An exploratory study of the Characteristics, Approaches and Methods of Valuation of Mines

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The perspective

The prediction of the value of metals and a mining company is a complex matter. Despite the fact that scientists have developed various methodologies to estimate properties and assets value (including company's value), many of these aren't applicable when it comes to the extraction industry. This is due to the heterogenetic nature of the industry, including but not limited to mining producers, financing of mining, finding the risk in terms of mining exploration, price cyclicality, dynamic nature of the industry and how it operates, capital cost structure, stock market vagaries, and circumstances volatility.

Introduction to Mines

Mining involves the removal of minerals and other geological resources from the earth. The process of mining asset valuation usually involves five phases: evaluation, development, production, closure, and reclamation.

Generally speaking, there are 3 main categories of mining assets, discussed below briefly.

• Exploration Assets:These are connected to the expenses incurred during the exploration and evaluation phases of the mining process. At this stage, the viability of extracting minerals and other geological resources has not been proven to exist.

• Development Assets:The viability of extracting minerals and other geological resources has been proven to exist by various studies, but the operation hasn't started yet.

• Production Assets:These relate to the mining projects that are in production

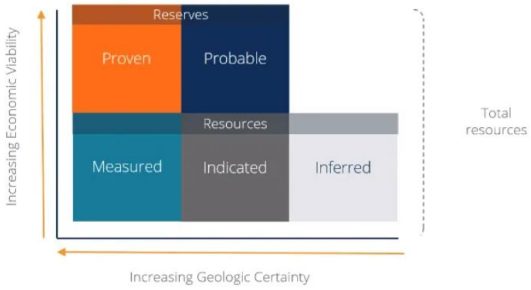
Metal Classification

The first thing to understand is before valuing mining projects, it's important to understand metallurgy. There are two main metal classifications.

• Ferocious Metals– Containing iron.
• Non- Ferrous metals- Containing (a) precious i.e., gold and silver (b) base i.e., aluminum and copper (c) minor i.e., cobalt and manganese.

The distinguishing factor between industrial metals and precious metal is, the industrial metals are driven bymarket factors (supply and demand factors), while precious metals are driven bysentiments.
The mineable (ore) reserves factor is the fundamental asset that underpins the value of any mining project. The tonnage and grade of any reserve are estimated from a limited number of samples which constitutes a very small proportion of the total deposit. Sampling, by its nature, is a statistical procedure and so is the estimating of the reserves. The estimates are subject to a greater or lesser degree of uncertainty. It is significant for a valuer to note that inaccurate analysis leads to an overestimation of reserves grade and an inadequate allowance for dilution leading to over-estimation in mined grade. This might lead to an overestimation of revenue.

• **Inferred** – This is when mineral resources can be estimated on the basis of geological evidence and limited sampling; reasonably assumed; but not verified. It is important to note that, at this point, there are only limited information and sampling gathered from outcrops, trenches, pits, and drill holes. The chance is 10%+ that mines are there.
• **Indicated** – Can be estimated with a level of confidence, mine planning, and evaluation of the economic viability of the deposit. The chance is 50%+ that mines are there.
• **Measured** – the establishments can be estimated with confidence, production planning, and evaluation of the economic viability of the deposit. Sampling is done in this stage with a richness of information. The chances are 90%+ that mines are there.



Moreover, mineral properties cover a broad spectrum; at one extreme lie those which are already in production and which have operating histories sufficient to permit reasoned estimation of future operational and economic parameters; and, at the other are properties which might be considered geologically attractive, but on which little or no exploration has yet been undertaken. Between these extremes lies a variety of mineral lands, including those upon which sufficient mineral resources have been demonstrated such that production can be considered, and those at earlier stages of exploration where the existence of an economic deposit remains unproven. Further, each of these properties will have specific physical and economic characteristics which differ from those of any other mineral property.

• **High Fixed Cost :** Another feature is metals and mining companies tend to have a high fixed cost, as the companies may have to keep mines operating even during low seasons in price cycles. This is done to prohibit the costs of shutting down and reopening operations.

• **Scarcity :** It is an agreeable understanding between scientists that the world has a finite quantity of natural resources, making commodity business finite itself. We only have so much in copper, gold, silver, and graphite. This makes mining a finite business with an expected real-life end-of-life date. Some companies prolong this through astute acquisition, successful exploration, and/or a range of non-mining or downstream businesses. When valuing commodity business, it is worth noting, scarcity of resources will play a role in what our forecasts of future commodity prices will be and may also operate as a constraint of assuming potential growth.

• **Other risks** include Financing risk— dilutive equity or high-cost debts, Permitting Risk—Feasibility, Geology risk—Low Grades, Metallurgy Risk—Recoverable Quantity, Country Risk—Politics, Taxes, Geographic Risks, Stability, etc.

Valuation of Mines

The mineral deposits in a mine can be valued by two methods.

Quantitative analysis by weight basis or by volume

basis

• The total extent of land purchased is considered.
• Adopting suitable percentage depending upon the shape and size of the land, the mining area is ascertained.
• Depth of persistence or the depth of the mineral ore available in the land as reported by the geologist is found out.
• The volume of recoverable mineral deposit is arrived, on multiplying the extent of land taken for mining with depth of ore available.
• The core recovery percentage of mineral ore in the land as reported by the geologist is referred.
• The total quantity of volume of saleable mineral ore deposit is arrived at by multiplying the volume of mineral deposit with the core recovery percentage. This forms the basis of calculation to find out the total volume of mineral deposit with the core recovery percentage by volume basis. Up to this it is common for both quantitative analysis by weight basis or by volume basis.
• The bulk density of the mineral ore available in the land is referred based on the chemical composition as reported by the geologist.
• In calculating the quantitative analysis by weight basis, the total volume of the mineral by weight basis is arrived by multiplying the bulk density of the mineral ore with the volume of ore with core recovery percentage.
• The cost of the mineral ore through market survey is determined.
• The value of mineral deposit in the mine is determined by multiplying the cost of mineral with the total volume of the mineral by weight basis or by volume basis.

Profit analysis or the tentative potential of mine

The above steps are repeated here to arrive at the total volume of the mineral by weight basis or by volume basis. The mining cost or the expenditure towards mining including the overheads is calculated per metric tonne of ore for weight basis or by cubic metre by volume basis as detailed below:

• The market value of the property as agricultural land
• Royalty paid to the Government
• Mining charges including drilling & blasting
• Cost for Removal of over burden (mines development charges)
• Cost of removal of waste material after core recovery of the mineral
• Loading and Unloading charges
• Transport within the mine site
• Dewatering charges
• Cost of minerals
• Overhead expenses

The cost of the mineral added to the expenditure

involved in mining operations will be the production cost of mineral ore. The selling price of the ore is determined

through market survey. The difference between the mineral ore cost and the selling price will fetch the profit expected from the mine. By multiplying the expected profit with the total quantity of deposit of ore after adjusting for the core recovery percentage will be the Profit or the tentative potential of mining land.

Undeveloped Properties :In the valuation of undeveloped, unequipped properties, whether having large or small ore reserves or none at all, consideration, must be given to time and expenditure required to equip, develop, and bring the mine into profitable production. The expenditures up to the time of profitable production (including the purchase price of the property), with interest thereon, must be amortized from profits.

Assessing Resource Potential :The starting point in valuing a miner is understanding the resource potential of their deposits. This means estimating the total ounces or pounds of gold, silver, copper or other metals within a company's projects. The larger the resource, the more potential value the miner has.

Modelling Production Outlook :The next step is modelling the potential production profile of a mining project. Technical studies like Preliminary Economic Assessments (PEAs), Pre-Feasibility Studies (PFS) and Feasibility Studies (FS) will outline production estimates over the expected mine life. How much metal can be mined per year and the total lifetime output determine potential revenues. Higher production equals greater value generation. It's also key to look at expected all-in sustaining-costs (AISC). Costs encompass everything from mining to milling to overhead. The lower the AISC per ounce or pound, the more profit the operation can generate at a given metal price. Cheaper assets have higher margins and are inherently more valuable. As with grades, investors want to see AISC well below industry averages.

Valuation Approaches

The prediction of the value of metals and a mining company is a complex matter. Despite the fact that scientists have developed various methodologies to estimate properties and assets value (including company's value), many of these aren't applicable when it comes to the extraction industry. This is due to the heterogenetic nature of the industry, including but not limited to mining producers, financing of mining, finding the risk in terms of mining exploration, price cyclicality, dynamic nature of the industry and how it operates, capital cost structure, stock market vagaries, and circumstances volatility.

The six key parameters in mine valuation are as follows:

1. **Grade:** The grade of the ore refers to the amount of valuable minerals or metals present in the ore. The higher the grade, the more valuable the ore.

2. **Tonnage:** Tonnage refers to the amount of ore that can be extracted from the mine. The more ore that can be extracted, the more valuable the mine.

3. **Recovery:** Recovery refers to the percentage of valuable minerals or metals that can be extracted from the ore. The higher the recovery rate, the more valuable the mine.

4. **Operating Costs:** Operating costs refer to the costs associated with mining, such as labour, equipment, and fuel costs. Lower operating costs can increase the profitability of a mine.

5. **Capital Costs:** Capital costs refer to the costs associated with building and developing the mine, such as construction costs and equipment purchases. Higher capital costs can reduce the profitability of a mine.

6. **Market Price:** Market price refers to the current price of the minerals or metals produced by the mine. Higher market prices can increase the profitability of a mine.

Valuing mining and metals companies is particularly complex due to the industry's unique nature, which includes risks related to financing, exploration, price cycles, fluctuating operational and capital costs, and stock market unpredictability. Traditional valuation methods like Discounted Cash Flow (DCF), Relative Multiples, or Real Options often require significant adjustments when applied to mining firms, particularly for exploration companies without revenue or cash flow. With that being said, the main valuation methods used in the mining industry are as follows

Cost Approach

The cost approach, also known as the appraised value method, is based on the premise that an exploration property, or a mineral resource property, is worth an amount equivalent application to past exploration expenditures plus warranted future costs to test remaining exploration potential. Technical knowledge and expertise must be applied to the analysis of past expenditures in order to determine which to retain and which to disregard; expenditures that date from more than approximately five years prior to the valuation date are usually excluded. And future costs, represented by an exploration budget to test the future potential, have to assessed for suitability. Inactive properties are more problematic than those with active exploration; again, the knowledge and experience of the valuator must be applied in order to gain an assessment of the remaining exploration potential which may take account of changes in technology or metal markets, as well as untested targets.

Market Approach – Comparable Transactions

This approach is based on the fundamental premises that there is a recognized open market forum and that there is

a standardization of the items traded in that forum. However, because there is no market in which mineral properties are traded and because each mineral property has unique characteristics, the analysis of comparable transactions is not an inherently robust valuation method. Valuation of mineral property by reference to comparable transactions must satisfy three basic requirements:

• The price paid in the comparable transaction was, in fact, an accurate measure of fair market value.
• The resources on the comparable and subject properties have been identified to a similar level of confidence.
• That appropriate adjustments can be made to the price paid in the comparable transaction, in order compensate for differences between the two properties.

Technical knowledge and experience must be applied by the valuator in order to assess the first two requirements. Parameters which have to be adjusted (such as date, location, climate, status of permitting, comprehensiveness of technical data, among many others) have to be identified and then judgement exercised in order to assess the magnitude of each adjustment.

Income Approach – Discounted Cash Flow Analysis

Provided that sufficient reliable data are available to support the analysis, the income approach – using a discounted cash flow analysis – is the preferred methodology, since it avoids some of the short-comings of the cost and comparable transactions methods.

It is based on the principle that a rational investor will look to the future profits expected to be generated by the property for a return on invested capital. Discounted cash flow analysis is simply a method of relating the initial cash investment to the anticipated cash return. The investor will require not only the return of his original investment, but also a rate of interest thereon that compensates for the perceived level of risk. All future cash flows are discounted back to the date of valuation at that required rate of interest. The sum of those discounted cash flows represents the net present value of the property and represents the amount that the investor would be prepared to pay to acquire the property at the effective date of valuation.

Since the concept of fair market value requires that buyer and seller be not only willing but also informed, in order to perform a robust discounted cash flow analysis, it is necessary to make a separate and informed estimate of each of the factors which will affect future cash expenditure and future cash revenue. Essentially, this means that sufficient data are available to prepare a Feasibility Study, Preliminary Feasibility Study or, subject to applying a higher discount rate, a Preliminary Economic Assessment. For a typical mineral property, these data include:

• The tonnage and grade of the mineral reserves or, where appropriate, mineral resources.

• The annual rate of production which can be sustained from those resources, having regard to the market available for the commodity to be produced.

• The annual cash revenue accruing from the production and sale of mineral commodities.

• The annual cash cost of producing those saleable mineral commodities.

• The annual level of cash income taxes and other taxes to be levied on the profits or, in certain instances, on production or sales.

• The levels of cash capital expenditure required to construct the mine and associated facilities and, subsequently, to replace obsolete or worn out equipment.

• Selection of the appropriate rate of discount to be applied in determining the present value of estimated future cash flows, having regard to the risks inherent in achieving such estimated cash flows.

In terms of their impact on value, certain factors are always the most significant:

• Tonnage and grade of the resource.
• Estimate of annual revenue.
• Selection of the discount rate.

Since production costs are determined by the number of tonnes of rock mined and processed, while revenues are determined by the number of pounds or ounces of metal produced, costs and revenues are related by the grade of the ore. Generally, however, profit is more sensitive to changes in revenue than it is to changes in cost, so grade and revenue are the cash flow factors which most affect the valuation.

Discount rate

Operating mines should be valued at a lower discount rate, or required rate of return, than that applied to

new projects since certain of the risks faced by new mines have been mitigated. Mineral properties which have been explored by drilling but have not yet reached the stage of resource assurance at which a definitive feasibility study can be undertaken, should be valued at a discount rate higher than that applied to later-stage projects. While there are generally accepted ranges of discount rates to be applied to properties at different stages of development and for different metals or

commodities, the selection of the most appropriate discount rate to be applied to any specific property depends on the judgement and experience of the individual evaluator.

Dynamic modelling of uncertainty

Valuators at the forefront of mine valuation are seeking to improve DCF calculations through three significant enhancements: the dynamic modelling of uncertainty, the recognition of the cash flow effects and contingent payoffs and the use of market-based risk discounting methods such as real options.

Standard DCF models are static; they incorporate a single net cash flow stream with most-likely or expected values of project and business variables such as metal grade. Analysts recognize that these variables are uncertain and may assess how uncertainty impacts NAV with a sensitivity analysis where variables such as metal price are discretely varied over a range. More involved uncertainty analysis may include Monte Carlo simulation, in which a set probability distribution describes possible changes in a specific variable during the project.Introducing stochastic processes into Monte Carlo simulation can provide a richer description of the dynamics of uncertainty and its effect on cash flow. For example, a log-normal stochastic process can be used to model reversion in base metal prices. Reversion is the tendency of a variable such as metal price to revert over time to a long-term equilibrium level and may act to restrain long-term cash flow uncertainty. These models can be extended to reflect other characteristics such as uncertainty in long-term equilibrium price levels and the structure of forward curves.

The Appraised Value Method

The Appraised Value Method is based on the premise that the real value of an exploration property or a marginal development property lies in its potential for the existence and discovery of an economic mineral deposit. The Appraised Value Method assumes that the amount of exploration expenditure justified on a property is related to its value. The cost approach is given some validity by the fact that option agreements on mineral properties are often based on expenditures required to earn

an interest. The basic tenet of the appraised value method is that an exploration property is worth the meaningful past exploration expenditures

plus warranted future cost. An important element of this method, which is often overlooked in its application, is that only those past expenditures which are considered reasonable and productive are retained as value.

Productive means that the results of the work give sufficient encouragement to warrant further work by identifying potential for the existence and discovery of an economic mineral deposit. Warranted future costs comprise a reasonable exploration budget to test the identified potential, which can be geophysical or geochemical anomalies, or promising showings or mineralized zones already identified. As noted previously, if exploration work downgrades potential, it is not productive and its cost should not be retained as value or should be reduced. Obviously, if the property is considered to have negligible exploration potential, it has little or no value.

The appraised value Method is best applied to properties which are actively being explored. It is more difficult to apply the method to properties that have been idle for some years, especially those which have had substantial expenditures in the past. The key to the valuation of inactive properties is a realistic assessment of the remaining exploration potential, which could be in the form of untested targets, potential to increase the grade or tonnage of the existing resource, or potential for development with changes in technology or economic conditions.

Main valuation methods used in mining industry

Price to Net Asset Value (P/NAV): "Net asset value" is the net present value (NPV) or discounted cash flow (DCF) value of all the future cash flow of the mining asset less any debt plus any cash. The model can be forecast to the end of the mine life and discounted back today because the technical reports have a very detailed Life of Mine plan (LOM).

The formula is as follows:

P/NAV = Market Capitalization / [NPV of all Mining Assets – Net Debt]

Price to Cash Flow Ratio (P/CF) :P/CF, or "P-cash flow" is also common but only used for producing mines, as it uses the current cash flow in that year, relative to the price in the security.The ratio takes the adjusted cash flow of the business in a given year and compares that to the share price.Operating cash flow is after interest (and thus an equity metric) it's also after taxes, but it does not include capital expenditures.

The formula is as follows:

P/CF = Price per Share / Cash from Operations per Share

EV/Resource:The EV/Resource ratio takes the enterprise value of the business and divides it by the total resources contained in the ground.This metric is typically used for early-stage development projects, where there is not a lot of detailed information (not enough to do a DCF analysis).The ratio is very basic and doesn't take into account the capital cost to build the mine, nor the operating cost to extract the metal.

The formula is as follows:

EV/Resource = Enterprise Value / Total Ounces or Pounds of Metal Resource

TAC (Total Acquisition Cost)

Another commonly used metric in the mining industry for early-stage projects is Total Acquisition Cost or TAC.This represents the cost to acquire the asset, build the mine and operate the mine, all on a per ounce basis.

The formula is as follows:

TAC = [Cost to Acquire + Cost to Build + Cost to Operate] / Total Ounces

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