Methodologies in the valuation of mineral rights

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Synopsis

A number of countries have introduced codes governing the valuation of mineral assets and securities. The African continent will follow suit in due course considering the importance of the global minerals industry as it relates to the attraction of foreign investment. South Africa is to introduce the Petroleum and Minerals Development Bill legislating the involvement of previously disadvantaged individuals and communities in the country's minerals industry.

One of the challenges facing the successful implementation of such codes and bills lies with the abilities of independent valuators to value mineral properties and projects on a consistent basis. Certain valuation principles and methodologies are applicable in all jurisdictions in the minerals industry. These valuation tools and principles are considered and developed in this report. They have been discussed and developed to encourage minerals valuators to consider and consistently apply the most applicable valuation methodologies.

Introduction

Frimpong (1992) considers four main uses of mineral property valuations:

- to highlight the value, viability and inherent uncertainty of a project
- to provide economic, technical and operational guidelines for exploitation of the property
- to form the basis for decisions relating to acquisitions, project financing, regulatory factors and taxation considerations and
- to afford management the flexibility to improve operating standards and control operating variances.

In addition, the valuation of mineral properties may be required for the following reasons:

- mergers and acquisitions transactions, including mineral asset disposals
- fair and reasonable opinions
- litigation
- security considerations for debt provisions by a financier
- expropriation considerations
- insurance claims
- accounting purposes and
- new listings and other equity raising exercises (rights offers, private placements, etc.).

Intuitively, in order to trade, purchase or dispose of mineral properties, an understanding of inherent value is required. The question of value has challenged individuals for many years, and recent developments in the resources arena have attempted to more closely regulate the industry including the valuation of mining properties and mineral rights. At a Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Annual Meeting convened in Quebec City, Canada, on 8 March 2000, Mr K. Spence, the Chairman of the Mineral Economics Society of the CIM, stated:

'There are varied methods and practices for valuing property, as there are industries in which they are applied. For example there are replacement value, insurance value, salvage value, appraised value, book value and fair market value.' (page 1 Spence, 2000)

Fair market value will be considered herein. Fair market value is equally applied to the determination of disposal and acquisition values as it is to the statement of value for purposes of fair and reasonable opinions as regulated by many stock exchanges across the world.

The Income Tax of Canada (Income Tax Act, R.S.C., 1985 (5th Supplement), c.1) defines Fair Market Value as:

'..the highest price, expressed in terms of money or money's worth, obtainable in an

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 SA ISSN 0038–223X/3.00 + 0.00. This paper was first presented at the SAIMM Colloquium: Valuation of mineral projects and properties: An African perspective, *19–20 March 2002.*

open and unrestricted market between knowledgeable, informed and prudent parties, acting at arm's length, neither party being under any compulsion to transact'. (page 7, CIMVal, February 2002)

Background

The proposed Petroleum and Minerals Development Bill intends to ensure equitable investment opportunities in the South African mining industry with a particular view to assisting Black Economic Empowerment (BEE) groups. One of the key considerations governing their entry into the mining and minerals industry is the question of fair value of their targets. That is, 'What represents a fair acquisitive price for the mineral property under consideration?'. Of course, the proposed acquisition price may not match the price at which the owner is willing to dispose of that property. In this instance, the State may have to intervene and the presupposed position of 'willing buyer—willing seller' may have to be encouraged by a third party and therefore compromised.

In general, the issue regarding fair price leads to a number of questions

- ➤ What is the purpose of the valuation (disposal, acquisition, liquidation, equity participation or debt capacity determination)?
- ➤ How is fair value determined for these mineral rights?
- ➤ Who determines the fair price for the acquisition and/or disposal?
- ➤ Are the valuations of the assets (mineral rights or mining operations) under consideration valued on a consistent basis and at arm's length?
- ➤ What level of subjectivity is adopted to determine the fair value?

The principles of valuation described in this paper are generic and can be applied to most commodities in any country whose national assets include mineral occurrences.

Valuation factors

The valuation of exploration properties is often considered to be a subjective rather than an objective process (Roscoe, 1986; Lawrence, 1988; Woodcock, 1989), significantly influenced by the qualifications and experience of the valuator. In brief, the explicit valuation of mining assets other than mineral rights, is not an onerously difficult task, assuming that certain key input parameters are known and that the valuator has access to the necessary modelling tools (and abilities). The key input parameters necessary to perform an explicit valuation include:

- ➤ reserve/resource statements (at stipulated cut-off grades)
- ➤ annual production profiles
- ➤ *in situ* grades (with anticipated recoveries) or yields
- ➤ total working cost assumptions and forecasts
- ➤ capital expenditure forecasts and

any other factor that may influence fundamental value (taxation policies, environmental considerations, potential retrenchment liabilities and future closure-related costs).

The only subjectivity in the analysis will be the assumed economic parameters used to determine the final value. These parameters are the mineral's projected price (existing spot price, forecast spot price and hedged price), exchange rate assumptions for products that generate revenues in a foreign currency (usually US Dollars), interpretation and application of taxation issues as well as the relevant discount rate applied to the resulting cash flow. Often it is the latter point, which will be discussed, that creates difficulties in concluding a consensus view on a valuation.

Decreased certainty exists in the determination of mineral property value, being non-producing mineral assets such as mineral rights or properties and resources that are excluded from operations' life of mine plans or feasibility studies. Numerous methodologies in the valuation of mineral rights have evolved over a period of time that form the basis for acquisition/disposal discussions.

Rand per hectare

Introduction to rand per hectare method

The R/ha method of valuing mineral rights is recommended where insufficient geological and related techno-economic information governing a mineral property exists. That is, a DCF valuation or any derivative of the DCF methodology cannot be used with confidence. The R/ha method has been developed specifically for use within the mining industry and continues to be refined over time as new transactions are completed. The method considers four key input parameters attributable to the mineral property in question, being the depth of mineralization below surface, the mineral category, its grade and its proximity to existing infrastructure.

The determination of values for mineral properties using the R/ha method relies upon the generation and use of a valuation matrix. The matrix is a compilation of factors combined or tabulated to provide an indicative valuing tool. It is therefore likely that valuators using this method will develop their own matrix dependent upon the information at their disposal and the consequent interpretation of such information. As a result of the subjective nature of the inputs to this valuation method, it is expected that the results regarding a mineral property, from two or more valuators, will differ to some extent. However, the order of magnitude by which their values differ will be small, assuming that the valuators have an understanding of the minerals industry.

The R/ha method and the US$/oz method are often referred to as the comparable transaction methods, which use the transaction price of comparable properties to establish a value for the subject property (Thompson, 1991; Roscoe, 1994; 1999, Ward and Lawrence, 1998). It is the valuator's responsibility to ensure that updating, modifying and improving the information base used as inputs for R/ha valuations occurs after each new transaction is completed in the industry.

In addition, the valuation of any mineral property will change as either the US$ gold price (or other commodity price) changes or in the event that the currency in which the property is located appreciates (or more likely depreciates) against its reference currency (usually the US$). If the commodity price or the local currency moves significantly over a relatively short period of time, the reference matrix discussed here (Table IV) will have to be adjusted accordingly. A short period of time will be determined depending on the period that has lapsed since the last valuation was completed using that specific matrix. For small moves in either of the two dependents, price or currency, the changes rendered to the matrix can be considered linear.

In the event that either or both of the two parameters (commodity price and the relative strength of the currency) move significantly over a short time period, the historical information used to compile the matrix will have to be adjusted to factor in the changes. The adjustment will not be linear and a new matrix may have to be compiled. It is wrong to assume that the percentage change in the commodity price or currency over that period of time can simply be applied to the historical value attributable to the valuation matrix. This is largely due to the non-linearity of the value relationship to commodity prices and currency.

Gold mineralization

Increasing demand for shallow gold-hosting deposits means that historical information governing transactions concluded over these mineral properties has been relatively simple to access. Gold mineral right disposals and acquisitions have recently been quite numerous in southern, central and West Africa, and to a lesser extent around the world. Australia is currently witnessing wholesale changes to its existing mining industry, although transactions are being conducted at a corporate rather than asset level. In addition, many of the transactions taking place involve existing operating mines and not mineral rights.

Matrix for input parameters

To determine or attribute value to mineral rights areas, a valuation matrix against which the key parameters were compared and awarded points has been devised. The matrix has been, and continues to be, modified (by the author) as and when new transactions are completed involving the acquisition and disposal of gold-bearing mineral rights. This caters for the dynamic nature of mineral rights transactions and ensures that new contemplated transactions and their associated values are based upon the most recent market transactions.

The four key assessment parameters relevant to a mineral right are:

- depth of mineralization below surface
- reserve/resource categorization
- *in situ* grade and
- proximity to existing mining or other essential infrastructure.

The four parameters are not all-inclusive and other factors such as multi-mineralic occurrences (i.e. multiple reefs or two or more mineral types occurring in one reef or on one property) as well as potential metallurgical and environmental inhibitors may impact on the final value determined for that area. A discussion of these factors is based upon the matrix shown in Table I.

The data provided in the matrix are the critically important parameters in the consideration of any gold-hosting deposit. They are the chief elements dictating costs and revenue in gold mines and provide the basis for the assessment of fair value for mineral property transactions. These parameters may be modified from time to time, although the tendency is to rather adjust the comparative table presented as Table IV.

Depth of mineralization below surface

The depth below surface of mineralization is often known through either the depth of intersection below surface of exploratory drill-holes, interpolation of known geologic occurrences through the use of seismic or sonar based surveys or alternatively through inference from surrounding mining operations or established drill-holes. The importance of this parameter is that it gives an idea as to the potential capital expenditure required to access the orebody. However, the depth of occurrence of mineralization will not singularly determine whether exploitation should be considered.

Depth below surface will also suggest the extent to which capital will have to be expended in order to ensure that underground working conditions firstly fall within the law in terms of ventilation requirements, as well as whether high-cost refrigeration equipment and reticulation systems for chilled water and/or air will have to be installed.

For purposes of the matrix, Table II suggests mining conditions at different depth categories.

As a general statement, many mining companies have embarked on a programme to replace deep-level gold mines with shallower operations. A significant reason for this shift is that new and expensive technologies, particularly in terms of access and support requirements, have to be used in deep mines. This together with the increased occurrences of seismic events occurring at greater mining depths that threatens workers' lives, can significantly reduce potential profits and negatively impact on the investor's perceptions of the operating entity.

Table I

Valuation matrix for gold mineral rights

Depth below surface		Resource category		*In situ* grade		Proximity	
km	Points		Points	g/t	Points		Points
0–0.3	0	Proven	0	0–1	7	Contiguous to HG*	1
0.3–2	1	Probable	1	1–2	6	Adjacent to LG+	2
2–4	2	Indicated	2	2–3	5	Non-contiguous	3
4–5	3	Inferred	3	3–4	4	Remote and large	4
+ 5	4	Blue Sky	4	4–5	3	Remote and small	5
				5–6	2		
				6–8	1		
				+8	0		

•HG—high grade; +LG—low grade

Table II

Depth below surface

Depth	Discussion
0–300 m	Open pit mining can be achieved to these depths
300 m–2 km	Extensive mining occurs down to 2 km using simple underground techniques
2 km–4 km	Increased mining activity is focusing on this depth range in South Africa as shallower deposits are depleted. Technical challenges increased
4 km–5 km	Very difficult mining conditions with rock mechanics and ambient rock temperatures being the major challenges. Option value exists
+5 km	Unlikely to be mined, although research continues into determining ways to mine high grade reefs at these depths. Option value exists

Reserve/resource categorization

In terms of using the R/ha method of mineral rights valuations, the terms 'reserves' and 'resources' do not explicitly reflect either the Joint Ore Reserve Committee (JORC, 1996) or the South African Code for Reporting of Mineral Resources and Mineral Reserves (SAMREC Code, 1998) codes of reserve and resource reporting although, as far as is possible, they should. Rather, the terms apply more loosely than these definitions with some reliance being placed upon the reporting entity or company and its standing in the mining industry. Hence, the parameter governing mineral categorization in the valuation matrix does not include an option for measured resources but does include the choice of 'Blue Sky'. The 'Blue Sky' category is very subjective and should only be considered for use by an experienced valuator.

The definitions for reserves and resources provided in Table III have been sourced from a number of competent person's reports, as defined and required by the JSE Securities Exchange South Africa, contained in circulars for the attention of shareholders in listed mining or mineral-related companies. However, considering the nature of mineral occurrences, these definitions cannot exclusively apply to the categorization of the types of mineral occurrences contemplated in this report. Some poetic licence will have to be tolerated for the classifications.

In situ *grade*

In conjunction with the previous two parameters, an understanding of the *in situ* grade of a mineral occurrence is essential in determining the ultimate value of the prospect. The estimated grade can be obtained from drill cores or other samples (such as bulk samples or trenching) or again by means of interpolation from surrounding geological information.

Historical experiences in the mining industry have suggested that gold grades of less than around 3 g/t for an underground operation will probably not be economically exploitable, whereas a deposit of similar grade occurring near surface most probably would be economic, both statements being gold-price dependent. Recent beneficiation advances resulting in improved recovery efficiencies have also resulted in lower grade deposits being economic. These improvements include leaching methods utilizing acid or bacterial leaching.

The *in situ* grade category does not take cognizance of the nature of occurrence of the gold, whether it occurs in oxides, transitional or sulphide material, or whether it occurs as free gold that is readily liberated from its host rock.

Proximity to essential infrastructure

The importance of the location of the mineral property is relevant since it could determine the extent to which capital

Table III

Reserve and resource definitions

Category	Description
RESERVES	
Proven :	The economically mineable part of a measured mineral resource. It includes diluting materials and allowances for losses that may occur during exploitation. Appropriate assessments have been completed and include consideration of assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. Exploration resulting in assayed core samples reflect the purported profitability of exploitation
Probable :	The economically mineable part of an indicated and perhaps measured mineral resource. It includes diluting materials and allowances for losses that may occur during exploitation. Appropriate assessments have been completed and include consideration of assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. However, lesser information than that for a proven reserve regarding its technical attributes of occurrence has been determined.
RESOURCES	
Indicated :	That part of a mineral resource for which tonnage, density, shape, physical characteristics, grade and mineral content can be estimated with a reasonable degree of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.
Inferred :	That part of a mineral resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes that may be limited or of uncertain quality and reliability.
Blue Sky :	An anomalous concentration of mineralization that can be inferred with less confidence than that for an inferred resource. No sampling has taken place, inference through adjoining properties is impossible, but expectations of mineralization run high.

may have to be expended on shaft developments, construction of beneficiating facilities and infrastructure ensuring the reliable availability of water and electricity. Not only will the proximity to existing mining and metallurgical infrastructure be considered important, but additional infrastructure such as access links (road and/or rail), water supply and electrical reticulation are considered equally important factors.

As can be expected, the proximity of mining operations to existing infrastructure becomes significant when the property is hosted in a country that does not have adequate infrastructure to support significant industrial activity such as mining. Many new mining operations established in Africa do not rely on national electricity grids for their power requirements, and instead have spent large capital amounts on diesel-powered electric generators (such as Sadiola Hill and Morila).

Assimilation of information

The valuation matrix ensures that gold mineral rights are valued on a consistent and equitable basis from one transaction to the next and from one jurisdiction to the next, as well as on a market-related basis. The market in this case is based in South Africa and is the market from which actual R/ha transactions have been collected.

The matrix provided in Table I above is used as follows:

- ➤ assign the necessary parameter category to the mineral right
- ➤ attribute the points associated with the assigned parameter
- ➤ sum the attributed points
- ➤ take the attributed points to Table IV below
- ➤ assign the corresponding attributable rating
- ➤ match the attributable rating with the applicable R/ha rating.

In the points summed column in this table it can be seen that gaps exist in the numerical sequencing. It then becomes discretionary as to which value to apply, taking into account other factors not already included in the critical parameters considered above. Additional factors would include reef width and type, rock mechanics factors, potential mining conditions and comparisons with other mining operations nearby or hosting similar conditions.

The final column in Table IV is determined based upon recent mineral rights acquisitions and disposals in South Africa and is, therefore, subject to continual refining and modification as new transactions are completed or economic fundamentals change.

Multiple reef occurrences

The application of the R/ha matrix valuation method can be easily extended to include mineral rights areas that host more than one economically exploitable reef. However, considering actual transactions that have taken place in the gold mining industry, it should be noted that although there may be, say, twice the amount of gold present *in situ* due to the existence of multiple reefs, the value attributed to that property is not doubled. The tendency is for the acquirer of the property to consider only the value of the main mineralized zone.

Non-gold mineralization

Introduction

The principles relating to the valuation of gold mineralization discussed in the previous section can be extended to the valuation of non-gold mineralized occurrences or mineral rights using the concept of gold-equivalence. As mentioned previously, the matrix discussed in the sections above is applicable only at a gold price similar to that for which the numbers tabled in the matrix were obtained. This consideration is equally applicable to the case where non-gold mineral rights are being valued using the principles of the gold matrix, or using the actual gold matrix through the concept and application of gold-equivalence.

Application considerations

Gold-equivalence is easily explained if one considers a PGM producing operation. In order to determine the platinum-equivalence of that operation, the revenues derived from the entire basket of metals sold, being typically platinum, palladium, rhodium, ruthenium, iridium, osmium and nickel, are each divided by the prevailing platinum price in order to

Table IV

Determination of applicable value rating

Points summed	Attributable rating	Attributable rating	R/ha applicable
1	1	1	70 000
2	2	2	65 000
4	3	3	60 000
		4	52 000
6	4–5	5	44 000
		6	37 000
9	6–7	7	30 000
		8	22 000
11	8–9	9	17 000
		10	13 000
13	10–11	11	10 000
		12	7 000
15	12–13	13	5 000
		14	3 000
17	14–15	15	1 000
+17	16	16 +	0

obtain, for each metal, a platinum-equivalent content. Thus, each PGM can be stated in terms of a platinum-equivalent content at that specific platinum price. The platinum-equivalent content can then be equated to a gold-equivalence, the basis of which is discussed in the following paragraph for base metals.

In order to extend the use of the R/ha matrix to base metals, the revenues derived from the proposed sale of the metals in question must be divided by the prevailing gold price in order to obtain a gold-equivalence. The resulting gold-equivalent content must then be divided by the estimated resource tonnage in order to obtain an anticipated gold grade. From the above exercise, the volume expressed in tonnes or ounces of metal, and grade of the deposit will now have been estimated in terms of gold-equivalence.

It often occurs that a base metal deposit is not tabular but rather occurs as a massive deposit extending vertically to significant depths. The determined values of these deposits would need to reflect the nature of the orebody and the commensurate fact that massive mining methods tend to experience lower unit working costs when based on the tonnes mined.

Where a mineral deposit is massive, the thickness of the deposit can be broken down into thinner slices of equal thickness. One slice will then be valued according to the principles discussed above and the resulting value will be multiplied by the number of slices representing the massive mineralized occurrence. The depth below surface to be used will be the average depth of the deposit below surface.

As one may have expected, the valuation matrix in its simple form cannot be used to assist in the derivation of value for fossil fuels, specifically coal, oil and gas and their associated deposits. The reasons for this are noted as follows.

- Coal property trades have been minimal in recent times (other than Eyesizwe's acquisition)
- Transactions are based on cents/tonne, which cannot be converted to R/ha owing to the physical properties of coal as well as to the end comparative markets of coal and metals. Coal qualities and sizes of product vary considerably such that no simple matrix can be derived that can be applied to all *in situ* coal
- Coal is consumable, with offtake largely secured by electricity facilities located adjacent to the coal properties or by industrial companies that use the coal for metal reduction
- Coal is a 'volume' product, with export limited by the availability of export entitlement through Richards Bay Coal Terminal (including the to-be-constructed South Dunes Coal Terminal), the Durban Coal Terminal Company and/or Matola located in Mocambique.

As will be discussed later in greater detail, certain difficulties arise when one attempts to apply this or any other method of valuation to mineral rights areas that reportedly host diamond deposits. In brief, geomagnetic anomalies may indicate the presence of kimberlite pipes, but these may not necessarily be diamondiferous. Alternatively, land occurrences incorporated in palaeo channels and marine occurrences equally present difficulties in terms of defining or estimating certainty relating to diamond grades and qualities. As a result, the R/ha method of valuation for diamond prospects should only be considered as a last resort, and even then, be applied with a high degree of scepticism by an experienced valuator.

Conclusions

The R/ha method of valuation is one of the most commonly used valuation methods for auriferous occurrences in South Africa. The method can be adapted and the matrices adjusted to include non-gold properties by either converting grades to gold equivalence or by radically adjusting the matrices to reflect non-gold transactions. Furthermore, the basis of the method can be used for almost any mineral property in any country in the world, but careful consideration must be applied in the application of the method to fossil fuel deposits and to diamondiferous occurrences.

US dollar per ounce

Introduction to US dollar per ounce method

The US Dollar per ounce ('US$/oz') method of mineral property valuations is extensively used throughout the world. In its simplest form, it is applied in a similar way to that already discussed for the R/ha method. That is, an *in situ* gold resource is calculated from exploration and/or interpolation results and, based upon recently concluded transactions within that country, a US$/oz value is attributed to that property. A number of mineral property transactions completed in Africa are listed in Table V.

The rated values vary from one country to the next dependent upon factors outside of the typical technical factors, such as the political stability of the region and country at large, its economic policies, taxation regimes and the perceived ease with which transactions and operations can be contemplated and concluded. Security of tenure is also a critical factor. A country in which mining activities are already taking place obviously provides the valuator with some useful insight into factors such as the application of mining law and general mining taxation principles. Numerous countries wishing to establish mining as a focus area for economic development offer entrants into their minerals industries tax holidays for periods of typically five years, and do not extend onerous tax rates to mining operations once these holidays have expired. However, those same countries also impose a policy of 'free-carried interest' clauses in their mining agreements.

These free-carried interests usually range from between 5 to 15 per cent of the project and are often associated with a state royalty based upon revenue derived from the

Table V

African mineral property transactions

Acquirer	Asset/property	Price paid (US$/oz)
Repadre Capital Investments	Golden Knight (Ghana)	5.05
Barrick Gold	Golden Ridge (Tanzania)	5.99
Gold Fields Limited	Iduapriem (Ghana)	6.31
AngloGold Limited	Geita (Tanzania)	28.08
AngloGold Limited	Morila 40% (Mali)	55.00
Gold Fields Limited	Abosso Goldfields (Ghana)	29.38
Harmony Gold Mine Limited	Elandsrand & Deelkraal (SA)	15.85

exploitation of the asset. It is tantamount to a tax. In terms of mineral rights valuations, the anticipated royalty resulting from the free-carried interest should be deducted from the value determined for that property or the resulting value should be reduced by the free-carried percentage interest. This represents consistency in that the free-carried interest for a mining operation is deducted from the revenue used as the basis for that specific valuation. These factors all play a role in determining values of mineral properties.

Non-gold deposits

The unit rates paid for the assets indicated in Table V above are specifically for gold-hosting properties since the determination of the cross-referencing final numbers have been based on mineral rights hosting gold mineralization. Intuitively, the US Dollar per ounce method can be extended to non-gold properties by either determining gold-equivalent compositions of the properties and then using the existing matrix, or by modifying the matrices to reflect transactions that have taken place in non-gold mineral rights.

Diamond deposits

The diamond industry has been, and to a lesser extent continues to be, very tightly controlled by a few industry players. Russian diamond production, as with its palladium production, presents an unknown volatility factor in the diamond industry in terms of the supply side of uncut stones, which makes it difficult to value diamond operations and assets due to the uncertainty introduced by this factor into the international diamond market and hence diamond prices.

A further point worthy of note is the ownership and retention of diamond assets. Transactions involving corporate entities have taken place fairly recently (Trans Hex purchased Benguela Concessions Limited and Gem Diamond Corporation Limited, while De Beers has been purchased by a consortium and has been delisted), but very few transactions involving diamond properties have occurred. This leads to challenges when attempting to compile a valuation matrix since historical acquisition/disposal data is limited.

Diamond deposit valuations are discussed below under their three main occurrence settings, being kimberlite pipes, alluvial deposits and marine deposits.

Kimberlite pipes

Diamondiferous kimberlite pipes present the simplest occurrences of diamonds in terms of valuations. In general, once delineated, a kimberlite pipe maintains an almost uniformly declining grade and quality of stone down to depth, allowing for the application of numerous valuation techniques, such as DCF, US$/oz or R/ha. However, in terms of a mineral right area, a number of complexities arise regarding valuations.

➤ Diamond exploration areas are generally extensive
➤ Geomagnetic surveys will identify kimberlite occurrences but cannot identify diamondiferous pipes
➤ Unlike other commodities, diamonds vary in value dependent upon a number of factors. The nature of the diamond occurrence cannot be identified in a mineral right, and only once drilling has been conducted can diamond qualities (values per carat) be estimated.

Therefore, the valuation of mineral rights anticipated to host diamondiferous pipes cannot be completed with any degree of certainty, and only the prospectivity of such an area can be considered. Ideally, for these mineral rights, the seller should accept a nominal up-front payment for the mineral right and should also share in the potential of the mineral right area through a retained equity participation.

Alluvial deposits

Significant geological uncertainty and discontinuity exists in inland alluvial diamond deposits, making valuations difficult. To the extent that sufficient bulk samples have been taken in the areas determined to host the palaeo-channels, an indicative life of mine plan can be compiled and a DCF can be performed. The difficulty lies more with the attempted valuation of alluvial mineral rights where no bulk samples and/or exploratory drilling has taken place.

Alluvial diamond deposits are the result of rivers coursing over the terrain thousands of years ago, having initially eroded kimberlite pipes. When the river was rerouted as a result of, say, the raising or lowering of the sea level which in turn alters the energy of the flowing river, a palaeo-channel is defined. This old river course may, depending on the depositional regime, have deposited diamonds along areas of lowering energy or into ‘value traps’, being potholes or deeper river channels. The importance of this geological setting is to highlight the irregularity and discontinuous expected occurrence of alluvial diamonds. The ideal mode of valuation will intuitively be one in which a nominal amount is attributed to the potential of the mineral right, and a residual value is then afforded the seller through participation in any future revenues derived from that property by means of an equity participation. This is not always possible since the acquirer may not agree to any free participation and hence desires an outright purchase.

Converting the R/ha method of valuation to assist in alluvial valuations is therefore encouraged. It must be borne in mind that alluvial diamonds that have survived hundreds of kilometres of harsh, abrasive water-borne travel are usually good quality, higher value stones. Therefore, cognizance must be taken of this fact when considering the development of a valuation matrix.

Marine occurrences

Marine diamond occurrences are irregular and difficult to define with any level of certainty. Sampling the seabed to prove up a mineral resource is a painstaking and costly process. An additional difficulty is that marine diamonds tend to be smaller and less valuable than alluvial diamonds for the same reasons that the bigger, higher quality stones occur inland. Again, an adaptation of the R/ha approach of valuation, where a DCF cannot be performed, is suggested. Cognizance must be taken of the vast area contained in any specific marine concession area, which typically extends over hundreds of square kilometres at varying sediment thicknesses.

As a result of the vastness of all marine concession areas, the R/ha matrix should be reduced to a R/m^2 basis. This will conform to the way in which marine diamond producers report on their diamond grades. Intuitively, marine diamond occurrences are even more difficult to estimate than land-based deposits, largely as a result of the comparative ability and associated cost of obtaining necessary pertinent information. Marine diamonds typically occur in localized channels on the sea bed and therefore exploration sampling has to be undertaken within these channels. Therefore, in any large concession area, the greater portion of the concession will be non-diamondiferous or alternatively sub-economic.

Market capitalization per ounce

For listed resource companies, the market capitalization of that company expressed as a function of the JORC (or SAMREC) compliant reserve ounces (or both the similarly compliant reserve and resource ounces) gives the valuator another factor upon which comparable values can be expressed. For minerals analysis, the market capitalization per ounce method is used by mining analysts who compare how listed mining entities fare with their peers on this basis.

Certain factors take precedence from one country to the next so that the value of a South African company will not be identical to the value of, say, an Australian or American company, each being attributed value by the market and compared on a market capitalization per ounce basis. It is an unwritten fact that South African ounces are attributed lower values than non-South African ounces. That is, an ounce of South African gold is perceived by the market to be worth less than an ounce of non-South African gold, as shown by the data provided in Table VI.

This can be argued when one considers implied discount rates on cash flows based on operations in and external to South Africa. That is, the markets' perception of risk, being both country risk and operational risk related to the South African gold mining industry and the non-South African industry.

Market capitalization per ounce is also a useful method for 'in-use' valuations. By in-use it is meant that the project under consideration is already in production or is at least being extensively explored and sampled. The obvious limitation to this method of comparative valuations is that the minerals company or operation has to be listed on a stock exchange so that a market-determined value of the entity exists (market capitalization). Although this may sound simple enough for a listed mining entity, consider the case whereby a minerals company is listed and its equity free-float is low. This impact of illiquidity in its stock will result in the market being constrained to inefficiency and the resultant market value of the entity will be impeded, rendering this mode of valuation unreliable.

Market capitalization per annual production ounce

A variation of the market capitalization per ounce method of comparative valuations for exchange-listed and operating mining assets is the market capitalization per annual production ounce. Although this is also not a true valuation tool, it does offer a means of comparing how the public or market rates two listed, mineral-producing entities. Consider the unit valuations for mining companies in Table VII, reflecting share prices translated to market capitalizations of JSE listed gold counters.

Conclusions

The US$/oz method of valuation has an international appeal owing to the bench-mark currency that is used. Intuitively, converting US$ to a local currency will depend upon the applicable currency conversion rate and since vast volumes of the world's natural resources are exploited in Third World countries, currency volatilities render direct conversions inappropriate. Currently, within smaller jurisdictions, this method of valuation is used extensively.

Discounted cash flow

Introduction to the discounted cash flow method

The DCF valuation technique (Van Horne, 1977, Schwab and Lusztig, 1969) is widely used, involving the modelling of critical input data and determining a resultant cash flow. The method is based upon the principle that for any initial investment in a mining opportunity, the investor will look to the future cash flows to provide a minimum return over their hurdle rate on that investment. The hurdle 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.

The critical input data referred to above will generally be incorporated in a comprehensive life of mine ('LoM') plan, such as that accompanying a pre-feasibility or a bankable feasibility study, and will include:

- reserves and resources associated with the proposed operation
- the forecast tonnage profile on a monthly or annual basis
- the grade distribution and recoveries expected (yield)
- forecast working costs
- the anticipated capital expenditure profile over the life of the operation and

Table VI

Market capitalization per ounce comparatives

Listed company	Market capitalization per resource ounce (US$/oz)
AngloGold	9.19
Gold Fields	15.60
Harmony	3.58
Western Areas	9.86
Placer Dome	35.66
Barrick	75.43
Normandy	19.66
Homestake	83.53
Newmont	70.45

Table VII

Unit valuations for listed mining companies

Listed company	Share price (cps)	Issued shares (mill)	Market capitali-zation	Annual ounces produced (Moz)	Market cap per production ounce (US$/oz)
AngloGold	30 700	107.2	32 905	7.0	522.3
Gold Fields	4 280	456.0	19 518	3.8	570.7
Harmony	5 160	144.6	7 459	2.1	381.9
Durban Deep	1 020	157.0	1 601	1.0	177.8
Western Areas	2 400	105.4	2 529	0.4	749.3

- rehabilitation, retrenchment, plant metal lock-up and other specific circumstances and/or liabilities surrounding the operation.

Working capital balances are generally calculated based upon historical balance ratios, applied to forecast revenues and working costs.

The resultant cash flow is then manipulated to derive the net present value ('NPV') of the operation at a pre-determined discount rate or a range of discount rates. The derived NPV or return on investment is used as a proxy for the operation's implicit value, which is often compared with the value or return attributed to the operation by the market, or compared with other investment opportunities.

The NPV of the project, derived from the DCF technique, can be formulated as follows:

$$NPV = \left(\sum_{t=0}^{n} C_f / (1+r)^t \right) - I_c$$

where:

C_f = anticipated free cash flow at time t in real terms;
t = time/period in which the cash flow occurs
r_r = real discount rate adjusted to reflect risk
I_c = present value of the capital outlay to bring the project to account.

The determination of the free cash flows upon which a valuation is based is dependent on the party considering the project. That is, the property owner will be considering the development of the property based on certain economic input assumptions. In the event that he is a seller of the property, certain base input assumptions may vary. These base input assumptions will not include the technical inputs to the project, but rather factors such as discount rates, metal price forecasts, inflation rates, rehabilitation liabilities and other less tangible inputs.

On the other hand, an acquirer of the property will use his own economic inputs probably including a higher discount rate, lower metal prices and a more positive view of the relative currency in which the property is being valued. Alternatively, a provider of finance (such as a bank), whilst using his own input economic parameters, will in addition impose certain covenant ratios to the free cash flow to determine the robustness of debt serviceability.

In all of the above cases, however, the technical inputs of the project will not vary from one analysis to another. The more comprehensive and reliable the technical forecasts, the greater the certainty that can be placed upon the results of the valuation. It is apparent that a high level of confidence cannot be placed upon the inputs to a valuation of a mineral right that has very limited information available governing its occurrence.

Trigeorgis (1986) has shown that the DCF method of valuation reflects an important inconsistency in the derivation of project values. The inconsistency is management inflexibility, which results in DCF valuations incorrectly valuing projects due to management decreasing downside forecasts or potential difficulties whilst simultaneously hyping the upside potential in the project, to factor in uncertainty. In addition, as far as DCF techniques are concerned, the inability to defer investment decisions could introduce high opportunity costs that cannot be factored into a DCF analysis.

Application of method to mineral rights

The DCF method of valuation can be used where lesser technical information is available such as for mineral rights. Cognizance is then taken of this through the application of a higher discount rate and a greater weighting being placed on sensitized critical inputs. At this lower level of technical definition, the DCF will be based upon preliminary estimates of the key input parameters. In order to apply the DCF technique in these cases, a resource estimation must be available. In addition, the mineral content must either be known or can be imputed as a result of its proximity to other known mineral occurrences. Information regarding the depth of the mineral occurrence below surface and, if significant, its anticipated dip, would also be required. The geographic location of the mineral right in question will provide some comfort as to the likelihood of specific mineralization.

As a result of the difficulty in obtaining agreement on the appropriate inflation forecasts to use in the valuation of a project, often valuators exclude incorporating forecast inflation rates. This, in itself, may be construed to be an inflation assumption anyway, in that inflation is taken to be zero per cent per annum. Experience has shown that the impact of inflation in valuations should be considered largely due to the effect it has on the determination of taxation as a result of unredeemed capital balances and assessed losses that can impact future free cash flows.

Discount rates

'Riskless portfolios must, in the absence of arbitrage opportunities, earn the risk-free rate of interest.' (Hull, 1997, page 195)

From 1998 to 1999, when the US Dollar gold price traded between US$280 to US$300 per ounce, it was observed (by the author) that listed South African gold mining operations reflected discount rates of between 3 per cent and 8 per cent in real terms. These were market-attributed discount rates. The more marginal the gold producer, the higher the applicable discount rate. However, the use of an applicable discount rate tends to vary from one valuator to the next, especially in the case where their valuation purposes and industry roles differ. An applicable discount rate suggested for use in considering a mining property will typically depend on three important aspects. These are:

- the long-term risk-free interest rate
- the perceived mineral property/project risks and
- country (political, social) risk.

The long-term risk-free interest rate can be obtained from the yield on a government bond, being the guaranteed risk-free return on money invested in the acquisition of that specific bond. Some risk-free rates, or yields, dependent upon the bond's time to maturity, are indicated below. They are given in nominal money terms and therefore the current inflation rate will have to be deducted from the percentage returns to obtain the risk-free rate in real terms. In the following list, inflation has been taken to be 6.9% per annum. The figures in brackets indicate the time to maturity of the bond.

- R150 (2005) $10.7\%_{nominal}$ $3.8\%_{real}$
- R184 (2006) $11.1\%_{nominal}$ $4.2\%_{real}$

- R153 (2009) 11.3%$_{nominal}$ 4.4%$_{real}$
- R157 (2015) 11.3%$_{nominal}$ 4.4%$_{real}$

Country risk can be determined by considering a number of factors such as civil stability/unrest, economic policies, leadership and their principles (which are factored into international credit ratings, as conducted by, say, Moody's or Fitch), and other factors including 'free carried interest' in a project.

Other than using the market as the sole indicator of an applicable discount rate, economic and finance theory can be used to assist. Many discussions are available on the subject of the corporate cost of capital, but it is possible to determine an applicable discount rate for a specific operation based upon industry expectations in terms of an operator's expected internal rate of return ('IRR') or project return, the risk factors governing the potential impact on the IRR of that specific operation as well as general mineral project risks. The use of the corporate cost of capital is proposed by economic and finance theory to determine an applicable discount rate for an operation. It represents the weighted average cost of funds available, and is expressed as an interest rate based upon the following:

$$r_{WACC} = r_e p_e + r_d p_d + r_p p_p$$

where:

r_{WACC} = weighted average cost of capital (WACC) (Van Horne, 1977)

$r_{e,d,p}$ = proportional costs of equity, debt (after tax) and preferred stock (%)

$p_{e,d,p}$ = proportions of equity capital, debt (after tax) and preferred stock that make up the corporate capital, the sum of which is 1.00 (i.e. $p_e + p_d + p_p = 1.00$).

On an all equity basis, only the cost of equity needs to be considered, which gives rise to the application of the capital asset pricing model (CAPM) method (Van Horne, 1977) of determining the cost of equity capital. This assumes that the return on any one listed stock can be related to the attained return of the entire market by the following formula:

$$r_e = f + R\beta$$

where:

r_e = expected return on the stock

f = risk-free return

R = risk premium of market returns over long-term risk-free rates

β = Beta factor for the stock (coefficient of systemic risk).

Overall market risk is ascertained by determining the volatility of each of the share price histories of all of the listed stocks on the securities exchange. Typically three-month, six-month and one year volatilities are determined.

There are inadequacies regarding the use of the market-based beta, being the coefficient of systemic risk, for the valuation of mineral-based projects. These shortfalls include:

- Betas indicate the volatility of a share price and not of a specific asset within a listed company, such as a mineral right. That is, the volatility of a mineral property cannot be isolated
- Betas of a specific listed entity vary as the market varies and not independently of the market
- Betas vary over time so that the value of a project would also vary over time through a changing discount rate
- Owing to the cyclicality of the different minerals' prices, relative betas will vary so that a perfect correlation becomes improbable.

The previous discussion on discount rates alludes to the difficulties faced in assigning a specific discount rate to a mining operation or to a mineral right. The use of economic and finance theory methods to determine discount rates for mineral-related entities are therefore assigned an element of subjectivity, dependent upon the valuator's experience in assessing the minerals market and associated discount rates. However, the approach supported by economic and finance theory should be used as the point of departure.

Differential discount rates

Owing to the uncertainty placed upon the explicit derivation of a discount rate for mineral and other projects, it is proposed that differential discounting should be considered. That is, a project's cash flow is broken down into finite periods (typically years). In the event that, say, a high level of confidence can be placed on all factors contributing to a project's cash flow over the first six years, these years will be attributed a discount rate of 'x'%. If the level of certainty regarding the same input factors covering the next five years is lower, then a discount rate of 'x% + y%' should be applied. Again, the parameters driving cash flows beyond year eleven may be treated with even greater scepticism and therefore a discount rate of 'x% + y% + z%' may be applicable, and so on.

This greater confidence cannot be quantified and will depend upon the valuator's experience in mineral property valuations. The reason why greater confidence will be placed on the resulting value is because greater uncertainty is discounted at a higher discount rate, lowering that uncertainty's impact on value. By how much should the discount rate be increased to reflect the uncertainty in future cash flows? It is necessary to be able to qualify and justify the increase in the rate. This is adequately illustrated by comparing the discount rate increase with, say, a working cost increase without altering the discount rate, or a decrease in the revenue through a reduction in the commodity price by a specific percentage.

The question should be asked whether it is more correct to apply a higher discount rate in the line of increased uncertainty in, say, commodity prices, working costs or mining risks, or should a greater weighting be applied to the sensitivity result that introduces a similar discount rate effect? That is, should uncertainty be factored into the discount rate, or should it be considered in terms of the inability to achieve a mining plan and therefore be factored into the cash flow through increasing forecast costs or capital expenditure?

Another factor that must be considered when differential discount rates are applied is that if an operation forecasts expending significant capital during the course of its life in order to access new reserves, cognizance must be taken of the timing of the implementation of a new discount rate bearing in mind that a lag exists between expenditure and production. To clarify, a risk lies in that the capital outlay could be discounted at one rate whereas the generated cash flows could be discounted at a modified rate, creating an incorrect application of differential discounting.

Sensitivity analysis

Owing to uncertainties in key input parameters, sensitivity analyses to these parameters should be conducted. The determined critical value drivers, typically being commodity prices, production rates, working costs and capital expenditure forecasts, are altered through a step-wise approach. The resultant values are then considered, and the overall value of the asset is weighted according to the valuator's perception of applicable risk associated with each parameter.

Conclusions

The application of the DCF method of valuation tends to be limited to circumstances wherein sufficient technical information can be sourced to complete the cash flow assessment with a fairly high level of confidence. However, in the valuation of mineral rights, generally insufficient input information can be secured to comfortably complete this exercise. In the first instance, to address the level of uncertainty attributed to the technical inputs for the property, a close look at the discount rate that is to be used is considered. Once an applicable rate has been decided upon, the value of the property can be determined.

The use of differential discount rates can also be considered by a valuator in DCF valuations. However, the factors discussed above must be considered to ensure that the use of this technique does not compromise the integrity of the resulting valuation.

A further consideration that alleviates some of the uncertainty surrounding the use of discount rates is the equivalent impact that can be derived by altering technical inputs rather than discount rates. In the event that a DCF method is considered inappropriate due to the uncertainty regarding technical inputs, then a modified approach can be considered, such as option pricing, a method that will be discussed in detail later.

Tail-ounce derived valuation

Introduction to tail-ounce derived valuation method

A new method, based on the DCF valuation method, of mineral property valuation has been developed and applied on a number of occasions by the author. The application of the tail-ounce derived valuation method tends to be limited to mineral properties for which a DCF can be performed for more than around 5 years. In addition, the property or project being evaluated should host indicated and measured mineral resources over and above the mineral reserves included in its exploitation, or LoM, profile. That is, a LoM plan or mining profile can be estimated with a degree of certainty because it uses mineral reserves, but the mining profile does not consider the exploitation of the total mineral resource. Alternatively, in the event that mineral rights are to be valued, these rights must be located adjacent to an existing mining operation from which certain assumptions regarding its probable operating parameters can be assumed or inferred.

To apply the tail-ounce derived valuation method to a mineral property, the risk element of the technical projections can be partially mitigated through the application of a higher discount rate than would have been applied for a pure DCF valuation. Once the cash flow profile of the operation has achieved a steady-state in terms of mineral production, working costs, ongoing capital expenditure, working capital and taxation, the free cash flow is unitized to a US$/oz or a R/kg rate, or any other commodity related unit.

The unit annual rates, which must be deflated to real money terms and must have been discounted at an appropriately determined discount rate, are calculated over a pre-determined steady-state period and are then averaged to reflect a single, deflated and discounted unit rate. This calculated rate is then applied to the determined recoverable ounces (the tail ounces), that fall outside the LoM profile but with confidence fall within recoverable resources, dependent upon that operation's existing mining dilution and metallurgical recovery factors.

In determining the unit rate, the steady-state profile cannot include years in which significant capital expenditure is factored in. This tends to discard the first few years of a new deposit's proposed exploitation profile or an operation's future profile that incorporates once-off capital expansions or equipment replacement costs.

Application of the methodology

The method tends to be restricted to the following situations:

- where a LoM plan does not cover the exploitation of the entire reserve/resource base
- the valuation of an adjacent mineral right area where the adjoining area to that mineral right area is being exploited or at least has sufficient data available associated with it for a valuator to compile a DCF analysis of it and hence determine an applicable unit value rating and/or
- a mineral deposit that, through interpolation owing to its similarity in certain key aspects to an existing operation or project/property is comparable to that mineral right area.

It is possible that the identified orebody that is to be exploited initially represents only a portion of that operation's exploitable resource. The rest of the operation's production is then expected to be derived from either a separate orebody or from an extension of the same orebody that will need to be accessed and serviced through the development of new infrastructure. This situation can occur where the deposit's owner has already satisfied himself that establishing a primary operation is economic. Only after either being awarded financing or commencing exploitation does the owner identify additional resources that may be brought into the existing LoM plan at a later stage. This situation then introduces the possibility of applying the tail-ounce valuation method.

The overall mineral lease area may have to be treated as two or more separate valuation blocks, each being accredited its own sustainable unit value per volume of product. Once again the discretion of the valuator needs to be applied.

Non-gold occurrences

The tail-ounce valuation method is not limited to gold assets since its basis reflects operating and profit margins per unit of mineral recovered. This is simple to understand if a single commodity is to be produced from the proposed project area. However, for a multi-metal deposit, the already discussed concept of 'equivalence' is reintroduced. The margin that is to be used for a mineral right must be per unit of mineral recovered and therefore the production of more than one mineral from a single deposit can either be converted to an equivalent (one) metal, or the method can be applied to just one of the minerals recovered from the project. If the latter is considered, the determined consistency of occurrence of the entire basket of commodities produced from that deposit becomes critical. The impact will be that an erroneous value will result if the grades of the metals fluctuate considerably over the proposed life of the project. The difficulty arises from the fact that the margins attributed to by-product sales may fluctuate excessively and therefore present uncertainty in the proposed sustainable margin.

This complication for a multi-metal deposit can be addressed if the revenues, costs, capital expenditure and taxation can be stripped out of the cash flows used to derive the sustainable margin. The likelihood of this being possible, though, is remote.

The tail-ounce method of valuation is equally applicable to fossil fuel deposits as well as to diamond deposits. Coal deposits are also simple to value using this method. Only diamond deposits occurring as kimberlite pipes will present an opportunity to use this method, owing to the general consistency associated with the occurrence whereas alluvial and marine diamond deposits will be more difficult to value by this method because of their inconsistent accumulation of diamonds.

Tail ounce incorporating differential discounting

An extension to both the tail ounce method and the differential discounting method of mineral properties' valuations is a combination of the two methods. The principle considers the initial use of the tail ounce method to determine a sustainable margin for the project under consideration. Once this is determined, the margin rate is applied to the remaining tail ounces that reflect similar risk in terms of certainty to those ounces upon which the unit value was based. In the circumstances where the risk or certainty profile of the project changes, the valuator can consider applying a higher discount rate to the remaining ounces. This modification allows the valuator greater flexibility regarding uncertainty associated with either the input data or with uncertainty relating to future commodity prices. The greater the uncertainty, the greater the differential discount rate applied and as a result, the lower the impact the uncertainty will have on value. Hence, the valuator can apply greater confidence to the resulting value.

An alternative to the above would be to decrease the unit margin as the risk of the project increases, but the valuator would be hard-pressed to justify decreasing the unit margin by any specific factor or amount.

Option pricing in valuations

Introduction to the option pricing method

Option pricing as a means of valuing mineral rights and mineral projects is infrequently used in South Africa largely due to the methodology being inadequately understood and considered too complicated to use. Numerous researchers have contributed to option pricing theory (Cootner, 1964). Modern option pricing (Hull, 1997) is most commonly undertaken by means of applying the Black–Scholes model (Black and Scholes, 1973).

The application of option pricing theory seldom finds a use wherein the mineral right owner wishes to determine whether a property offers adequate returns in the event of exploitation, since the technique does not explicitly consider free cash flows as the determinant of returns or value. The option pricing methodology does not give the owner of the mineral right the necessary information (results) required to decide whether or not the property should be exploited. However, option pricing theory does provide an invaluable tool for mineral property valuations since it reflects such a property's option value, dependent upon that property's gearing to commodity price changes.

In terms of using this method of valuation for a mineral right hosting some degree of gold mineralization, the gold price can be considered to follow a Markov process. A Markov process is a particular type of stochastic process where only the present value of the gold price is relevant for predicting the future price. A stochastic process is one in which the gold price changes over time in an uncertain way. That is, the prediction of future prices is not dependent on past prices but rather only on the current price. Since the gold price is reflected in US Dollar terms globally, it is the US Dollar gold price that must be considered in option pricing for gold-hosting mineral rights. The US Dollar gold price is a stochastic variable.

The basis of valuation using the option pricing technique depends on the establishment and (perceived) accuracy of the DCF valuation model. The principle of the technique's application lies in the acknowledgement that a mineral property which hosts an exploitable commodity or mineral, whether economic or not, possesses an option value. Even if the spot price is so low that the property has a negative NPV, the property would probably have a positive value at a higher commodity price. This is especially important where the commodity price is expressed in the local currency since currency depreciation enhances the export value of minerals. The property therefore possesses an intrinsic value correlated to the commodity price and therefore has an option value.

This is easy to understand if the metal or mineral can be hedged or sold into a forward market. However, the application of the option pricing technique is not limited to only those metals that have an existing forward market since forward markets for specific metals are developed commensurate with their demand. The reasons behind poorly developed forward markets vary from one commodity to the next. For some, the volatility in commodity price based primarily on supply and demand fundamentals is the reason, while others reflect financial factors resulting in long-term contangos and backwardation.

An option is a contract that gives the holder the right and not the obligation to buy or sell the commodity or stock at some specific future date (European option) at a predetermined price, or at a specific price over a period of time (American option). This suggests that any deposit hosting a metal or commodity can at least be attributed some value on the basis of a contract or option. That is, a mineral deposit will have an implicit *in situ* value based upon the expectation that it will be exploited at some future date assuming that the (local) price of the mineral improves. That future-dated contract is tantamount to an option contract.

Consider a mineral project that requires an initial capital amount of US$150 million, but owing to uncertainties in metal prices and other factors at the time of the investment, may return either US$250 million or only US$40 million. Therefore, the net value of the project is either a profit of US$100 million or a loss of US$110 million. Assuming an equal likelihood for each outcome, the expected value of the project is negative US$10 million. However, if the capital investment decision can be delayed, the expected value of the project will change. That is, if the metal price is lower than at the time the decision was taken to potentially develop the project, the project will not be developed. The reciprocal is true. Therefore, the value of the project is represented by the value of an option to develop a project worth US$100 million with a 50 per cent probability.

The development of the option pricing valuation technique for mineral rights will be based upon European options in this report since they are simpler to both understand and evaluate.

Options are either 'put' options or 'call' options. Put options give the holder the right but not the obligation to sell the commodity at the pre-determined price at a specific point in time. Call options give the holder the right but not the obligation to buy the commodity at the pre-determined price at a specified point in time. Intuitively, these puts and calls can either be bought, a long position, or sold, a short position.

Put options increase in realizable value for the owner as the spot price of the commodity decreases, since the delivery price is fixed. Similarly, in the event that the commodity price increases above the delivery price, the option will not be exercised and the holder will only be out of the money to the extent that the option contract cost him money to enter/purchase it in the first place. For the owner, call options become more valuable as the price of the commodity increases, since he has the right to deliver the commodity at that higher price.

Hence, options valuations are focused on the value attributable to flexibility. Valuation techniques that ignore the value associated with the optionality inherent in a mineral property tend to undervalue that property because those methods do not take into consideration the additional value of flexibility in the face of future uncertain events. Therefore, in the event that two mineral projects are identical except that one has greater operational flexibility, then the project that has greater flexibility will have a greater value. The reason for this is that the project with greater flexibility affords the owner the opportunity to react to impending events in ways that will enhance the project's value or at least minimize its potential losses. Considering the less flexible operation, little opportunity exists for the owner to alter the course of the project in the event of inherent challenges.

Another important consideration for the use of the option pricing tool is that in which a decision needs to be made regarding whether an existing mining operation should be placed on care-and-maintenance (i.e. temporary closure) as a direct consequence of a change in economics, such as adverse metals price changes. Brennan and Schwartz (1985) used contingency claims analysis to model the temporary closure of a mine. Contingency claims analysis is a project evaluation framework that can model uncertainty resolution and claimholder interaction, having originated from models such as the Black and Scholes (1973) option pricing model.

To determine a range of values for a specific gold mineral property based upon this approach, the gold price that will result in the NPV being as close to zero as possible must be determined. This gold price represents the strike price of an option for that specific quantity of gold upon which the valuation is based. As discussed previously, the application of an appropriate discount rate is critical. Practically, the determined gold prices at which an operation's NPV is zero will constitute the option strike values at which gold call options could be written in respect of the property's estimated remaining LoM gold ounces over a desired option term. These option terms are typically 5, 7 or 10 year terms, which coincide with the option terms that are most often used in gold price hedging. As a general rule, a realistic term should be used.

That is, whilst a typical option holder would be perfectly geared to gold price fluctuations above the required option strike value, this would not apply to a gold mineral right holder. In terms of the mineral right, significant up-front capital and in due course operating expenditure necessary to turn the mineral right to account will be incurred. That is, for each R1/kg rise in the gold price the option holder would typically increase his profit and therefore the value of his investment by R1/kg. However, for the gold mineral right holder, the increase in unit value for each R1/kg increase in the gold price above the strike price will be less than R1/kg owing to the up-front expenditures.

The rate of change of the increase in the gold price, expressed as a unit of value (say, R/kg), relative to the rate of change of the increase in the mineral right value expressed in the same unit of value (in this case, R/kg) is referred to as the proportionality constant. Typically, for an undeveloped mineral right, the proportionality constant determined for that property will tend to be low (significantly less than 1.0 but greater than 0), indicating that the property either requires significant capital to be expended for its development or, more likely, the fact that mining of the proposed ounces of gold would only commence after either existing ounces in the LoM plan were depleted or indicating that the lead time to exploitation was significant. That is, the impact of the discount rate applied over time will also result in the determination of a lower proportionality constant.

The option pricing technique

The application of option pricing theory in determining values of mineral rights will require that each value-dependent element is adequately understood as it critically applies to this method of valuation and not necessarily explicitly to the valuations of options listed on a bourse. As a first point, cognizance must be taken of the existence and nature of option-value inherent in undeveloped mineral assets and mineral rights.

To introduce basic option pricing theory, an understanding of the Black-Scholes formula is required. The formula indicated below is the result of extensive research conducted by Fischer Black and Myron Scholes in the early 1970s on non-dividend paying stocks. The principle of a non-dividend paying stock can be extended to include mineral rights valuations for the following reasons:

- the lead-time to a mineral right being brought into production tends to be long. A long lead time, during which no dividends will be paid, will invariably cover the option term and
- once commissioned, the mining operation will still require repaying outstanding loans or may still be exposed to capital commitments, thus restricting the payment of dividends to beyond the option term.

The principle of option pricing in the valuation of mineral rights considers the construction and commissioning period in bringing that mineral right to account. Dividends will therefore not be paid during this period, and hence for purposes of valuation, the valuation of mineral rights can be considered to be of a non-dividend paying stock.

The Black-Scholes option pricing formula is:

$$c = SN(d_1) - Xe^{(-r(T-t))}N(d_2)$$

with

$$d_1 = \left(1n(S/X) + \left(r + \sigma^2/2\right)(T-t)\right)/\left(\sigma\left(sqrt(T-t)\right)\right); \text{ and}$$

$$d_2 = \left(1n(S/X) - \left(r + \sigma^2/2\right)(T-t)\right)/\left(\sigma\left(sqrt(T-t)\right)\right)$$

where:

c = European call option price (risk neutral valuation)
S = current R/kg gold price
X = strike price (NPV at 0 inflated to 5, 7 or 10 years)
$T - t$ = years to option's strike (5, 7 or 10 years)
σ = volatility
r = risk-free rate
$N(x)$ = cumulative probability distribution function with mean of zero and a standard deviation of 1.

It must be borne in mind that the Black-Scholes option pricing formula relies on certain assumptions. These assumptions are:

- interest rates remain constant over the option period and they are known
- the returns on the mineral properties are lognormally distributed and
- the volatility of these returns are constant.

The above assumptions may not always be valid under all circumstances for which the Black-Scholes option pricing formula may be used and the valuator should be aware of these limitations.

Conclusions

The lack of understanding in the minerals industry regarding the use and abilities to use the option pricing valuation technique has rendered the methodology less popular than warranted. This is unfortunate since the method takes into account factors that no other methodology does. Critically, the inclusion of flexibilty in terms of either starting a new project or placing an existing operation on care-and-maintenance while markets recover or new technologies are commissioned, must have attributed value above that of the inherent property/project value. This flexibility is attributed value in the option pricing method of valuation.

Multiples of exploration expenditure

Introduction to multiples of exploration expenditure method

Some mineral rights and property transactions have been considered and based upon a multiple of exploration expenditure quantum, and from these expenditures, an indicative value has been determined.

Baxter and Chisholm (1990) consider the use of the multiples of exploration expenditure method of valuation an acceptable approach to mineral property valuations provided that only expenditure relevant to significant exploration is included, and that the quality of the exploration work is considered acceptable.

In this valuation approach, the original owner of the property in question wishes to at least recover his exploration outlay expended on the property, but ideally wishes to secure a premium to that capital outlay. This method is also often referred to as the cost approach method. As can be expected in the application of this method, the seller's view on the time value of money becomes important in determining a price, whereas the potential acquirer will not share this point of view. Historical expenditures should be inflated for the passing of time in order to state the expenditure in money-of-the-day, or real, terms.

The cost approach method focuses on the amount that was spent on the property added to which, or deducted from which, is a premium, or discount, as the case may be (Roscoe, 1986, 1988). The premium or discount will depend upon meaningful historic exploration costs plus warranted future costs or any outstanding obligations. Commensurate with the above, the anticipated degree of mineralization on the property, based upon exploration results, or if insufficient drilling has been completed to at least sufficiently delineate a mineralized zone then based upon anticipated mineralization through inference, will ultimately determine whether the property should be attributed any value at all. Assuming that mineralization has been identified, it must be decided to what extent a premium to the original exploration expenditure may be offered.

Hence an intrinsic value of the exploration property can be based upon the exploration potential of that property (Roscoe, 1994, 1999) and, as discussed in this section, one measure of the exploration potential is the amount that has been or can be justifiably spent on the exploration activity. The cost approach is based on the assumption that an exploration property is at least worth the meaningful past exploration expenditures plus budgeted future costs to complete the exploration.

Historical exploration work is analysed to retain only those past expenditures that have resulted in the identification of mineralization (Thompson, 1991). On the other hand, budgeted future expenditure will be those anticipated costs associated with proving up to a higher degree of certainty the prospectivity or the actual occurrence of mineralization of that property. The cost approach is often referred to as the Appraised Value Method and is described further in papers by Agnerian (1996a) and Lawrence (1989, 1998)

Farm-in analysis

Often a junior mining company has performed some level of exploratory work, at a cost, on a mineral property but does not have the financial ability to either expend additional capital to improve the certainty of prospectivity of the property or to develop it. Typically under these circumstances, an approach is made by the junior mining company to a larger mining company that possesses stronger financial resources. However, there is a price to be paid by the larger mining house for that participation, being either some multiple of the already expended amount or an agreed-upon price suitable to both parties. This, of course, assumes that the junior company is not a desperate seller and that the sale or partial sale is not a 'fire sale'.

The larger company will have to 'earn-in' to the equity of the project either by means of an outright acquisition of some or all of the junior's equity, but more commonly through the continued funding of the development of the project in exchange for increasing equity commensurate with expenditure. Intuitively, as the larger mining company spends more on exploratory work and increases its equity stake in the project, the junior company's participation in that project is simultaneously diluted.

A notable premium will have to be paid to the junior company in the event that the larger company wishes to take either equity control or management control of the project. The junior company will thus become a passive shareholder in the project that may either participate in the profits of the eventual operation, or will possibly be paid a royalty based upon the commodity produced, effectively being a royalty on revenue. The junior company's shareholding often does not require it to contribute to the continued development of the project, although this may change in the event that an existing operation is to be expanded or a new, adjacent project is to be commenced.

Farm-ins are generally considered over a one-to-two year period beyond which the property will either be developed into a mining operation or the project will be shelved and exploration discontinued. Farm-ins do not follow a linear relationship between expenditure and equity participation. Typically, the more prospective a property becomes through exploration work, the greater the contribution to exploration required for lesser amounts of equity.

Conclusions

This method is used (and discussed) extensively in Canada and Australia (Roscoe, 1994, 1999), Agnerian (1996a), Thompson (1991) and Lawrence (1989, 1998) and therefore presents an opportunity for further development in South Africa as an accepted valuation methodology.

Summary

The need to understand the value drivers for mineral properties and the ability to effectively value mineral projects and prospects on a consistent basis is essential for the South African minerals industry. Numerous valuation methodologies have been developed over time, including:

➤ the Rand per hectare method

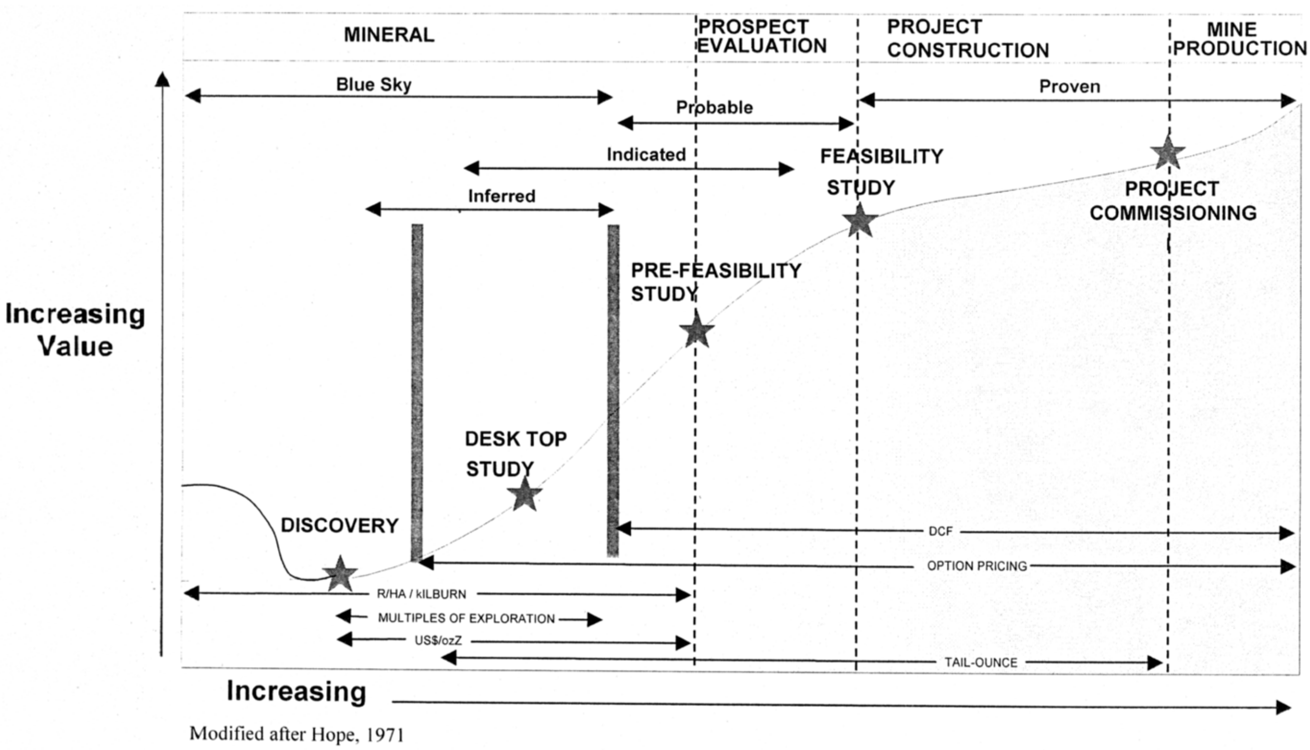

Figure 1—Valuation methodologies at various stages of project development

Table VIII

Key value drivers for mineral property valuations

Methodology	Metal prices	Exchange rate	Technical information	Economic information	Comparative transactions	Uncertainty Risk
DCF NPV	✓	✓	✓	✓	x	✓
Differential discounting	✓	✓	✓	✓	x	✓
R/ha	x	x	✓	x	✓	x
US$/oz	x	x	✓	x	✓	x
Tail-ounce	✓	✓	✓	✓	x	✓
Option pricing	x	x	✓	✓	x	✓
Exploration expenditure	x	x	✓	x	x	x

- the US Dollar per ounce method
- discounted cash flow methods
- tail-ounce derived valuation method
- multiples of exploration expenditure
- option pricing methods.

The applicability of each of these methods depends on the available information governing the property under consideration. A schematic representation of the preferred application of the various methods commensurate with levels of information attributable to specific properties is shown in Figure 1. The terms used in the diagram indicating geological certainty of mineral resources and mineral reserves are defined in Table III.

Figure 1 associates levels of certainty governing critical mineral property factors with mineral property value trends. That is, as the geological certainty of a mineral property improves, the valuation methodologies available to complete a valuation are broadened to include more accurate methods. For any mineral property that has to be valued, generally more than one method can be applied.

As a final consideration, Table VIII indicates the key value drivers that must be taken into account in order to determine the value of a specific mineral property using one of the methodologies discussed in this report.

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