Reserves: The Cornerstone of Any Mineral Appraisal

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ABSTRACT

The value of mineral properties, operations, and equity interests is dependent in large part on the nature, quality, and quantity of the reserves controlled. Although it is widely recognized that the appraisal of such properties and operations is a two-step process—first, delineating the reserves and, second, completing the appraisal—there is disagreement over the role of the mineral appraiser in the first step. This paper examines the concept of *willing and knowledgeable buyer* in defining market value, makes the case that the mineral appraiser should bear some responsibility for the reserve estimates on which the appraisal is based, discusses ways in which the validity of reserve estimates can be assessed, and provides examples of specific problems encountered by the author.

INTRODUCTION

A widely accepted definition of *market value* is that used by the regulatory agencies of federal financial institutions,[1] presented below.

> The most probable price which a property should bring in a competitive and open market under all conditions requisite to a fair sale, the buyer and seller each acting prudently and knowledgeably, and assuming the price is not affected by undue stimulus. Implicit in this definition is the consummation of a sale as of a specified date and the passing of title from seller to buyer under conditions whereby
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> 1. buyer and seller are typically motivated;
> 2. both parties are well informed or well advised, and acting in what they consider their own best interests;
> 3. a reasonable time is allowed for exposure in the open market;
> 4. payment is made in terms of cash in U.S. dollars or in terms of financial arrangements comparable thereto; and
> 5. the price represents the normal consideration for the property sold unaffected by special or creative financing or sales concessions granted by anyone associated with the sale.

Of particular significance is the assumption stated in the narrative "[…] the buyer and seller each acting prudently and knowledgeably […]" and the statement in Note 2 that "both parties are well informed or well advised […]."

One should thus expect the appraiser to be as knowledgeable of the asset(s) being appraised as would be knowledgeable buyers and sellers, so as to reflect to the extent possible the perception of the market in the estimate of value that is developed.

This is not to say that all buyers and all sellers will necessarily be knowledgeable regarding reserve issues nor that they will be using synonymous definitions of *reserves* and related terms in their negotiations. However, the fact that this may be the case does not relieve the appraiser of having to meet the conditions of the definition of *market value* when that is the premise of value being used.

More often than not, the mineral appraiser is provided some form of reserve estimate for the property or operation that is to be valued. Such estimates may be something as elemental as a spreadsheet summarizing tonnage and grade (or quality), continuing through a spectrum of documents of increasing detail, the ultimate of which may be a detailed feasibility study. Assuming that there is supportable documentation that the material provided was prepared by recognized professionals such as geologists and/or mining engineers, why then should the appraiser not accept the results of this work at face value?

Six reasons come to mind.

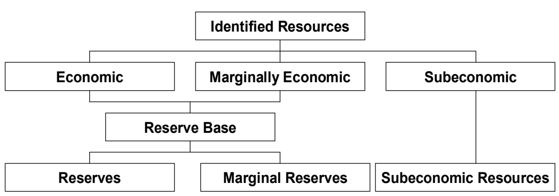
- Some estimators have only superficial knowledge of reserve terms and their definitions and thus use them incorrectly.
- Some estimators have knowledge of reserve terms and their definitions, yet fail to use them correctly for any number of reasons.
- Some estimators do not use methodologies that are generally accepted practice in the mining industry.
- Some estimators have bias built into their work.
- Some estimators just do sloppy work.
- The method by which the reserve estimates were developed lacks transparency.

CLASSIFICATION SYSTEMS

In order to effectively communicate the nature and characteristics of mineral deposits, it is necessary to have a system of agreed-upon terms, generally termed *reserve and resource classification systems* in the mineral industry. There are numerous such systems, with virtually every major mining country having one or more of its own. In the United States, two of the most frequently relied upon systems are those presented in joint publications of the former U.S. Bureau of Mines and the U.S. Geologic Survey in Circulars 831 and 891. These deal with the mineral industry as a whole and with the coal industry, respectively.

The basic structure of these systems is shown in Figure 1. At the top of the pyramid is the primary classification of identified resources, which is subdivided into three components—economic, marginally economic, and subeconomic.

Figure 1 – Resource Classification System



The reserve base comprises the economic and marginally economic portions of a mineral deposit in-place, with the operative phrase being *in-place*. The reserve base is further subdivided into reserves and marginal reserves, both of which comprise the recoverable portion of the material in-place. The operative word for these two subdivisions is *recoverable.* The difference between the reserve base and the reserves or marginal reserves is a critical distinction, one which, unfortunately, is either ignored or not understood by many estimators.

An integral part of a classification system is terms by which one characterizes relative degrees of geologic assurance of each component. These degrees of assurance are expressed through terms such as *measured, indicated, and inferred* or *proved, probable, and possible*. In some sectors of the mining industry, terms such as *geologic reserves* and *drill-indicated reserves* are also used to define assurance levels.

Although there is disagreement among potential buyers and sellers and among mineral appraisers regarding how many of these subdivisions should be included in an estimate of value, this is not the issue in this paper and from this point forward all discussions will speak only of *reserve*s.

RESERVES DEFINED

One of the most widely recognized and widely used definitions of the term *reserves* among publicly traded companies in the U.S. is that set forth in Securities Act Industry Guide 7 issued by the United States Securities and Exchange Commission ("SEC"), to wit:

> "*Reserve* – That part of a mineral deposit which could be economically and legally extracted or produced at the time of the reserve determination."

An additional and widely used similar definition is that presented by the U.S. Geological Survey in its Circular 831 titled *Principles of a Resource/Reserve Classification for Minerals*, as follows:

> "*Reserve* – That part of the reserve base which could be economically extracted or produced at the time of determination."

Yet a third commonly used definition is that presented by the U.S. Geological Survey in its Circular 891 titled *Coal Resource Classification System of the U.S. Geological Survey*, as follows:

> "*Reserve* – Virgin and/or accessed parts of a coal reserve base which could be economically extracted or produced at the time of the determination considering environmental, legal, and technologic constraints. "

These definitions have two key words in common—*economically* and *extracted,* as do all definitions of the term *reserves* with which I am familiar. As evident as the concept created by the use of these two words should be, a significant percentage of reserve estimators fail on two counts. That is, they:

1. include material in their estimates characterized as reserves that is not economic to extract, and they
2. estimate the quantity of material in-place (that is, the *reserve base*) and not the material that can be extracted.

By way of comparison, the definition used by Canada's provincial security commissions[2] is excerpted below:

> "A "*mineral* r*eserve*" is the economically mineable part of a measured or indicated mineral resource demonstrated by at least a preliminary feasibility study."

> "Mineral Reserves are those parts of Mineral Resources which, […] in the opinion of the Qualified Person(s) making the estimate, is the basis of an economically viable project after taking into account of all relevant processing, metallurgical, economic, marketing, legal, environment, socio-economic and government factors."

It should be noted that three of these definitions, including those of the SEC and the Canadian Securities Administrators, include the requirement that the tonnage estimated can *legally* be recovered.

Simplistic as it may sound, one of the first steps in assessing the validity of a reserve estimate prepared by others is to establish that the material termed *reserves* is both economic and legal to produce and comprises only that portion of the deposit that can be recovered and sold.

POTENTIAL PROBLEMS

Some of the more common problems the appraiser may encounter that can invalidate a reserve estimate are discussed below.

The reserve estimator

Although in an ideal world, all professionals would adhere to similar standards and criteria, in the real world this is not the case. If the estimator is employed by the mining company for which the reserve estimate is being prepared, there may be a subconscious (or conscious) bias in favor of the company. Similarly, certain independent estimators gain the reputation of being *sellers consultants*, with others gaining a reputation for being *buyers consultants*. If the mineral appraiser is experienced in the mining sector in which the appraisal is occurring, knowledge of these issues will assist in establishing the depth to which an assessment is required.

Date of estimate

Upon receipt of a reserve estimate, the critical first step is to determine the date it was prepared. Even though the estimator may have done a first rate job applying the appropriate economic factors in the preparation of the estimate, changes in market conditions since the date of the estimate can cause the estimate to no longer be meaningful. Reserve estimates for materials for which pricing is particularly volatile may have a shelf life of only a year or two.

Miscorrelation

Miscorrelation is another common error, particularly in bedded deposits such as trona and coal and unconsolidated material such as sand and gravel or marine phosphate deposits. This is particularly true in the use of computer-based geologic models, in which key beds are identified and cross-sections prepared solely on a computer screen. Call me old fashioned, but you can't do a better job of correlation than by hanging strip logs on the wall with all their color codes and annotations and studying the heck out of them until you can visualize the deposit in three dimensions.

In-place versus recoverable material

Unfortunately, one of the most common errors that I see committed in estimating reserves is the use of in-place quantities rather than recoverable quantities. I am constantly amazed by the number of reserve estimates I see in which the tonnages characterized as *reserves* is actually the *reserve base*.

Inappropriate criteria

To be credible, any reserve estimate must clearly state and define the criteria that are used to define *reserves.* Examples of these criteria for reserves in the underground category include grade cut-offs, minimum mining widths and/or heights, pillar sizes, maximum depths, and minimum size of the deposit. Examples io these criteria for reserves in the surface category include grade cut-offs, maximum stripping ratios, maximum depth of pit, bench widths and wall heights, and minimum size of deposit.

If the relationship between the criteria used and then-current mining costs and selling prices is not apparent in the reserve material provided, it is incumbent on the appraiser to establish to his/her satisfaction that the criteria used will result in favorable economics. There is considerable judgment required to accomplish this, and substantial disagreement within the industry regarding how reference mining costs and appropriate selling prices are developed. For example, does one use current pricing (i.e. – at the date of the estimate) or does one use longer-term price trends? Although this is a topic worthy of discussion, it is too lengthy and complex to be addressed adequately in this presentation.

Inappropriate recovery factors

There are two basic components to recovery—mining recovery and yield. Mining recovery represents the portion of the deposit in the ground that can be extracted by the mining process. Yield is that portion of the mined material that remains and is available for sale after processing. Having determined that the estimator is estimating recoverable material, one should then determine what recovery and yield (where appropriate) factors are being used and assess them for reasonableness.

Mining recovery factors obviously have considerable impact on the reserve estimate, and a variation of only 5 to 10 percent in the factor used can translate to a considerable variation in the final estimate of value, particularly in smaller deposits. Although there are no absolute standards that dictate what constitutes an appropriate mining recovery factor, a competent mineral appraiser arguably should be familiar enough with the mineral being appraised, or bring in someone who is, so as to use factors that are generally accepted in the industry.

The same is true with yield. One of the most common problems encountered involving yield factors is the direct extrapolation of the results of bench testing, laboratory analyses, and sink-float testing to forecast yield through the processing system. Because laboratory conditions typically can't be duplicated in actual processing, and because of mechanical inefficiencies in processing systems, double-digit variances between forecast yield and actual yield are common.

Errors in data development and model input

A significant percentage of reserve estimates are now prepared using computer-based modeling systems. To say that such systems lack transparency is an understatement. One can obtain an initial degree of comfort, however, by reviewing the data sets that were used as input in the model or, for that matter, used in estimates prepared by hand.

By far the most common problem is a failure to proof data entry. As elementary as this may appear to be, in my experience a significant percentage of the data sets reviewed have substantial errors, including simple transposition of numbers, entries being made in the wrong columns or rows, and wrong numbers being entered in the right places. Proofing is required not only for data entry, but also for formulas when spreadsheets are being used. Although proofing is time consuming and tedious, it is essential to developing a credible reserve estimate.

Computational errors

With the advent of computer modeling, it is often difficult to determine whether there are computational errors, or "busts," in the model. There are ways in which this can be tested, however. For computations done by hand or by using spreadsheets, take a handheld calculator and walk through a number of the basic calculations to determine whether they are correct.

ASSESSMENT CHECKLIST

In assessing the validity of reserve estimates, it is useful to have a brief checklist such as the following, derived in part from the discussions above.

1. Determine who prepared the estimate.
2. Determine the date of the estimate.
3. Determine whether appropriate methodology was used.
4. Check correlations when appropriate.
5. Establish that appropriate criteria are used.
6. Establish that the tonnage estimates represent recoverable material.
7. Establish that appropriate recovery factors are used.
8. Establish that data entry and model input (where appropriate) appear to be correct.
9. Establish that computational errors are unlikely to have occurred.

PRACTICAL APPLICATIONS

In many instances, it is not feasible to review all the supporting data entry and calculations by which a reserve estimate was prepared, particularly for large deposits with numerous data points. It is possible, however, to assess the validity of the estimate by reviewing a small portion of the data entry and calculations as a test of the methodology and of the accuracy of the data being used. Several examples are provided below.

Scattered and discontinuous kaolin deposits

The reserve estimates at a kaolin mining operation were developed from hundreds of drill holes on closely spaced centers, the major portion of which had been tested for key physical characteristics. The first step in assessing the validity of the reserve estimates was to enter the drill hole numbers into a spreadsheet and, using a random number generator, select a starting drill hole.

Based on the number of drill holes involved, a determination was then made of the number of drill holes that would be required to provide a 90+ percent probability that the holes selected were representative of the universe of holes available. This number was then divided into the total number of holes to establish the interval to be used in selecting the holes. This interval, or *n,* was then used to select the holes to be reviewed by starting with the randomly generated drill hole number and selecting every *n*th hole. This is termed a random start, periodic sampling technique.

For the holes selected, a detailed review was conducted of individual logs to check footage and lithologic descriptions, the results of testing, and the entry of these data into the reserve estimation sheets. This review established a high degree of confidence in the accuracy and integrity of the data being used.

A number of individual deposits were then selected and the calculations involved in the estimation process were done using a handheld calculator. This work also established a high degree of confidence in the calculation process. As a result, the company's reserve estimates were accepted and the appraisal was conducted on this basis.

Extensive trona deposit

The deposit under consideration underlay 15 square miles or more, in an irregular fashion. A substantial number of drill holes were available, with reserves estimated in multiple beds. All drill logs were available.

The initial step was to review bed correlation. Because not all beds contained reserves within the area under consideration, the correlation process did not require that all beds be correlated in all holes. Based on the review conducted, the accuracy of the correlations was established to a high degree of certainty.

The company had estimated reserves in individual sections (one square mile), and in testing the reserve estimation process, one section was selected and all drill holes within that section were reviewed and used to estimate tonnage in the primary bed. This process yielded an estimate that correlated closely with the estimate prepared by the company, thus providing a high degree of certainty regarding the validity of the reserve estimates for the entire deposit. The company's reserve estimates were then used in the appraisal.

Massive sulfide deposit

Multiple iterations of reserve estimates had been prepared using Vulcan® geologic modeling software. As a result, the actual calculations were not transparent. Reserves had been estimated by proposed mine block. After reviewing the criteria and factors used in the estimation process, spot checks were made comparing drill and analytic data to the data entry sheets used in modeling. A single reserve block was then selected and estimates of tonnage and grade were prepared in a spreadsheet. There was less than five percent variance between the estimates prepared by the modeling software and those prepared using a spreadsheet, thus establishing a high degree of confidence in the estimation process. The company's estimates of tonnage and grade were then used in the appraisal.

SPECIFIC EXAMPLES

Egregious examples of faulty reserve estimation abound, four of which are presented below.

Surface mineable coal deposit

A relatively large deposit with the potential for extraction by mountaintop removal methods consisted of several hundred feet of stratigraphic interval containing numerous coal beds and benches. The reserve estimate that was provided estimated tonnage in numerous isolated benches as thin as six inches, none of which could economically have been recovered in mining. The inclusion of these benches inflated the reserve estimate, understated the stripping ratio, and thus led to faulty projections of mining economics.

Underground mineable coal deposit

Reserves were estimated on the basis of room and pillar mining for a large and irregularly shaped deposit, the outcrop of which was defined by steep-sided drainages and relatively narrow ridges. A mining recovery factor of 75 percent was used. Although such a recovery factor is theoretically capable of being achieved within the limits of a well-defined room and pillar mine block—assuming that no adverse geologic conditions are encountered—such a high rate of recovery can't be achieved in an irregularly shaped deposit with extensive outcrop and underlying relatively narrow ridges. A more appropriate mining recovery factor would be 50 percent.

Crushed stone quarry

Reserves were estimated using the exterior limits of the planned pit, assuming a vertical wall and a hundred percent recovery. This estimate meets the definition of a *reserve base*, not of a *reserve*. In actuality, the walls of this quarry likely would be developed with safety benches on the order of 25 feet in width at vertical intervals of no more than 50 to 75 feet. Additionally, one could expect a loss of material during mining as a result of local occurrences of stone that was weathered or did not meet specifications and through spillage in transporting from the pit to the crusher. A mining recovery factor of 90 to 95 percent in a situation such as this would likely be appropriate.

Sand and gravel pit

Tonnage had been estimated for three components of the deposit—gravel, a relatively coarse sand, and an extremely fine sand. The total tonnage in the deposit was classified a *reserve*. During the site visit and during the investigatory phase of the appraisal, it was determined that there were insufficient markets for the extremely fine sand and that the major portion was either stockpiled as waste or disposed of in mined-out pits. This material was thus excluded from the reserve estimate used in the appraisal.

SUMMARY AND CONCLUSIONS

The widely accepted definition of *market value* assumes a buyer and a seller, each being well informed or well advised, and each acting prudently and knowledgeably. In relying on this definition, one must then assume both parties will be sufficiently knowledgeable to make meaningful assessments of the reserves available at the subject property.

It thus follows that in the preparation of an appraisal in which the premise of value is *market value*, the appraiser must establish to a reasonable degree of certainty that the reserve estimates meet the standards that knowledgeable and prudent buyers and sellers would set in their reserve assessments. To do otherwise is likely to yield an estimate of value that does not meet the definition of *market value*.

There are a number of definitions of the term *reserves*, all of which share a number of key defining words—economically, extracted, <u>and</u> legally. One of the first steps in assessing the validity of a reserve estimate is thus to establish that the term *reserves* as used in the estimate is defined in this fashion.

Experience has shown that a number of problems can be anticipated when using reserve estimates prepared by others, which the mineral appraiser should consider before accepting such an estimate. In assessing estimates prepared by others, it is helpful to use a checklist reflecting these potential problems.

There are a number of techniques by which reserve estimates prepared by others can be assessed. These include such techniques as reviewing a statistically meaningful sample of the drill data and analytic data used, preparing an estimate of a defined portion of the overall reserve summary for comparison with the estimate being reviewed, and checking data entry in those instances in which computer-based modeling is done.

It is the author's conclusion that a mineral appraiser has an implied, and an expected, responsibility concerning the reasonableness of the reserve estimates on which an estimate of market value is based. Acceptance of estimates prepared by other parties without at least a cursory "reasonableness" review by the appraiser seems at odds with the assumptions of those commissioning the appraisal and can potentially lead to erroneous value conclusions. Further, techniques exist by which an assessment of the reasonableness of reserve estimates can be conducted in a timely fashion.

[1] Office of the Comptroller of the Currency under 12 CFR, Part 34, Subpart C-Appraisals, 34.42 Definitions [f].

[2] Canadian Securities Administrators *National Instrument 43-101, Standards of Disclosure for Mineral Projects*

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