A Critique of Valuation Methods for Exploration Properties
And Undeveloped Mineral Resources

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ABSTRACT

Exploration properties form a continuum from grass roots to those with favourable geology, geochemical and/or geophysical anomalies, mineralization, showings (prospects), and finally to those with defined mineral deposits. Often properties exhibit a composite of these categories.

The most problematic to value are properties or deposits that are not economically exploitable at the time of the valuation, due to a lack of exploration, insufficient grade or tonnage, poor mining conditions, or the imposition of socioeconomic, environmental, or legal constraints.

Various acceptable methods of valuing the range of all such mineral properties or deposits are reviewed. Some inappropriate methods are also discussed.

BIOGRAPHY

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INTRODUCTION

This paper is presented in response to the request of the Mineral Economics Society of the Canadian Institute of Mining and Metallurgy for a Review of Approaches to Valuation of Mineral Properties, as recommended by the TSE/OSC Mining Standards Task Force.

Exploration properties with undeveloped mineral resources range from grassroots acreage without exploration history, to those containing mineralization (or a mineral resource) that is insufficiently explored, to well explored deposits which lack either continuity, or sufficient grade/tonnage, or have poor mineability or metallurgy, such that they are not currently exploitable at the time of the valuation. This does not imply that they do not have value.
For the purpose of valuations, “Fair Market Value” is defined as the highest price agreed upon in terms of cash, or reasonably equivalent to cash, between a willing buyer and a willing seller, both prudent and fully informed, dealing at arms length and under no compulsion to act in an open and unrestricted market, based on the time and conditions (i.e. market, commodity prices, economy, etc.) existing at a specific date.

The objective of the valuator is to use a methodology that removes as much subjectivity as possible and establishes a fair market value, so that ownership of property can be transferred, even if an identifiable public market may not exist. Criteria for property evaluation are summarized below. (Thompson 1991).

**VALUATION METHODS**

The Fair Market Value of Exploration Properties and Undeveloped Mineral Resources can be determined by four general approaches: Geoscience Factor; Cost; Market; or Income. For properties without mineral resources, the income approach is not appropriate and the following approaches are used by the geologist to establish value (Thompson 1991):

- Ranked and weighted geological aspects, including proximity to mines, deposits and the significance of the camp and the commodity sought. *(Geoscience Factor Method)* Woodcock (1985), Kilburn (1990, 1998), Goulevitch (1991), M. Lawrence (1994);

- Results and costs of historic exploration and the program and cost of future exploration, if warranted *(Appraised Value Method)* Roscoe (1986), R. Lawrence (1989, 1998), Thompson (1991) and Agnerian (1996a); and


For exploration properties on which undeveloped mineral resources have been identified by drilling, the *Income Approach* can be the most relevant, i.e.: a forecast of the after-tax cash flow that would accrue from mining the deposit, discounted to the present day and factored by the probability that the deposit (resource) would be put into production if the deposit is not commercially exploitable at the time of valuation.\(^1\)

**A. GEOSCIENCE FACTOR METHOD**

An early version of the Geoscience Factor approach, which rated properties by a point system, rather than assigning a dollar value, was developed by Woodcock (1985) to assist the BC Securities Commission (BCSC) in assessing the suitability of an exploration property for public financing.

The Kilburn (1990) Geoscience Factor method, derived partially from Woodcock’s approach, determines a base dollar value per claim to arrive at an overall property value. According to Kilburn: “This geological engineering method is based on four main characteristics of mineral properties, viz.; location; inclusion of valuable mineralization; inclusion of geophysical and/or geochemical targets; and inclusion of geological targets. These are subdivided into 19 subcategories, which are used to determine the value of the property. The 19 subcategories are prioritized and assigned relative value factors of 1.3 to 10. Value of each mineral claim is determined by applying the appropriate factor to a base value of $400 per 16.2-hectare unit. Property value is calculated by totaling the values of such individual claim units. The value of a property is ultimately influenced by additional, subjective factors to arrive at a fair market value; the expertise of geologists and engineers, commodity markets, financial markets, stock markets, mineral property markets, metal prices and political and economic conditions which vary with time.”

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\(^1\) Provincial Securities Commissions will accept income-based valuations (Discounted Cash Flow) for only proven and probable ore (mining reserves), and for which a detailed pre-feasibility or a feasibility study has been prepared.
Mike J. Lawrence, a co-presenter in this volume, provided a detailed analysis of the Geoscience Method in his 1994 paper. He commented on its first public use in 1993 and went on to prepare a modified template and propose a slightly different maximum relative weighing, suitable for Australia, as follows: location (22%); volume/tonnage and grade (44%); geophysical/geochemical targets (16%); and favourable geological patterns (18%). He is also philosophically attracted to the systematic nature of methods such as Kilburn (also Goulevitch and Roscoe) but “believes that they are not suitable for use without support by other methods”. Finally he expresses his strong conviction that only experienced geologists can value properties at the Grass Roots or Early Exploration stage and regards site visits as critical to a valuation. He states that “tenement (claim) size alone is no guarantee of value and offers a partial solution that only the relevant prospective portions of the total tenement should be used.” I would also endorse both these opinions.

Kilburn revised and updated his approach in 1998 in response to queries from practitioners. The value of a claim unit was adjusted in 1998 to $450 for any claim unit up to 24 ha (60 acres) to cover the cost of prospecting, before staking, in Western and Northern Canada and elsewhere. Some reviewers have referred to this erroneously as staking costs.

He revised the maximum rating as follows: grade (51%); location (30%); geophysical/geochemical targets (12%); and geology (7%). Kilburn refers to the process as “Geotechnical Value” which is confusing terminology (i.e. rock mechanics) and I would prefer to stay with Geological Engineering or preferably Geoscience Factor. American authors, Sandri & Abbott (1999) call it a Geoscience Matrix Method and have extended it to industrial minerals, where marketability of the product cannot be assumed, in contrast to most products of the metal mining industry.

The Geoscience Factor Method is classified as a variant on the Cost Approach by Roscoe (1999), a co-presenter, who states that “a major disadvantage of the method is that the degree of dependence of the property value on the assumed basic value of each claim (or area unit). A change in the basic claim value has a proportional effect on both the claim and the property value. In addition, large properties would tend to have very high values and very small properties would tend to have very low values, which may not reflect the real exploration potential. These disadvantages make it difficult to recommend the Geoscience Factor Method for valuation of exploration properties and marginal development properties.”

Ross D. Lawrence (1998), also a co-presenter, states that “that is not an elegant approach but it has sometimes been found to be helpful in dealing with certain kinds of exploration properties, or as a test of other methods. It must be carefully applied, claim by claim to a property and so is tedious in the application”.

Goulevitch (1991) in Australia, strongly endorsed Kilburn’s Geoscience Method of justifiable, quantitative valuations of the technical merits of properties and concurs that all five components of value (geology, commodity markets, financial market, stock markets and mining property markets) should be identified separately in a valuation. This is a very subjective task and only the first (geology), has been described by any practitioner. Goulevitch notes that in each main characteristic there is no sub-category for the absence of the characteristic. I agree that this modification would be helpful.

In my experience I would only carry out the Geoscience Method as a test of other methods, or as a relative property ranking mechanism and do not necessarily feel obliged to carry it out in all studies. Rather than measuring on a claim by claim basis I customarily assign value rankings for different parts of claim groups, ranging from basic staking (or basic acquisition) cost to high values depending upon exploration prospectivity. This is in turn related to the next warranted logical exploration program.

In conclusion, the Geoscience Factor Method is a method wherein a geologist tries to convert subjective scientific opinions into a numeric engineering system, and as the VALMIN CODE (1998) states; “this method should not be used in isolation from other methods”.
B. APPRAISED VALUE METHOD


Roscoe (1999) describes the method as a cost approach to valuation and a basic tenet that an exploration property is worth “meaningful past exploration expenditures plus warranted future costs”. The latter represent a reasonable budget to advance the property to the next decision stage as determined by a prudent and responsible explorationist, i.e. a seasoned exploration geologist.

The appraised value may have to be adjusted to market value if the local market for properties is elevated or depressed.

In this method a property is deemed to be worth what has been spent on it, with a premium, if results are positive, or a discount, if results are poor. Sometimes costs are adjusted for inflation, although, if applied indiscriminately to old costs, this can result in an overly large value bonus for inflation. Replacement costs to carry out the relevant work may be more appropriate in some cases.

R. Lawrence (1989, 1998) and Agnerian (1996) restrict the accumulation of such expenditures to the past three or four years, rather than to all historic costs, with the accumulation basis ranging from 100% for positive results, to 25% for negative results but with some exploration potential, to 0-10% with little or no potential.

Derry, Michener, Booth & Wahl (Thompson 1991, 1992) developed a standardized cost per claim method, which is applicable for large property holdings of mining companies. This is based upon the cost of conducting exploration on a current standard contract basis, which accounts for the effects of inflation. The purpose is to provide a standard basis for valuing historical work on large property positions where there is a wide range in historic costs for similar work completed. Costs, particularly for diamond drilling, are then factored for significance; e.g. if 24 holes have been drilled to test several targets on a property and only eight of these on two targets intersected mineralization worth following, up then credit is given for only eight holes. Some allowance may also be made for drilling which provides useful geological data aiding target selection.

M.J. Lawrence (1994) refers to the appraised value method as a “Multiple of Exploration Method (MEE) which involves allocation of a premium or discount to the relevant and effective Expenditure Base (represented by the past and future expenditure) through the use of the Prospectivity Enhancement Multiplier (PEM), a factor directly related to the success (or failure) of the exploration completed to date and to an assessment of the future prospects of the tenement(s). The selected PEM would usually range from 0.5 to 3.0, but it could be as low as zero or as high as 5”.

The Expenditure Base includes only the current owner’s/joint venturer’s relevant past expenditures plus any firmly committed future expenditures (normally only for one budget year in advance) but sometimes for two field campaigns. Past costs include acquisition costs and relevant previous data including that which is not in the public domain. In his opinion the valuation can only be done by an exploration geologist.

In essence, the MEE is the Appraised Value but with the addition of subjective PEM. If the value is large, say, $1-5 million, then the selection of the appropriate multiplier is critical to the success and acceptability of this method. I have not often seen this multiplier method in use in Canada. Presumably one would need a well-developed data or experience base (as Lawrence would have for his Australian valuations). The subjectivity involved is akin to that in a Geoscience Factor.

Another method, “Multiple of Past Expenditure” was used successfully by Anderson & Schwab/RobSearch Australia for their estimate of the realizable (market) value of grassroots and other diamond exploration properties with prospectivity, but without defined resources. Only past costs were taken as the base. This was done for the Ashton Mining takeover offer of Australian Diamond Exploration (Adex) in late 1996. The multiples ranged from 0.5 to 3.0 with zero representing a complete write-off and values greater than 1 applying where exploration had successfully upgraded the property.
C. MARKET APPROACH METHOD (COMPARABLE TRANSACTION)


If a property in the recent past was the subject of an arms-length transaction, for either cash or shares (i.e.: from a company whose principal asset was the mineral property) then this forms the most realistic starting point, provided that the deal is still relevant in today’s market.

Complicating matters is the knowledge that properties rarely change hands for cash, except for liquidation purposes, estate sales, or as raw exploration property when sold by an individual prospector, or entrepreneur.

Properties can be also valued on the earn-in approach, based on actual deals and commitments (arms-length) for future exploration expenditures, or by analogy with deals on adjacent properties within a general district, or properties of that type elsewhere. In these circumstances vesting is an important consideration because many deals are “all or nothing”; hence, the proposed exploration expenditures would then have to be factored by the probability of the company making all or part of those expenditures.

The resultant earn-in value is a function of past costs, results and the extent of the future program, and can be compared directly to the Appraised Value Method. It is a useful technique because it is a real-world exploration approach and is the manner in which most exploration properties are explored beyond the initial stage of data acquisition.

Any underlying royalty or net profits interests or rights held by the original vendor of the claims should be deducted from the resultant property value before determination of the company’s interest. Also, reductions in value should be made where environmental, legal or political sensitivities could seriously retard the development of exploration properties (e.g. Montana or Labrador).

It should be noted again that exploration is cyclical, and in periods of low metal prices there is often no market, or a market at very low prices, for ordinary exploration acreage (inventory property) unless it is combined with a significant mineral deposit, or with other incentives. This malaise has unfortunately persisted since the Bre-X fraud in late March 1997 with few current transactions (mostly for low values). Truly Comparable Transactions are rare at present for early stage properties without defined drill targets for showings. If however, the bloom is off that local market then adjustments must be made.

As an example of the difficulty using the Comparable Transaction approach, in a mid-1999 valuation of a portfolio of gold properties in the Caribbean, I reviewed about 60 deals in the Caribbean, Mexico and Central America that took place over a two year period. Only five were found to be suitable, and these resulted in a wide value range of $650,000 to $4,900,000. Transactions in the larger South American countries such as Chile, Peru, Argentina and Brazil could not be used as they reflected more fashionable locations, a much larger/richer mineral potential, or a more advanced exploration stage. This market valuation was compared to a valuation worked out in detail by the Appraised Value Method, with the latter given more weighting in the selection of the final valuation range.

D. INCOME (DCF) METHOD

In addition to standard DCF methods noted earlier, the following technique has been used successfully.

Option Pricing

Glanville (1990) and Roscoe (1998) have described this method for exploration properties and undeveloped mineral resources. The property is considered as an option and as such has a positive value, even if it is currently uneconomic. Some options are:

- Explore, hold, or drop property
- Option to sell or lease
- Option to put into production (rare)

One part of this was discussed in the Farm-in (Commitment) Approach of Market Methods wherein the proposed exploration terms have to be factored by the probability of the farm-in company making all of the expenditures. This is a variation of the discounted cash flow technique for the marginal (undeveloped) development properties, which in the real world are transferred for significant consideration, even although standard DCF techniques show low or negative values. It is an extremely useful technique in my opinion.

Another option variation is the sale of property by means of an advance NSR or tonnage royalty. The present value of the assumed royalty stream, factored by the probability of occurrence, will be the value of an inactive property with an undeveloped resource. It is not necessary to demonstrate economic viability in this case but one must assume a royalty stream life.
E. OTHER METHODS

1. Statistical or Probabilistic/Conceptual Ore Body Method is based on a statistical analysis of the average value of an economic deposit (mine), the chance of discoveries becoming economic and of anomalies (drill targets) becoming discoveries. MacKenzie (1987) published extensive statistical data on the expected cost of finding a deposit for the period 1977-1984 and the average return for an economic deposit (both on a discounted after-tax basis). The expected cost of finding a gold deposit was found to be $36 million and the average return was estimated at $55 million.

This method requires the valuer to determine the probability of a mineral occurrence becoming a mineral deposit expressed as a ratio between the cost of finding an occurrence and the expected cost of finding an economic deposit. While MacKenzie’s data are based on actual expenditures and measurable returns, the cost of finding an occurrence must be evaluated by geological criteria, and may be a highly subjective amount. Accordingly the Probabilistic Method can be regarded, particularly for properties in the early drilling stage, without quantifiable resources, as a combination of the Geoscience Factor and Appraised Value Methods. It might be valid for a large portfolio of properties in the same camp with similar targets.

Decision Tree Analysis

In an application of the Appraised Value (Cost) Method, R.D. Lawrence (1998) has also developed a “Decision Tree Analysis”. The value is arrived at by considering first the annual costs that might be required to successfully explore the property and establish the existence of an orebody. In the example chosen, large, medium and small orebodies are given nominal values of $500 million, $50 million and $5 million, respectively. Using a five-year time frame with annual budgets starting at $1 million, and rising to $5 million, probabilities are assigned to the outcome of each annual budget, i.e. find targets (p = 0.70), or withdraw (p = 0.30); find ore (p = 0.70) or withdraw (p = 0.30), and in the last year find a large deposit (P = 0.10), medium deposit (p = 0.20) or a small deposit (p = 0.70). The cumulative probability over the period adds up to 1.00.

He states that, “by experimenting with various probability factors for a given property, one can determine a range of values over a spectrum from optimistic to pessimistic”. While the Decision Tree is mathematically attractive it is a theoretical and highly subjective Probabilistic option method and prone to “financial engineering”.

I have rarely attempted this method and only as a check on other methods. I do not consider Probabilistic/Conceptual ore body methods as appropriate and agree with M. Lawrence (1994) “that their lack of transparency means that they are variations on the “Trust Me – I’m a Valuer” (lump sum estimate) approach.

2. Committed Future Expenditure by Optionor is a variation of the Appraised Value Method in which no value is assigned for past exploration costs and all value is based on committed future expenditures. This approach is probably most useful for “grassroots” properties (or land bank) with limited previous work; their intrinsic value would be based largely on the exploration program that a prudent explorationist would recommend and to which a company would be prepared to commit.

On more advanced properties, but still without quantifiable resources, assigning no value for past expenditures may be unduly harsh.
3. **Rule Of Thumb Methods**

**Net In Situ Value**

For more advanced properties with undeveloped resources, value is expressed as value/unit of metal in the ground (commonly gold but also copper) or as a value/ton of resource. This approach is extremely arbitrary since for each property the unit value is dependent on the site-specific relationship between grade, recovery, metal prices and costs.

Commonly unit values are market derived, based on transactions involving deposits with reserves, often in production and arbitrarily factored downward to account for the valuer’s/user’s assessment of uncertainty of ore, grade, etc.

Loucks and Dempsey (1997) quoted a range of gold values/in situ ounce, illustrating that mining projects are worth more as investment risk is reduced at successive stages of development. For example the value per in situ oz. rises from exploration projects (US $7/oz.) to prefeasibility stage projects (US $15/oz.) feasibility stage projects (US $30/oz.) and producing mines (US $150/oz.). These yardsticks are familiar to all of us but they should never by used as a primary value method for exploration properties with undeveloped resources.

**Gross In Situ Value**

Parrish & Mullen (1998) surveyed about 40 worldwide transactions involving major copper, gold and zinc-lead properties with stated resources (including reserves) over the period 1993 – 1998. The price range was, as expected, wide for gold (or gold equivalent) at US $6/oz to US $227/oz. For copper the range was tighter at <1¢ to 7¢/lb of in situ copper (or equivalent copper). Base metal properties were traded in an even tighter range from 0.5¢ to 1.1¢/lb of in situ zinc. Canadian examples were the zinc-lead deposits at Grevet (Quebec) and Midway (YT) in 1996 at 0.5¢/lb and 0.7¢/lb, respectively, Izok Lake (NWT) at 0.7¢/lb copper; Doyon (Quebec) in 1998 at $64/oz and Snip (BC) in 1996 at $277/oz (an outlier).

Contrast these to Bajo de la Alumbrera (Argentina) in 1995 at 6¢/lb, Porgera (PNG) in 1996 at $80/oz and Antamina (Peru) in 1996 at 4.8¢/lb.

When transactions were studied on the basis of purchase price as a proportion of gross in situ value the range was somewhat similar, ranging from <1% to 7% for copper and from 2% to 58% for gold properties.

At best, these senior mining company examples can be only used as crude numbers to which more junior exploration properties may or may not be compared. Gross in situ value is generally not an appropriate valuation technique for early stage exploration properties, although it gives a rough estimate of value for advanced projects with substantial resources.

**$/Unit Area or $/Property**

Ward & Lawrence (1998) have made comparisons on the basis of “dollars per unit area of favourable ground” (emphasis on favourable) for properties without reserves or commodities other than gold. Two interesting observations, which I can confirm from my own experience, are that: (1) larger properties have a lower unit value/hectare than smaller ones and (2) in a hot area most properties will sell at similar prices, irrespective of size, or even exploration prospectivity.

Also in Roscoe (1988) the Market comparables are better expressed as a range of the total purchase price per property. In a survey, 50% of 445 transactions for gold properties in 1995 and 1996 lay between $100,000 to $1 million; 27% were less than $100,000 and 23% were greater than $1 million.
4. **Market Capitalization.** The value of an exploration property can, rarely, be determined by market capitalization of a (junior) company if its sole asset is that property, or a collection of similar exploration properties, or if the property is adjacent to one with an identifiable public market value. For thinly traded stocks the price of share transactions on any particular day are not indicative of the price for which the entire company could be sold. Furthermore the trading price of a junior mining company is affected by many factors, often having little relationship to the fair market value of the company’s properties. This can be misleading particularly, if the public company holds only a minority interest in the property. For these reasons market cap generally is an inappropriate valuation method. However, if there is substantial trading volume, this method may provide an indication of value.

5. **Miscellaneous.** There are two other techniques that have been attempted in the past to value exploration properties: Book Value from Financial Statements and Replacement Cost. Neither of these is applicable to exploration properties.

- **Book Value** is often used as the basis for negotiating farm outs since most companies capitalize exploration costs until a development or abandonment decision is reached. As noted there is often no relationship between cost and value. (However, see new proposed CDN-X policy.)

- **Replacement Value** is the capital replacement costs of mine, mill and infrastructure for producers and former producers and does not usually apply to exploration properties. Sometimes the current cost of reproducing relevant exploration data such as geochemical and geophysical surveys, drilling and assaying or exploration openings is considered under the Appraised Value Method.

Replacement value is often confused with salvage, or disposal value that for exploration properties can be quite low or nil.

F. **COMMENTS FROM REGULATORS**

Redwick & Stevenson (1992) of the BCSC did not approve the application of a premium to past costs. They would prefer the valuator to use a different method to value what they called “spectacular” exploration properties. The BCSC accepts the Comparable Properties Method, but with many reservations, however they generally do not accept the Probabilistic Method or the Geoscience Factor Method since their subjective nature contravenes established policy. Sometimes they accept the Metal in Situ Method, but only as a check on other methods.

The VSE policy (Oddy 1995) was that valuations based on Appraised Value, or Geoscience Factor or the Conceptual Ore Body (Probabilistic) Method are generally not acceptable. Valuations based on a Premium or Discount on costs, or Comparable Transactions, or Value of Metal in Situ, or on Option Terms, appeared to be the most useful in support of the issuance of a significant number of free trading shares, as a portion of the consideration for resource property acquisitions.

A recent Vancouver Stock Exchange (VSE) opinion (K. Karchmar 1999) is that “prior expenditures must be judged on their value to the purchaser” and that, “in most cases the VSE does not consider proposed future expenditures to be a valid basis for establishing Fair Market Value”. I agree with the first comment, but not the second. A proposed policy for the new Canadian Venture Exchange (CDNX) is currently in the discussion stage.

**CONCLUDING REMARKS**

The process of valuation of exploration properties and undeveloped mineral resources is one where the experience and impartiality of the geologist are critical. It is important that value be examined from several viewpoints, as the fair market value so determined will be a notional rather than a real value. The Market Approach and Appraised Value methods, in my opinion, are the most defensible of the methods.

The valuation should be a range of values, if possible, rather than an absolute, and should be time and circumstance specific. This will leave the seller and the buyer room for negotiation, and, if a transaction results, a fair market
value. The valuation is an subjective estimation and can be challenged; however, independent and responsible geologists should be able to value exploration properties within the same general range, say plus or minus 50%.

As a result of the need to test a particular valuation method with other methods, the client should be aware of time and cost needed to complete these tasks, which can be significant. Geologists should visit exploration properties.

The fundamental feature, however, in all valuation methods is the worthiness of future exploration; that is, the cost and extent of an achievable program is a measure of the esteem in which a property is held by others. Properties that are not explored do not increase in value unless mineralization exists in the property and the price of the commodity, or the potential of the area, changes dramatically.

Valuations are affected by the maturity of the country government and infrastructure is variable, with North America, Western Europe and Australia meriting higher unit values than those of developing countries.
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