach is considered to provide fair market value, since it reflects the balance of supply and demand in the market place” (Kota, 2010:85). The SAMVAL code (2008) generally accepts the three mentioned approaches to mineral valuation and notes the applicability and usage as follows:-

- **Cash Flow.** The cash flow approach is widely used in developmental and productive (mining) properties. The code does not recommend the use of real options.
- **Cost.** The cost approach is used in exploratory and defunct properties; and
- **Market.** The market approach is recommended to be used in exploratory, dormant and defunct properties.

The applications of these approaches are set out in Table 1.1. below.

<table>
<thead>
<tr>
<th>Valuation Approach</th>
<th>Exploration Properties</th>
<th>Development Properties</th>
<th>Production Properties</th>
<th>Dormant Properties</th>
<th>Properties</th>
<th>Defunct Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Flow</td>
<td>Not generally used</td>
<td>Widely used</td>
<td>Widely used</td>
<td>Widely used</td>
<td>Not generally used</td>
<td>Not generally used</td>
</tr>
<tr>
<td>Cost</td>
<td>Quite widely used</td>
<td>Not generally used</td>
<td>Not generally used</td>
<td>Not generally used</td>
<td>Less widely used</td>
<td>Quite widely used</td>
</tr>
<tr>
<td>Market</td>
<td>Widely used</td>
<td>Less widely used</td>
<td>Quite widely used</td>
<td>Quite widely used</td>
<td>Widely used</td>
<td>Widely used</td>
</tr>
</tbody>
</table>

Source: Adapted from SAMVAL code (2008:74)
Capital budgeting is needed in order to make an informed decision about whether to develop or abandon the asset. “South African mining companies do not generally disclose details of investment decision making processes publicly” (Kota, 2010:7). As a result, the Kota (2010) study evaluated published literature rather than making use of questionnaire surveys. Overseas, Bhappu & Guzman (1995:36) surveyed 20 mining companies in United States, Canada, Mexico, Australia and Great Britain and found that the IRR is the capital budgeting method mainly used and this is followed by the NPV and payback period methods. No such surveys were available for South Africa.

1.2. Problem Statement

There are different capital budgeting methods for valuing mineral assets. Mining and exploration companies in South Africa use different capital budgeting methods for valuation of mining properties, but are not required to share these with the public and do not do so. As a result the method most often used is not public knowledge. This is a problem because:

- the methods used cannot be easily questioned by the public,
- it is difficult to compare capital budgeting techniques between companies,
- company valuations by external parties such as investment analysts are more complicated and
- research in the field is inhibited.

1.3. Purpose of the Research

The study aims to discover which capital budgeting method is most often used for mining property valuations in South Africa. In so doing, the study will probe the reasons why some methods are preferred over others and establish if there are any particular strengths or weaknesses in the approach to valuing mineral assets in South Africa.
1.4. Chapter Outlines

This chapter sets the background of the research. The SAMREC and SAMVAL codes are critical in guiding mining companies during financial valuation of mineral assets. Proper valuation methods have to be used in order to protect shareholders from scandals and for making an informed decision on the efficient use of capital. Chapter 2 follows with a literature study of the concepts involved in the financial valuation of mineral assets, which includes uncertainty and the risk involved. Chapter 3 describes the research methodology. Chapter 4 presents the results and a discussion of the findings. Chapter 5 presents the summary and conclusion.
2. Chapter 2

2. Literature Review

2.1. Introduction

Bhappu & Guzman (1995) indicated that the IRR, NPV followed by the payback period were the most widely used tools for evaluating investment in United States, Canada, Mexico, Australia and Great Britain.

Lilford & Minnit (2002) summarised diagrammatically the mineral project evaluation process (see Figure 2.1 below), which includes project development through the mineral resource and mineral reserve stages, and the financial valuation methodologies used at various stages of the mineral project development process. As stated in Chapter 1, the SAMVAL code (2008) published practices of performing financial valuation of mineral assets and recommended three approaches, namely the cash flow, market and cost methods.

Kota (2010:7) criticized different capital budgeting methods used by mining companies, but the research was limited due to the lack of disclosure by South African mining companies and a failure to obtain approval for the use of membership databases of South African mining associations, such as the Chamber of Mines.

![Figure 2.1. Exploration results, mineral resource, mineral reserve categories and associated valuation methodologies. Source: adapted from Lilford & Minnit, (2002:383)]
Capital budgeting methods used to value investment projects including mineral assets are discussed below.

2.2. Types of Methods Used in Valuation of Mineral Assets

2.2.1. The Cash Flow Method, Payback Period

“Payback period is the amount of time it takes to break even on an investment” (Salehi & Tavakkoli-Moghaddam, 2008:86). The authors further reported that the payback rule states that a project should be accepted if its payback period is less than a specified cut off period. “If there are two projects whose payback periods are shorter than the maximum payback period requirement, the decision-maker should select the project with shorter payback period” (Atrill & McLaney, 2008:355).

Brealy, Myers & Marcus (2009:230) indicated that if a particular company would use the payback rule to decide on an investment, they would have to decide on an appropriate cut-off period. The payback period method will be biased against firms accepting long term projects because the cash flow that arrives after the payback period is not considered. The method does not assess the profitability of a project.

2.2.2. Discounted Cash Flow (DCF) Method, Net Present Value (NPV)

The NPV of a project is the present value of the future cash inflows minus the present value of investments calculated using an appropriate discounting rate. Domingo & Lopez-Dee (2007:7) pointed out that the NPV method requires predictions of the net income flows of an asset over its entire life, which entails forecasting the stream of future net revenues and then discounting this revenue stream using the appropriate rate. According to Brealy, et al (2009) a project with a positive NPV is acceptable, while one with a negative NPV should be rejected. In this way, optimistic, pessimistic and most likely scenarios can be determined or a more sophisticated Monte Carlo simulation can be used to establish the statistical distribution of NPVs.
Lilford & Minnit, (2002:377) explained that the NPV method does not take into account management’s ability to defer investment decisions. According to Damodanan (2000), the NPV does not capture the value of management’s ability to expand the size and scope of a project. Spencer-Young & Durand (2004) further explained that the NPV method does not reflect the value of delaying the start of the project until conditions become more favourable. “The NPV method is very limited in dealing with the uncertainties and flexibilities of mineral assets that can increase the value of a project” (Zhang, 2005:28). In short, the NPV method ignores the value of embedded options, which are the options to expand, delay or abandon the project.

2.2.3. The DCF Method, Internal Rate of Return (IRR)

“IRR is the discount rate which makes the NPV of revenue flows equal to zero” (Salehi & Tavakkoli-Moghaddam, 2008:86). It represents the compounded annual return on the investment. Atrill & Mclaney (2008:371), Brealy, et al. (2009:232) stated that for a project to be acceptable the IRR must be greater than the cost of capital. The greater the IRR, the more attractive is the project. Atrill & Mclaney (2008:372) pointed out that IRR ignores the scale of the investment and has difficulty handling projects with unconventional cash flows. The limitation of the IRR is that it is only an indicative or notional return rather than an actual return since it assumes all cash flows from the project can be reinvested at the particular IRR and this may not be possible. As long as the IRR is greater than the cost of capital, a large NPV is more important than a high IRR.

2.2.4. The Real Options Method

Dixit and Pindyck (1995:110) observed that an investment opportunity can be like an option which can help managers understand the crucial role uncertainty plays in the timing of capital investment decisions. The greater the uncertainty over the potential profitability of the investment, the greater the value of the opportunity, and the greater the incentive to wait and keep the opportunity alive rather than exercise it by investing at once. “Flexibility is the ability to deal with variability and uncertainty” (Schirm, Efstathiou, Calinescu, Sivadasan, & Fjeldsoe-Nielsen, 1999:2).
“An option is a contract that gives the holder the right and not the obligation to buy or sell the commodity (mineral) at a predetermined mineral price, at some specific future date (European option) or over a period of time up to some specific future date (American option)” (Lilford & Minnit, 2002:380). Resource deposits can be valued as American options. This suggests that any deposit can be attributed a value as an option. Options are either puts or calls. Resource deposits can be considered call options where the parameters that determine the value of the options are controlled by management rather than the market as in the case with financial options. These options are known as real options. “Real options valuation facilitates more efficient management of investors’ return expectations from inherently risky investments, allowing justification of capital allocation partially on strategic grounds after factoring in the value of uncertainty and flexibility” (Gitelman, 2002:59).

Zhang (2005) compared financial call options with real options (see Table 2.1 below).

Table 2.1. Financial options compared to real options

<table>
<thead>
<tr>
<th>Financial Option</th>
<th>Real Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of financial option</td>
<td>Value of real option</td>
</tr>
<tr>
<td>Present stock price</td>
<td>Present value of the benefits stream from extracted reserves</td>
</tr>
<tr>
<td>Exercise price</td>
<td>Present value of the costs of extraction of reserves</td>
</tr>
<tr>
<td>Dividends</td>
<td>Net present value of cash flow from reserves</td>
</tr>
<tr>
<td>Risk free rate</td>
<td>Risk free rate</td>
</tr>
<tr>
<td>Variance of the stock price</td>
<td>Variance of the present value of the benefit of streams from extracted reserves.</td>
</tr>
<tr>
<td>Time to maturity</td>
<td>Time over which investment right is held.</td>
</tr>
</tbody>
</table>

Source: Adapted from Zhang (2005:30)
The real options method incorporates the NPV of the project as well as the flexibility management has during its life and the opportunity the volatility of the price of the underlying assets may provide. It offers a way of dealing with the flexibility and maturity of a mineral project, which the NPV method does not address. This flexibility is important because “mineral asset projects always have long durations, large investments and high risks” (Zhang, 2005:28). The real options method can therefore be viewed as an improvement of the NPV method as it also includes any embedded optionality that the project may have.

2.2.5. The Cost Method

Ellis (2001) described the cost method as a method based on the principle of contribution to value and attempts to determine the depreciated replacement cost for the mineral asset in question. “The method is based upon the principle that the owner of the mineral asset wants to recover the expenditure incurred in its acquisition” (Lilford, 2002:105). Lilford & Minnit (2005:34) stated that the method is based on the premise that the mineral asset is worth at least that meaningful mineral exploration expenditure incurred as well as the warranted future costs necessary to improve the geological understanding of the mineral asset. “The method assumes that the amount of exploration expenditure justified on a property is related to its value and only considers those expenditures which are productive. Productive means that the results of the work give sufficient encouragement to warrant further work by identifying potential for existence and discovery of an economic mineral deposit” (Domingo & Lopez-Dee, 2007:11).

According to Lilford (2002) historical expenditures are compounded for the time passed in order to state the expenditure in today`s terms. The method assumes that the amount spent on exploration historically and budgeted to be spent in the next period is equal to the present value of the mineral asset. Lilford & Minnit (2005) mentioned that the fundamental principle of this approach is that a purchaser would not be justified in paying more for a property than it would reasonably cost to acquire the land and construct improvements that had comparable utility with no undue
delay. Domingo & Lopez-Dee (2007:12) states that the method is best applied to properties which are actively being explored and more difficult to properties that were left unexplored for some years. “One advantage of the method is that exploration cost information and technical data are readily available for most exploration properties” (Domingo & Lopez-Dee, 2007:12).

2.2.6. The Market Method

The market method relies on the value in use principle and requires that the amount obtainable from the sale of the mineral asset is determined as in an arm’s length transaction. Ellis (2001) indicated that the method assumes that a purchaser would not be justified in paying more for a property than it would cost him to acquire an equally desirable substitute property. An example of the market method is the use of comparable sales prices based on previous transaction values. Lilford & Minnit (2005) state that the use of comparable sales prices for mineral asset valuations relies on databases of historical mineral property transactions. The method is applicable when the value of the opportunity is found by comparing the location, size and grade (quality) of the mineral deposit against similar sales recently concluded.

According to Domingo & Lopez-Dee (2007), in the case of mineral assets, only mineral resources and mineral reserves can be valued at direct market prices and the disadvantage with this method is that most projects are different in terms of their geology, mineralisation and costs which make it difficult to compare one to the next. Notwithstanding this limitations, “the market approach is considered to provide the best indicator of fair market value, since it reflects the balance of supply and demand in the market place” (Kota, 2010:85).

2.3. Uncertainty Factors Affecting the Valuation of Mineral Assets

In addition to the methods discussed above, valuing a mineral asset has a number of constituents which might increase or decrease the value of a mineral asset. Snowden, Glacken & Noppe (2002) mentioned that during pre-feasibility studies indicative mineral grade cut-offs are derived, potential mining methods are
considered and optimum production capacities are determined, preferred mining methods are selected, followed by more refined ore definition that is often obtained from borehole data representing only a small fragment of the actual orebody. "Primary infrastructure options are then established and the analysis taken through to global extraction sequencing" (Mayer & Kazakidis, 2007:170). All factors considered during pre-feasibilities have associated uncertainties and risk.

Jaafari (2001) stated that value at risk refers to the exposure to the possibility of loss or gain, or the probability of occurrence of loss or gain, multiplied by a respective magnitude. Snowden, Glacken & Noppe (2002) indicated that the dominant source of risk in mining is the orebody itself. According to Perminova, Gustafsson and Wiksrom (2008), risk originates from the amount of uncertainty that is present in a project. “The risk associated with a mining project comes from uncertainties involved in the industry” (Topal, 2008:63). Kota (2010) defines uncertainty as the difference between the information currently available and the information required to make the decision. The uncertainty in the analysis will be the assumed economic parameters used to determine the final value. Lilford and Minnit (2002) pointed out that these parameters are the mineral product projected price, exchange rate assumptions for products that generate revenues in foreign currency, interpretation and application of taxation issues as well as the relevant discount rate applied to the resulting cash flow. Mayer & Kazakidis (2007:170) classified uncertainties as being from external and internal conditions or sources. According to Snowden, et al. (2002), internal sources are related to ore body model and in-situ grade distribution, technical mining specifications, equipment, workforce and management. Rendu (2002) indicated that external sources of uncertainties consist of the commodity price, political risk, legislation and government policy.

2.4. Methods for Assessing Uncertainties

“Decision criteria in investment decision making are very diverse, but the most important is defined by setting the technical, economic, and social risk that might manifest in investment performance” (Ispas, Lovin & Tilina. 2009:641). Kota (2010:13) explained that capital investments occur when the level of uncertainty is
acceptable, and it may be necessary to collect more relevant information to achieve this.

A mineral project has to go through a risk analysis during valuation in order to reduce uncertainties. Risk analysis involves classification of risk. According to Ho & Pike (1998) risk analysis techniques emphasize a comprehensive awareness of the uncertainties associated with critical project variables, and usually involve evaluation of the expected values and variance of a project outcome before any risk–return trade-off decision is made. Ho & Pike (1998:248) state that the commonly prescribed risk-analysis techniques for strategic large scale projects include sensitivity analysis and real option pricing (which have been discussed above) amongst others.

2.4.1. Sensitivity Analysis

Snowden, et al. (2002) describe sensitivity analysis as the process of examining the impact of errors, while Shih & Trappey (2008:60) explained that sensitivity analysis demonstrates how risk attitudes and investment costs influence the optimal investment decision. Brealy, Myers & Marcus (2009) consider it to be the analysis of the effects on the project profitability as a result of changes in costs, sales and other variables.

“Sensitivity analysis can be used to vary risk tolerance to determine at what point the decision changes” (Snowden, Glacke & Noppe, 2002:3). It is used in mineral asset valuation to assess the impact of errors in grade, metal price, metallurgical recoveries and other parameters on the project value (NPV). Monte Carlo simulation is a practical example of sensitivity analysis.

2.5. Summary

The literature review outlines the different capital budgeting methods, and the strengths and weaknesses associated with each approach. The review also discusses the methods available to assess the uncertainties that are involved when capital budgeting methods are used to value mineral assets.
The payback period is used to estimate approximately when a project will break even, but it does not incorporate cash flows arriving after the payback point has been reached. The NPV indicates if a project will return more than the amount invested under prevailing forecasts, but does not account for managerial flexibility and any new changes to these forecasts that can occur once the project has begun. The IRR is used to identify the discount rate that the project will return, but it is an indicative rather than an actual return. The real options method takes into account NPV but also places value on managerial flexibility and ability to exploit project uncertainties and, as such, is an improvement of the NPV method. However, it is not recommended by the SAMVAL code (2008).

Both the advantages and disadvantages are highlighted in the literature review and it is clear that each method has some strengths and weaknesses that can be addressed by other methods. The reviewed literature does not reveal which method is preferred for the valuation of mining properties and this motivates the research question below.

2.6. Research Questions

From the literature survey, it is apparent that there are different approaches to valuing mining properties. There is no published research to show which capital budgeting method is most often used by South African mining and exploration companies for mining property valuations. Kota (2010) has also highlighted that South African mining companies do not generally share capital budgeting processes.

The research will address the following questions:-

a) Main question.
   - Which capital budgeting method is most often used for mining property valuations?

b) Sub questions
   - Do the Bhappu & Guzman (1995) findings (that the IRR and NPV followed by the payback period were the most widely used tools for capital budgeting in
United States, Canada, Mexico, Australia and Great Britain) apply in South Africa?

- Why does the SAMVAL code not recommend the use of the real options method?

The answers to the research questions will facilitate:-

- questioning of adopted methods,
- comparisons of capital budgeting techniques between companies,
- company valuations by external parties; and
- more research within the field.
3. Chapter 3

3. Methodology

3.1. Introduction

The purpose of this chapter is to describe the methodology adopted for the study. The population and the sample selected are defined and the approach to data gathering and constant analysis is stated.

3.2. The Research Approach

The study targeted individual experts within the South African minerals industry. Questionnaires were sent to selected experts involved in the valuation of mineral assets to determine which valuation methods are used. Qualitative research was undertaken. “Qualitative research method is a non-numerical examination and interpretation of observations for the purpose of discovering underlying meaning and patterns of relationship” (Barbie & Mouton, 2009:646). Willes, Durrant, De Broe & Powell (2009) indicated that qualitative methods are more commonly used in research than quantitative methods. Gwyther & Possamai-Inesedy (2009) mentioned that it is necessary to not only review the nature of research with its various theoretical and methodological underpinnings, but also to consider conditions outside the academic wall, such as the economy, politics and others.

This research is descriptive. It reveals the capital budgeting method that is most often used by mining companies to value mining properties and identifies whether the Bhappu & Guzman (1995) findings apply in South Africa. It also establishes why the SAMVAL code does not recommend the real options method.

3.2.1. Population

Barbie & Mouton (2009) defined a population as a collection of data whose properties are analysed. For this study, the population was made up of individuals within institutions who are involved in the valuation of mineral assets.
3.2.2. Sample

Barbie & Mouton (2009) mentioned that the ultimate purpose of sampling is to select a set of elements from a population in such a way that the description of those elements accurately portrays the parameters from which the element is selected. A sample is a part of the population of interest, a sub collection selected from a population. Non-probability sampling was employed for this study. Social research is often undertaken in circumstances where the probability samples used in large scale surveys cannot be selected. In these cases probability purposive or judgemental sampling is used. A sample of 19 expert individuals involved in financial valuation of mineral assets was selected.

3.2.3. Data Gathering

Knowledgeable individuals were contacted with a questionnaire comprising open-ended questions. The participants occupied positions ranging from chief executive officers, chief financial officers, chief operating officers, project managers, geological and mining consultants at middle and senior management level.

The participants were involved in the valuation of different commodities ranging from industrial minerals (Coal, Fluorspar, Cement, and Tin), base metals (Nickel), and precious metals (Gold and Platinum). Table 3.1 represents commodities that the respondents valued.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Numbers in a survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>3</td>
</tr>
<tr>
<td>Nickel</td>
<td>2</td>
</tr>
<tr>
<td>Cement, Fluorspar, Tin</td>
<td>1</td>
</tr>
<tr>
<td>Diversified</td>
<td>13</td>
</tr>
</tbody>
</table>

The questionnaire listed different capital budgeting methods used in valuing mineral assets. Each participant was asked to respond to the questionnaire, by identifying the method or methods most often used. The participants were asked to rate the usage of each method on a scale of “always, often, seldom and never”. They were also asked to give reasons why they did or did not use a particular method and why the SAMVAL code does not recommend the real options method.
Every response was recorded. All 19 experts responded to the questionnaire. The results will be made available to the mining companies involved and this was a motivation for the respondents to participate. The questionnaire used for the interviews is shown in Appendix 2.

3.2.4. Method of Content Analysis

According to Taylor-Powell & Renner (2003), the basic approach to interpreting data is often referred to as content analysis. The following steps were followed during analysis:-

**Step 1.** The data collected was captured into an excel spreadsheet for better analysis. The hardcopy data was compared to the excel data in order to identify any discrepancies which might have occurred.

**Step 2.** The data was categorised for each capital budgeting method.

**Step 3.** The relationships between categories were assessed to interpret the meaning of the data.

3.2.5. Ethical Considerations in Research

Barbie & Mouton (2009) explained that ethics are typically associated with morality as both deal with matters of right and wrong, and are defined as conforming to standards of conduct of a given professional group. “It is increasingly required that plans for any social research project be subject to approval by an ethics committee” (Hammersley, 2009:212).

There are several ethical issues that are considered during a social research. Among the ethical issues mentioned by Barbie & Mouton (2009) are anonymity, confidentiality and voluntarily participation. During the research, none of the participants asked to be anonymous and no confidentiality agreements were required. All the participants in this study were voluntary.

The research proposal on financial valuation of mineral assets was submitted to the university ethics committee for approval. According to Munro (2008), approval
indicates that the research is of relevance to both policy and practise, and demonstrates that ethical considerations have been thoroughly considered by the research team and reviewed by a committee of academics from a range of disciplines.

3.3. Summary

A judgemental sample of 19 individual experts was selected and interviewed. They were asked to identify the frequency with which they used the available range of capital budgeting methods for the valuation of mining properties and invited to comment accordingly. The data was collected ethically and the methodology used ensured unbiased findings.
4. Chapter 4

4. Findings and Interpretations

4.1. Introduction

The aim of the study was to determine which capital budgeting method is most often used for mining property valuations in South Africa. The different methods used in capital budgeting with their advantages and disadvantages have been discussed in Chapter 2. These methods provide exploration and mining companies with tools to carry out capital budgeting before making any decisions and were used as a theoretical basis for the questionnaire. The data collected from the questionnaires used in the study is presented and analysed in this chapter.

The respondents were qualified professionals who undertook valuation of mineral assets. They occupied influential positions and determined which method would be used by their organisations for capital budgeting mining decisions. Their experience ranged from the valuation of single to multiple commodities. Some 68% of the respondents valued multiple commodities. This indicated that the responses were from knowledgeable individuals with vast combined experience.

4.2. Valuation Methods Used (Responses per Method)

The participants’ responses are outlined in table 4.1 below. The boxes show the usage distribution of respondents as a number and a percentage for each method.
Table 4.1. Percentage responses per valuation method

<table>
<thead>
<tr>
<th>Methods most used for capital budgeting</th>
<th>Never</th>
<th>Seldom</th>
<th>Often</th>
<th>Always</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payback (PP)</td>
<td>Count</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>15.8%</td>
<td>21.1%</td>
<td>47.4%</td>
<td>15.8%</td>
</tr>
<tr>
<td>IRR</td>
<td>Count</td>
<td>1</td>
<td>5</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>5.3%</td>
<td>26.3%</td>
<td>68.4%</td>
<td>100.0%</td>
</tr>
<tr>
<td>NPV</td>
<td>Count</td>
<td>1</td>
<td>4</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>5.3%</td>
<td>21.1%</td>
<td>73.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Real Options (RO)</td>
<td>Count</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>58.8%</td>
<td>29.4%</td>
<td>11.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Cost</td>
<td>Count</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>16.7%</td>
<td>22.2%</td>
<td>22.2%</td>
<td>38.9%</td>
</tr>
<tr>
<td>Market</td>
<td>Count</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>10.5%</td>
<td>26.3%</td>
<td>42.1%</td>
<td>21.1%</td>
</tr>
</tbody>
</table>

The results are also represented graphically in Figure 4.1 and show the NPV method having the highest usage in the “always” category.

Figure 4.1. A graphical plot representing usage distribution for each method.
4.2.1. The DCF Methods (NPV and IRR)

NPV was found to have the highest percentage in the always category and the lowest in the never category, while IRR had the second highest percentage in the always category and the second lowest in the never category. This made NPV the capital budgeting method most often used for mining property valuations.

The preference expressed for the DCF methods is intuitively logical in the light of the long term nature of mining investments and the need to take into account the time value of money. In addition, the fact that NPV was preferred over IRR is theoretically sound because IRR is a notional rather than an actual return since it assumes all cash flows from the project can be reinvested at a particular IRR, which is extremely unlikely. As long as the IRR is greater than the weighted average cost of capital, a large NPV is more desirable than a high IRR.

This finding is in stark contrast to that of Bhappu & Guzman (1995) which placed IRR ahead of NPV in the United States, Great Britain, Canada, Mexico and Australia and shows that South Africa is ahead of these countries in this regard.

4.2.2. The Cost Method

The cost method had the third highest percentage in the always category after NPV and IRR. The cost method was avoided by the valuators because it requires historical cost data which is not usually applicable to mining properties. The finding is acknowledged by the SAMVAL code (2007) and Domingo & Lopez-Dee (2007) who indicated that the method is best suitable for exploration properties.

4.2.3. The Market Method

The market method had the fourth highest percentage in the always category after the NPV, IRR and cost methods. Valuators pointed to limited availability of information on projects that are truly comparable in nature as the main reason for this placing.
The disadvantage of the method is well recognised (Domingo & Lopez-Dee, 2007) and shows again that South African valuators are theoretically sound.

4.2.4. The Cash Flow Method, Payback Period

The payback period had the fifth highest percentage in the always category. Valuators disapproved of the fact that it does not assess the profitability of a project since cash flows that occur after the payback period are ignored.

The valuators views are well supported in the literature, particularly by Brealy, Myers & Marcus (2009).

4.2.5. The Real Options Method

The real options method received the lowest percentage in the always category and the most in the never category even though it accounts for uncertainty and managerial flexibility which the other methods ignore. Table 4.2 below shows that the majority (63.2%) of the respondents sighted real options being “too complex and hence not widely understood” as the reason the method is not recommended by the SAMVAL code. Only 5.3% thought the omission was an oversight.

<table>
<thead>
<tr>
<th>Valid</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>An oversight</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Too complex and hence not widely understood</td>
<td>12</td>
<td>63.2</td>
</tr>
<tr>
<td>Do not know</td>
<td>6</td>
<td>31.6</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>100.0</td>
</tr>
</tbody>
</table>

In addition to the NPV for a mining project, the real options method provides a means of placing value on the flexibility management has during its life including the opportunity the price volatility of the mineral provides. “The NPV method is very limited in dealing with the uncertainties and flexibilities of mineral assets which can increase the value of a project” (Zhang, 2005:28). Real options provide a way to
profitably exploit uncertainty and risk (Gitelman, 2002). It follows that the neglect of the method in South Africa could be an indication that the country may not be factoring in the value of flexibility and uncertainty inherent in its mineral assets. An omission of this nature could result in missed opportunities and the sub optimum exploitation of the minerals in the country.

Given the valuators logical behaviour with respect to the DCF methods, the neglect of the real options method can be considered anomalous.

4.3. Responses to a Specific Combination of Methods

The respondents indicated that at times more than one capital budgeting method was used based on the availability of data and the stage of the project. The results for specific combination of methods are presented in table 4.3.

<table>
<thead>
<tr>
<th>Method</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCF (NPV &amp; IRR)</td>
<td>11</td>
<td>57.9</td>
</tr>
<tr>
<td>DCF &amp; Market Approach</td>
<td>4</td>
<td>21.1</td>
</tr>
<tr>
<td>IRR, NPV &amp; Real Options</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Monte Carlo &amp; Sensitivity</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>NPV at Market discount</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Payback, IRR, NPV</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The majority (57.9%) of the respondents indicated that they used DCF which is a combination of NPV and IRR, while 21.1% used NPV, IRR together with the market approach. The other 5.3% used NPV, IRR with the payback period, while 5.3% used NPV, IRR with real options.

The fact that the DCF methods are sometimes used together with the market, payback or real options methods could be an acknowledgement that each approach has strengths and weaknesses and that comparisons can be useful. This is
particularly so when cash flows are difficult to predict, uncertainty prevails and management flexibility can be utilised.
5. Chapter 5

5. Conclusions

5.1. Introduction

Chapter 5 gives a summary of the research purpose and the findings of the study. It also includes the limitations of the study and recommendations for future studies in the valuation of mineral assets.

5.2. Summary

The study investigated different capital budgeting methods for valuation of mineral assets. Capital budgeting is important in making an informed decision of whether or not to continue mining or to abandon the asset. Mining and exploration companies in South Africa each use different capital budgeting methods for valuing mineral assets but they are not required to share these with the public and generally do not make them known. This led to the main question, “which capital budgeting method is most used for mining property valuations in South Africa”? A related study was done in United States, Canada, Mexico, Australia and Great Britain by Bhappu & Guzman (1995). This raised the first sub questions, “Do the Bhappu & Guzman findings apply in South Africa”?

Mineral asset valuation in South Africa is performed under the guidance of the SAMREC and SAMVAL codes. The SAMVAL code does not recommend the use of real options method for valuing mineral assets. This led to the second sub question, “why does the SAMVAL code not recommend the use of the real options method”?

A judgmental sample of 19 expert valuators was questioned for the study. The research revealed that NPV is the capital budgeting method most often used for mining property valuation. This was followed by the IRR method. These findings did not support the study by Bhappu & Guzman (1995) which showed these preferences to be reversed. Since the IRR method represents a notional rather than an actual
return on investment, it was concluded that South African valuators were more logical than their overseas counterparts in the application of these DCF methods.

The findings also revealed that the cost, market and payback methods were less preferred to the NPV and IRR methods. The reasons given were all consistent with the literature. The cost method was avoided because it uses historical cost data which is not usually applicable, the market method was limited due to the lack of available information on truly comparable projects and the payback method was shunned for undervaluing mining properties by ignoring cash flows that arrive after the payback period.

The experts also indicated that the real options method was the least used. The method (which incorporates NPV and the value of management flexibility as well as mineral price volatility) was regarded as complex and thought to be not widely understood which could also explain why it is not recommended by the SAMVAL code. This finding indicated that in South Africa embedded optionality may not be taken into account when mining projects are valued and consequently opportunities may be missed and its mineral assets may not be optimally exploited.

The study also found that the DCF methods were also sometimes used together with the market, payback or real options methods. This was considered an acknowledgement that each approach has strengths and weaknesses and that comparisons can be useful in particular situations.

Given the valuators logical behaviour with respect to the use of DCF methods and combinations of other methods, the use of the real options method was identified as a neglected opportunity that should be explored.

5.3. Benefits of findings

Revealing the mining valuation method most often used for capital budgeting in South Africa allows the public to question the techniques used and serves as a benchmark against which companies can compare themselves. In addition, it
facilitates a less subjective, more standardised approach to company valuation by external parties such as analysts.

Identifying that the real option method was the least used in South Africa and was not recommended by the SAMVAL code (2008) highlighted an opportunity for miners in the country. By including the value of embedded optionality in their mining projects, missed resource exploitation opportunities could be identified.

5.4. Suggestions for future studies

The current study has indicated that there is a lack of application of the real options method on mineral assets valuations in South Africa. More research into the barriers preventing the application of the method could help encourage its use in South Africa and reduce the probability that its mineral assets are not optimally exploited.

5.5. Limitations of the study

Not all the commodity sectors were covered and the results may only hold for the specific commodities covered.
6. References


Appendix 1 (A practical example).

1. Background

A fluorite mine project example is presented to demonstrate a mineral asset is valuation process.

The mine is situated in the Limpopo province of South Africa. The project was developed from a mineral deposit to a mineral reserve. A mineral deposit is a concentration of a particular mineral with unknown quality and quantity. When quality and quantity of a mineral deposit is known, it is termed a mineral resource. To convert a mineral deposit to a mineral resource, data has to be collected through exploration in the field. The exploration results include mapping of rocks; drilling and sampling of boreholes.

The value of mineral assets increases with an escalating level of geoscientific knowledge and confidence through exploration results to a mineral resource. The value increases further from a mineral resource to a mineral reserve by performing technical and economic evaluation (pre-feasibility and feasibility) studies, which consider the mining, metallurgical, economic, marketing, legal, environmental and governmental factors. Following the feasibility studies, a life of mine (LoM) was determined. The LoM plan includes:

- SAMREC compliant mineral resource and mineral reserve estimates.
- Estimated tonnages that will be mined annually.
- Mineral grade (percentage) with the host rock and the quantity of the mineral that will be recovered from the concentrator plant.
- Estimated working cost.
- Capital expenditure over the LoM; and
- Rehabilitation and other liabilities.
1.1. SAMREC compliant Mineral Resources

Quality analysis and quality control (QA/QC) is important during the conversion of a mineral deposit to mineral resource. QA/QC ensures the reliability and validity of reporting of mineral resources and reserves. The quality of the work done by mining and exploration companies is monitored by independent auditors who ensure that the reporting on the mineral asset is compliant with the SAMREC code.

Exploration results, used in estimating a mineral resource, were collected in the following manner:-

- **Geological mapping.** A detailed surface geological mapping was carried out with the aim of delineating the subcrop and outcrop positions of the mineralised layers.
- **Aerial survey.** Aerial and ground photo control surveys were used to determine the contours of the area of interest.
- **Borehole core drilling.** Drilling was done in order to identify the position of the mineralised bearing layer below the surface.
- **Core logging.** Core logging followed drilling and involved identifying different subsurface rocks and identifying the mineralised layer from the drilled core.
- **Sampling.** Sampling was carried out to remove part of the mineralised layer from the core and sent to the laboratory for analysis; and
- **Laboratory analysis.** The mineral quality (grade) and specific gravity within the host rock was determined using laboratory techniques.

Following the exploration results, the mineralised area was identified and a SAMREC compliant mineral resource was estimated as indicated in Table 1 below:
Table 1. Mineral resource estimation

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Tonnes (000)</th>
<th>Contained mineral (000) tonnes</th>
<th>Mineral grade (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>11460</td>
<td>3384.90</td>
<td>29.50%</td>
</tr>
</tbody>
</table>

1.2. SAMREC Compliant Mineral Reserve

Feasibility (techno-economic) studies were then conducted in order to upgrade a mineral resource to a mineral reserve. The modifying factors used for the conversion were:-

- **Governmental.** This included all legal and licensing that was required such as the mining right and water use licence which include an integrated water and waste management.

- **Environmental.** This involved all the environmental issues that are going to be affected by the mining process. It includes the effect on the land, traffic, ecology, surface and ground water, air quality, noise, heritage, social and the economy. According to the Environmental Impact Management Act 62 of 2008, all applicants of mining rights are required to prepare an environmental management program. The environmental management program needs to be approved first before the mining right is approved. An environmental management program entails the implementation of the environmental program during mining. In addition, the Mineral and Petroleum Resources Development Act 28 of 2002, requires all mining companies to have a rehabilitation trust fund in which annual contributions are made in preparation for closure and rehabilitation of the mined out areas.

- **Mining.** This involves designing the mine, which takes into account the mining method to be used, access to the mineralised layers, personnel
and material handling, ventilation, water, power and other technical requirements including mine production and scheduling.

- **Metallurgical test work.** This involves testing alternative ways of extracting the mineral of interest from the host rock. The preferred method will be used in the plant to concentrate the mineral; and

- **Marketing and Economic.** This involves investigating global supply, demand, prices and trade of a particular mineral commodity.

The above modifying factors were applied to the mineral resource and a mineral reserve was estimated as shown in Table 2. The mineral grade (quality) was reduced in order to allow for an increase in tonnages.

### Table 2. The Mineral reserve statement of the mineral project

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Tonnes (000)</th>
<th>Contained Mineral (000 tonnes)</th>
<th>Mineral grade (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>12970</td>
<td>3314.10</td>
<td>27.20%</td>
</tr>
</tbody>
</table>

#### 1.2. Capital Expenditure

The following capital expenditure needed to begin mining was revealed during the feasibility studies (Table 3).

### Table 3. Estimated initial capital expenditure needed to begin mining

<table>
<thead>
<tr>
<th>Discipline Activity</th>
<th>Costs (R/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Purchase</td>
<td>R 35.7</td>
</tr>
<tr>
<td>Mining</td>
<td>R 35.209</td>
</tr>
<tr>
<td>Concentrator plant</td>
<td>R 604.521</td>
</tr>
<tr>
<td>Tailings Dam Facility</td>
<td>R 33.444</td>
</tr>
<tr>
<td>Water Supply</td>
<td>R 54.893</td>
</tr>
</tbody>
</table>
Rehabilitation and Closure  R 5.666  
Owners costs  R 40.639  
**Total**  R 810.071

The total initial capital expenditure required to execute the project, was estimated to be R 810.071m and excludes; growth allowance, escalation, contingencies, accuracy provisions, allowances for ongoing capital expenditure and working capital. The mineral reserve will be mined for 12 years.

### 1.4. Operating Cost

Table 4. Total operating costs for producing high grade mineral

<table>
<thead>
<tr>
<th>Discipline area</th>
<th>Cost (ZAR/ tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>R 460.50</td>
</tr>
<tr>
<td>Concentrator plant</td>
<td>R 435.99</td>
</tr>
<tr>
<td>Tailings dam facility</td>
<td>R 10.57</td>
</tr>
<tr>
<td>Water Supply</td>
<td>R 19.94</td>
</tr>
<tr>
<td>Rehabilitation and closure</td>
<td>R 24.31</td>
</tr>
<tr>
<td>Owners Cost</td>
<td>R 63.15</td>
</tr>
<tr>
<td>Transport</td>
<td>R 315.27</td>
</tr>
<tr>
<td>Social and labour plans</td>
<td>R 6.29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>R 1336.05</strong></td>
</tr>
</tbody>
</table>

The total operating cost was based on an average annual concentrator plant throughput of 1,000,000 tonnes per annum (tpa) run off mine (ROM). Production is, on average, 700,000 tpa high grade mineral and is estimated at R1 333.05/t of the mineral produced (Table 4).
1.5. SAMVAL Code and Valuation Methods

1.5.1. DCF approach

The calculation is shown in table 5 below. The inputs used are as follows:

- Mineral price = US$ 314
- Exchange used= R 8.20
- Discount rate = 12 % per annum
- Expected Inflation = 10%
- Taxation = 30%

Under these assumptions a NPV of R 444.887 m was placed on the project. The IRR was 20.18% per annum.
### Table 5. NPV Calculation

<table>
<thead>
<tr>
<th>NPV Model years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate R/US $</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Mineral price US $/oz</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
<td>314.48</td>
</tr>
<tr>
<td>Ore production tonnes</td>
<td>1,000,000</td>
<td>1,000,000</td>
<td>1,000,970</td>
<td>2,000,000</td>
<td>2,000,000</td>
<td>2,000,000</td>
<td>1,000,000</td>
<td>1,000,000</td>
<td>1,000,000</td>
<td>1,000,000</td>
<td>1,000,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Mineral grade %/t</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
<td>27.20</td>
</tr>
<tr>
<td>Mineral production tonnes</td>
<td>-</td>
<td>-</td>
<td>700,000</td>
<td>700,000</td>
<td>700,000</td>
<td>1,400,000</td>
<td>1,400,000</td>
<td>1,400,000</td>
<td>700,000</td>
<td>700,000</td>
<td>700,000</td>
<td>-</td>
</tr>
<tr>
<td>Revenue ZAR</td>
<td>1,761,088,000</td>
<td>1,761,088,000</td>
<td>1,762,796,255</td>
<td>3,522,176,000</td>
<td>3,522,176,000</td>
<td>3,522,176,000</td>
<td>1,761,088,000</td>
<td>1,761,088,000</td>
<td>1,761,088,000</td>
<td>1,761,088,000</td>
<td>1,761,088,000</td>
<td>1,761,088,000</td>
</tr>
<tr>
<td>Operating cost ZAR</td>
<td>1,336,050,000</td>
<td>1,336,050,000</td>
<td>1,337,345,969</td>
<td>2,672,100,000</td>
<td>2,672,100,000</td>
<td>2,672,100,000</td>
<td>1,336,050,000</td>
<td>1,336,050,000</td>
<td>1,336,050,000</td>
<td>1,336,050,000</td>
<td>1,336,050,000</td>
<td>1,336,050,000</td>
</tr>
<tr>
<td>Operating margin ZAR</td>
<td>425,038,000</td>
<td>425,038,000</td>
<td>425,450,287</td>
<td>850,076,000</td>
<td>850,076,000</td>
<td>850,076,000</td>
<td>425,038,000</td>
<td>425,038,000</td>
<td>425,038,000</td>
<td>425,038,000</td>
<td>425,038,000</td>
<td>425,038,000</td>
</tr>
<tr>
<td>Capital cost ZAR</td>
<td>300,000,000</td>
<td>510,000,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta w cap ZAR</td>
<td>700,000,000</td>
<td>323,000,000</td>
<td>333,688,506</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(334,012,500)</td>
<td>-</td>
<td>-</td>
<td>(700,200,000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital allowances ZAR</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td>90,000,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxable income ZAR</td>
<td>246,983,600</td>
<td>246,983,600</td>
<td>247,310,474</td>
<td>583,967,200</td>
<td>583,967,200</td>
<td>583,967,200</td>
<td>246,983,600</td>
<td>246,983,600</td>
<td>246,983,600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax (30%) ZAR</td>
<td>74,095,080</td>
<td>74,095,080</td>
<td>74,193,142</td>
<td>175,190,160</td>
<td>175,190,160</td>
<td>175,190,160</td>
<td>74,095,080</td>
<td>74,095,080</td>
<td>74,095,080</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cashflow ZAR</td>
<td>(300,000,000)</td>
<td>(359,904,600)</td>
<td>(282,891,402)</td>
<td>266,085,550</td>
<td>498,777,040</td>
<td>498,777,040</td>
<td>498,805,940</td>
<td>262,888,520</td>
<td>262,888,520</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cum cashflow ZAR</td>
<td>(300,000,000)</td>
<td>(359,904,600)</td>
<td>(542,796,002)</td>
<td>498,777,040</td>
<td>997,554,080</td>
<td>997,554,080</td>
<td>997,360,940</td>
<td>262,888,520</td>
<td>262,888,520</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payback period</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.24</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Discounted CashFlow ZAR</td>
<td>267,857,142.86</td>
<td>406,568,877.55</td>
<td>(406,568,877.55)</td>
<td>(267,857,142.86)</td>
<td>(267,857,142.86)</td>
<td>(267,857,142.86)</td>
<td>(267,857,142.86)</td>
<td>(267,857,142.86)</td>
<td>(267,857,142.86)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max cash exp</td>
<td>267,857,142.86</td>
<td>406,568,877.55</td>
<td>267,857,142.86</td>
<td>267,857,142.86</td>
<td>267,857,142.86</td>
<td>267,857,142.86</td>
<td>267,857,142.86</td>
<td>267,857,142.86</td>
<td>267,857,142.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV(12%)</td>
<td>444,877,439</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>20.18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount rate</td>
<td>12%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. NPV Calculation.
1.5.2. The Market Method

The method requires comparison with relatively recent transactions of mineral assets that have similar characteristics to those of the assets being valued. A search for recent transactions on similar mineral projects is done on the public domain and the following similar fluorite transactions were identified (see Table 6 below).

<table>
<thead>
<tr>
<th>Company</th>
<th>Mine (Fluorite)</th>
<th>Seller</th>
<th>Year</th>
<th>Price (ZARm)</th>
<th>Paid (ZARm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koppies Ltd</td>
<td>Wilton</td>
<td>Lebowa Lebowa Mining Company</td>
<td>2 June 2012</td>
<td>R 340</td>
<td>R 340</td>
</tr>
<tr>
<td>Empire Ltd</td>
<td>Capstar</td>
<td>Viljoen Viljoen Mining</td>
<td>30 June 2012</td>
<td>R 365</td>
<td>R 365</td>
</tr>
<tr>
<td>Verge Ltd</td>
<td>Verge</td>
<td>Meter Meter Mining</td>
<td>4 April 2012</td>
<td>R 400</td>
<td>R 400</td>
</tr>
</tbody>
</table>

All of the above transactions occurred at arm`s length. The transaction occurred in 2012 and the value of the fluorite mine was estimated at between R 340m and R 400m based on this approach.

1.5.3. The Cost Method

Domingo & Lopez-Dee (2007) and SAMVAL code (2008) have indicated that the cost approach is mainly suitable for exploration and not mining properties.
1.5.4. The Real Options Method

Valuation using this method was not done, because the method is not well understood in South Africa.
# Appendix 2.

## Financial Valuation of Mineral Assets

<table>
<thead>
<tr>
<th>Name of Respondent</th>
<th>Level of Respondent</th>
<th>Commodities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Valuation Methods

Which method/s is mostly used during capital budgeting. Mark the answer with an X

<table>
<thead>
<tr>
<th>Method</th>
<th>Never</th>
<th>Seldom</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payback Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Options</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others /Specific Combinations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please circle a reason why the Real Options method is not recommended by SAMVAL Code.

1) An oversight.
2) Too complex and hence not widely understood.
3) Do not know.

Why is the preferred method used?
Below is a list of some advantages and disadvantages of the stated valuation methods. Please choose dis/advantages that lead to the choice above.

Internal Rate of Return (IRR)
Disadvantages
- It ignores the scale of the investment (it can mislead where there are competing projects of different sizes).
- It has difficulty handling projects with unconventional cash flow.

Advantages
- It discounts future cash flows, not the real yield.
- It is an indicative of the yield from an investment opportunity.

Payback Period
Disadvantages
- It is not concerned with the profitability of the project, but its payback period.
- Cash flows arising beyond the payback period are ignored.
- It does not take the time value of money into account.
Advantages
- It recommends projects that pay for themselves quickly.

Net Present Value (NPV)

Disadvantages
- The assumptions and expectations made on the actual income flow make it difficult to determine the cash flow of a project.
- It is very important to choose an appropriate discount rate for NPV calculation.
- The method is based on the assumption that a positive NPV will be accepted regardless of the capital required.
- NPV uses information known at the time of the completion of the analysis and does not allow any future changes.
- NPV ignores embedded real options.

Advantages
- An NPV calculation recognises the time value of money.
- NPV accounts for the risks associated with a project using the income flows and the cost of capital as the discount rate.
- Unique risks are accounted for during the NPV calculation.

Cost Method

Disadvantages
- Experienced judgement is required to separate the past expenditures considered to be productive from those considered not to contribute to the value of the property.

Advantages
- It is applied to mineral assets which are currently being explored.
- It uses the exploration cost information and technical data that is available.
- Costs are covered.
Market Method
Disadvantages
- There is limited data on Mineral Asset transactions.

Advantages
- The method uses standard, accepted economic techniques.
- The method uses data based on observed consumer preferences.

Real Options Method
Advantage
- It accounts for managerial flexibility during valuation.
- It incorporates NPV and the value of managerial flexibility and mineral price volatility.