# Valuing Mineral Opportunities as Options

Robert T. McKnight, P.Eng., MBA
*Pincock Allen & Holt, Ltd.*

**Abstract**

Traditional techniques for valuing resource projects companies have been primarily based on discounted cashflow methods (DCF) or by comparison to similar projects with an apparent market capitalization. Many resource projects are really forms of options to invest rather than a future cashflow stream. Employing the DCF method to value a resource project which is really an option to invest, can dramatically underestimate the real value of the project. The analytical tools required to evaluate options, while more complicated than the usual spreadsheets used for DCF, are becoming more easily available and usable by managers. This paper will discuss the background of options valuation and some of the tools which will make it easier for managers to estimate the value of projects and companies which have significant real option values.

**Résumé**

Bob McKnight is a graduate of the University of British Columbia in Geological Engineering, supplemented by an MBA from Simon Fraser University. Following several years in the oil patch with Cities Service and Brascan, Bob returned to Vancouver in 1979 to work for Wright Engineers. He subsequently went on to work for Cassiar Mining, Getty Resources and Endeavour Financial before joining Pincock Allen & Holt Ltd. in 1998. His experience ranges from exploration to feasibility studies, financial evaluations of mining and oil & gas projects, due diligence, project finance, valuations and mergers and acquisitions. He has extensive international mining experience pertaining to such countries as Chile, Mexico, Uruguay, Thailand, Indonesia, Angola, Papua New Guinea, Kazakhstan.

## What are Options?

Options have been around for centuries. They were familiar to Roman and Phoenician traders who were shipping cargoes from Mediterranean seaports. In the financial world, options are types of contracts that generally include the right, but not the obligation, to buy or sell a share, currency or commodity. The underlying commodity price or share price changes are assumed to be lognormally distributed. In this context, options are of two general types, "call" options and "put" options. Call options have the characteristic of having the right to buy a tradable commodity or currency at a predetermined price for a specified period of time. For the owner of call options, they become more valuable as the price of the underlying commodity increases. For the seller of call options, these options become an increasing liability as commodity prices rise, since there is the obligation to sell the commodity at a predetermined (perhaps lower-than-market) price. This characteristic of call options recently became high profile with the sharp rise in gold prices last year. The value of gold call options sold by certain producers increased their associated liabilities to the point where margin calls were made.

In contrast to call options, put options include the right (but not the obligation) to sell a tradable commodity or currency at a predetermined price for a specified period of time. Put options therefore increase in value as the price of the commodity drops. Puts are common features of gold loan financings where the lending banks require a certain level of hedges (oftentimes as puts) to assure a minimum gold revenue stream.

Until 1973, there was little understanding of how financial options were valued. In that year, two researchers, Fischer Black and Myron Scholes published a description of a financial model for valuing options. This model is based on replicating the returns for an option with a portfolio of riskless bonds and shares in the underlying asset (i.e. shares, currency, etc). The payouts to the portfolio mimic that of the option, therefore the value of the portfolio, which can be solved analytically, must equal the value of the option. The Black-Scholes model has become widely accepted in the financial world for valuing and pricing financial and other types of options contracts. The five parameters needed by the Black-Scholes model are the periodic risk-free interest rate (r); the exercise or strike price (K), the current price (S) and the volatility (ó) of the underlying asset, commodity (eg metal); and the length of the time the option is in force (t). The Black-Scholes model for a valuing call option is shown below in equation form.

$$C = S * N(d_1) - K e^{(-r*t)} * N(d_2)$$

where N represents the standard normal distribution and $d_1 = (\ln(S/K) + (r + ó^2/2)^t)/(ó \quad t)$ and $d_2 = d_1 - ó \quad t$. The put option formula is similar and related.

The general form of a call option curve is shown in Figure 1 below. It displays increasing non-zero values as the underlying stock or commodity price increases. Figure 2 displays a typical put option curve showing the increasing value of a gold put option as gold price decrease.

Figure 1. Call Option Value

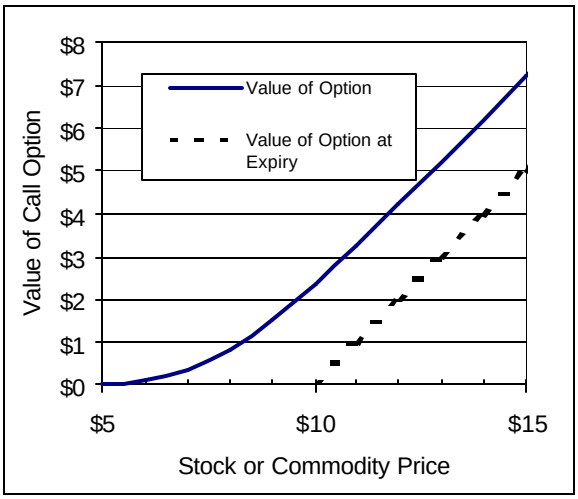
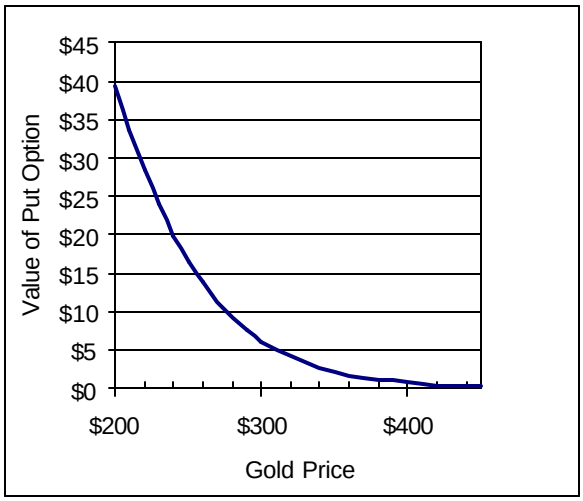



Figure 2. Put Option Value




In the call option case, the option parameters are r=5%, t=5 years, S=$10, K=$10 and ó = 20% per year. Suppose this represents an option to purchase a share of Glorious Mining Company for a price of $10 for 5 years. The value of one share purchase option is approximately $2.50 if the current share price is $10. The option will still have value even if the current share price drops below the exercise price of $10 per share. At a share price of $7.50, below the exercise price, the value of the share purchase option is still $0.50. This is sometimes referred to as an "out-of the money" option.

Using gold as an example of a put option, the Figure 2 shows the value of a put option. The curve displays the value of a 5 year put (the right to sell gold) at an exercise price of $250 per ounce (volatility, risk free rate and term of option if the same as for the call option). Put options increase in value as the price of the underlying commodity decreases. Using this model as a guide, if a gold producer wishes to purchase a $250/oz put, it must pay slightly over $5 per ounce, if gold prices at the time of purchase are at $300 per ounce.

It is important to note that the Black-Scholes model makes some assumptions including market efficiency, interest rates that remain are constant and known, asset returns that are lognormally distributed and the volatility of these returns are constant. The assumptions may not always be valid under all circumstances for which the Black-Scholes model may be used and the analyst or valuator should be aware of these limitations.

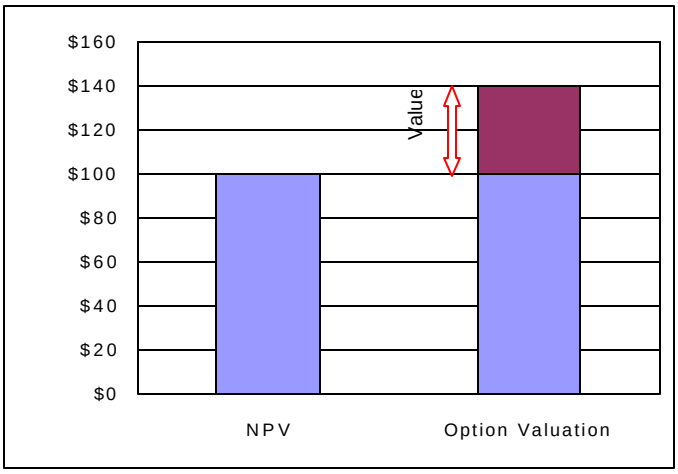
**Flexibility and Option Value**

Options valuation is really all about the value of flexibility. For example, if two projects are identical except that one has more inherent operational flexibility, then the project with more flexibility has more value. Why is this so? Well it's because the project with flexibility allows the owner to respond to future events in ways that will increase the value to the firm. The project with little or no flexibility has no ability to change and survive should future economic conditions turn bad (or change and take advantage if conditions are good). Valuation techniques that ignore the value of the options imbedded in a project will systematically undervalue opportunities because they fail

to capture the additional value of flexibility in the face of future uncertain events. This can lead to poor decision making by analysts and managers, and loss of potential value to the firm.

Consider a simple example from the minerals industry: suppose Magnificent Mining Company has the opportunity to earn the same interest in two identical advanced mineral properties (A and B) held by two owners. Apart from the usual expenditure commitments, the owner of A is requiring that Magnificent Mining make a production decision within 2 years or walk away. Owner B has the same expenditure commitments but gives the major 5 years to make a production decision. Which deal is Magnificent Mining likely to take? Obviously Project B will be the preferred alternative because it more valuable to Magnificent Mining. It is more valuable because it allows more flexibility by providing more time for the company to evaluate the project, look for development alternatives and, hopefully, the chance to develop the project when metals prices are higher.

Figure 3. The Additional Value of Flexibility




Another example familiar to the mining industry is a temporary mine closure. When metal prices drop, some mining operations are able to temporarily close and avoid losses. For some types of operations this closure option is much easier, less costly and, hence more valuable, than others. Underground operations may have to be kept from flooding during closure – an expensive proposition, whereas an open pit mine may not face this expenditure. This type of option is analogous to a put option – incurring closure costs is exercising the option in order to avoid further (perhaps large) losses. Once closed, however, the project takes on the characteristic of a call option. Incurring re-opening costs when metal prices have moved higher is analogous to exercising the option. In this situation, options theory can be extremely useful, assisting management in making mine opening and closure decisions by providing the optimal metal price at which a closure (or opening) should be made.

## Share Equities as Options

Shares in public companies have many of the characteristics of options. By virtue of their limited liability, shareholders of limited liability companies have some protection against bankruptcy and insolvency. This is a form of put option that limits shareholders exposure to losses. Common shares also represent a contingent claim (option) on the assets of the firm. Since debtholders (and other stakeholders, such as Revenue Canada) often times have priority rights to the cashflow and/or assets of the firm, the equity stakeholders claims are therefore contingent on the value of the firm exceeding the claims of the stakeholders having priority.

## What are "Real Options"?

The share purchase and gold option examples shown in an earlier section are examples of "financial" options. That is they involve options that are based on traded commodities, currencies or stocks which probably have high liquidity and/or the options themselves may be traded in their own right. The market values of gold call and put options can be found in the newspaper financial pages.

"Real options" is a term that has become popular in recent years to describe the types of complex options occurring the "real world" of business. For example, a manager is contemplating a new electric power generation project, he has the choice of fuels including oil, natural gas or a dual-fuel boiler. The dual-fuel boiler unfortunately is more expensive than the others, so the manager needs to evaluate the options carefully in light of the historical variability of oil and natural gas prices. This is an example of a "real option" situation. Traditional DCF or NPV-style analysis will not provide the correct decision-making framework for this situation because it does not consider the value of the option to switch between fuels as the relative future prices of these vary.

The types of real options found in business can be generally categorized as "call-like" or "put-like". For instance, the option of closing or downsizing an operation in response to lower product prices or economic conditions is a "put-like" option. By exercising this option, the manager can avoid or lessen losses. Of course, there may be a cost associated with exercising the option and this must be considered in the analysis. Similarly, the option to start a new project development as product prices rise is analogous to a call option. Many business situations combine both call and put options.

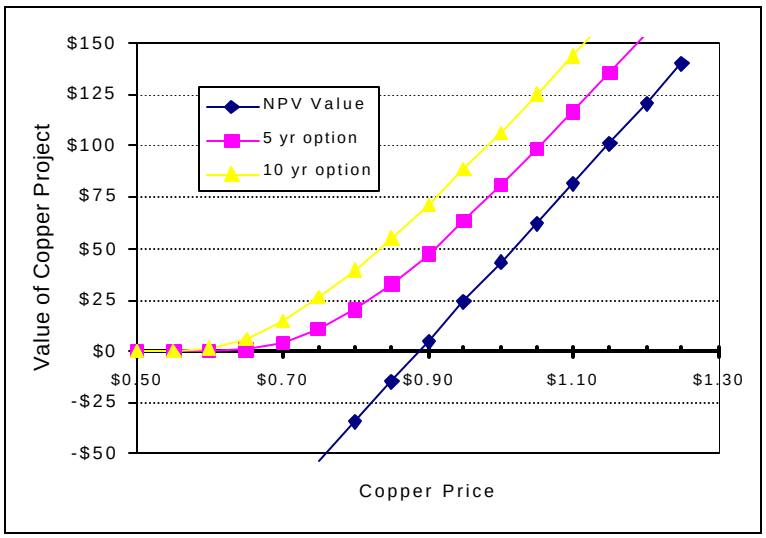
## Real Options in the Mining Industry

As in other businesses, the mining industry also has numerous examples of real options. In valuing exploration options, the analyst must consider the same factors that influence the value of all options, that is, the term of the option, the volatility of the underlying asset, and the costs of exercising and of course, the potential value of underlying asset. Although exploration agreements contain features typical of options (or contingent claims), this paper is focused on more advanced project developments.

In 1983, Michael J. Brennan and Eduardo Schwartz, (U.B.C. researchers at that time) published an article entitled "Evaluating Resource Investments". This paper, a version of which was later published by the CIM, was the seminal article for use of options tools in the minerals industry.

Option valuation in the minerals industry is most directly applicable to those projects that have progressed beyond the exploration stage to at least the pre-feasibility stage. There will likely be a defined resource and a reasonable estimation of capital and operating costs. The project economics may indicated a "marginal" project, one that may only just barely payback its capital costs at current metals prices. As an example, an undeveloped copper project has a recoverable resource of 500 million pounds of copper that can be produced over 10 years at a cash cost of $0.50 per pound. Capital costs are $150 million. At a copper price of $0.80/lb, undiscounted future cashflow is $15 million per year for 10 years or $150 million dollars, equal to the capital cost. At $0.80 per pound copper, the project just repays capital with no economic returns.

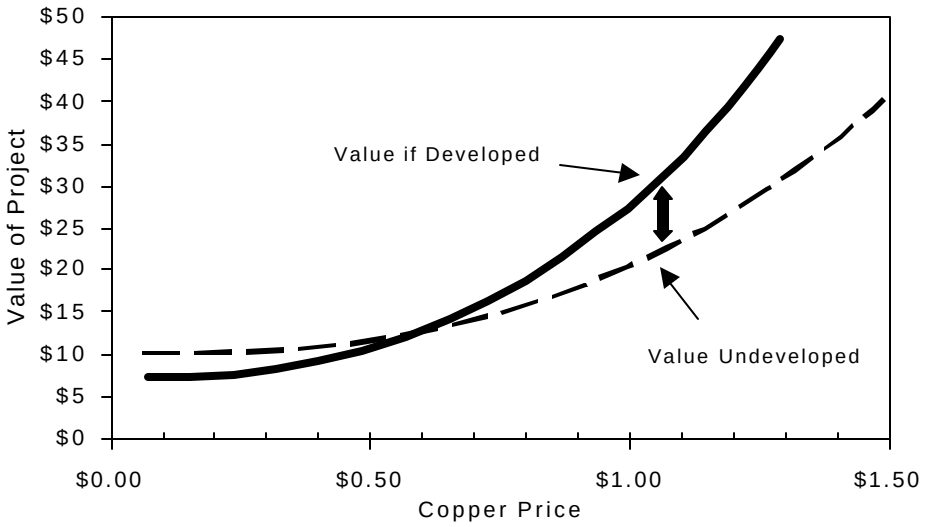
Figure 4. Copper Project: Option Value vs NPV



Traditional NPV valuation would project future net cashflows at an assumed "reasonable" long term copper price and discount these some interest rate which reflects "risk". Or perhaps the cashflows are risk-adjusted then discounted. The NPV valuation of the project is represented by the lower straight line in Figure 4. A risk free discount rate of 5% was assumed in this case (higher discount rates would lower this line). Note that the NPV valuation is negative at lower copper prices. In contrast, an options-based valuation considers the project as a form of call option (upper curves). These represent an estimate of the value of the right or option to develop the copper project at some future date. The longer the option period, the higher the option value.

Another valuable insight can be gained with options analysis. In Figure 5. below, two schematic curves display the option value of a developed (heavy line) versus an undeveloped copper project (dashed line). At lower prices, the project is has more value left in its undeveloped state (i.e. put on the "backburner"). At some higher copper price, the value of the project in its developed state exceeds the undeveloped value. When this difference between the developed and undeveloped value exceeds the project development costs (i.e. the exercise price), it is optimal to initiate the project construction. This example illustrates the insights that can be provided to management from a carefully considered options analysis.

Figure 5. Value of Developed vs Undeveloped Copper Project




**Tools to Calculate Option Values**

One of the reasons options theory has been slow to be adopted in valuations is the more complicated math involved and the lack of widely available tools for the analyst. Spreadsheet tools are now widely available that make it easy to compute option values for the types of problems that can be handled at least at the simple level with the Black-Scholes model. Excel shareware add-in can be downloaded from an Internet site (http://ray.steele.org/options.html). This add-in makes Black-Scholes model call and put option (and other) functions available.

More complex option situations require more powerful tools using either the binomial or numerical approximation techniques. The simpler of those is the binomial approximation method, which essentially breaks an option problem into a series of time increments with an up or down variation for each time period of the underlying asset or metal price. The method is suitable for spreadsheets and handle quite complex types of problems.

Numerical approximation requires more elaborate computer software and a familiarity with numerical methods. This method would likely be used for a problem such as described in Figure 5 above. A number of consulting groups (such as McKinsey & Company) have expertise in this area, although not necessarily directed specifically at the mining business.

## What Options Resources are Available?

For valuators who are interested in learning more about real options and option valuation, there are resources available in a number of areas. On the internet, there are several excellent sites, with links, devoted to the subject of real options the best one being: www.puc-rio.br/marco.ind/main.html#contents. The appropriate search phrase is "real options". There is at least one course specific to mine valuation which includes option valuation at the Colorado School of Mines and a number of other institutions have real option-related coursework.

There are also a number of excellent books and papers on real options, some of which provide examples useful in the mining industry. The most useful of these are: Real Options by Lenos Trigeorgios; Project Flexibility, Agency and Competition by Michael Brennan and Lenos Trigeorgios; Real Options: Managing Strategic Investment in an Uncertain World by Martha Amram and Nalin Kulatilaka. The author can provide further information sources by e-mailing me at: bob_mcknight@telus.net.

## Options Valuation Issues

Option theory provides a powerful framework for analyzing a multitude of business problems, including valuation of investment opportunities, research and development expenditures, capital structure, divestment decisions, timing of investments and open/closure decisions. Mining valuation work covers a broad spectrum of projects from early stage exploration with little information and a wide range of possible outcomes, to valuations relating to project developments, acquisitions and divestment. Options theory has most direct applicability to the latter end of the valuation spectrum, when there is reasonably good information about resources, capital and operating costs. While options theory is a valuable additional to the valuator's toolbox, it is not applicable in every situation; it complements, rather than replaces, other valuation methods.

## Conclusion

Options are the right, but not the obligation, to buy, sell or invest at a known price for a specified period of time. While more commonly known in the finance world, more complex options form part of business decisions in many industries. Understanding option theory will help valuators and managers make better judgments and business decisions.

"Real options" is a term that has become popular in recent years to describe the types of complex options that occur in the "real world" of business. The knowledge and use of real options has exploded in the last few years and has gained wide acceptance amongst practitioners in a number of other industries. Mining has been seemingly slow to adopt new valuation technologies over the years. The reason for this is not entirely clear. One possible reason is the level and types of risks in mining. Not only are these risks high, but they are also more numerous and involve natural risks (i.e. mother nature) compared with other industries. This should not excuse industry practitioners from making themselves familiar with, and using, the best and most appropriate valuation techniques available. Real options analysis as applied to valuation work is most directly applicable to advanced minerals projects with a mineral resource and reasonably well understood capital and operating costs, and especially for projects which may be marginal or uneconomic at current metal prices.

Perhaps the greatest benefit of options theory comes from simply understanding that options are present in all types of business decisions. Once the understanding of how options increase value is there, one can select the tools necessary to properly evaluate these business decisions.

**References:**

Amram M. and Kulatilaka N., 1999, *Real Options: Managing Strategic Investment in an Uncertain World,* Harvard University Press, Boston MA.

Trigeorgios, L and Brennan M.J., 1998, *Real Options: Project Flexibility, Agency and Competition*, Oxford University Press, New York, NY.

Trigeorgios, L., 1998, *Real Options*, The MIT Press, Boston MA.