According to the U.S. Securities and Exchange Commission (SEC) definitions, a reserve is a mineral deposit that can be economically and legally mined at the time of the reserve determination.

Proven (measured) reserves are “reserves for which (a) quantity is computed from dimensions revealed in outcrops, trenches, workings or drill holes; grade and/or quality are computed from the results of detailed sampling and (b) the sites for inspection, sampling and measurement are spaced so closely and the geologic character is so well defined that size, shape, depth and mineral content of reserves are well-established.”

Probable (indicated) reserves are “reserves for which quantity and grade and/or quality are computed from information similar to that used for proven (measured) reserves, is high enough to assume continuity between points of observation.”

The key words for proven reserves are well-established, and for probable reserves assume continuity. Classification into these reserve categories is the ability to accurately predict the thickness, lateral continuity and geologic character of the next drill holes, outcrops, trenches or other data points.

Proven reserve estimations typically require more drill-hole data than probable reserves. For most deposits, reserves at the probable classification stage are adequate. For example, if there is one boring in each of the four corners and the center of a square- or rectangular-shaped parcel, and the overburden and aggregate thickness and geologic character are fairly consistent in these holes (i.e., thickness does not vary by more than about 10 percent), additional borings may not be necessary to assume continuity of the reserves.

The difference between proven and probable reserves is the degree of certainty that the thickness and geologic character are continuous throughout the deposit. Proven reserves indicate that there is strong certainty of the thickness, lateral continuity and geologic character, and that additional drilling is unnecessary.

If continuity of thickness, lateral extent and geological character of the deposit can be assumed, re-

Landowners choose to multiply aggregate price, operating income or a royalty rate by tons to arrive at a value for their reserves. In doing so, they probably overstate the value of their land.

By Arthur Pincomb
serves are probable, and additional drilling may not be necessary. Simply stated, it would be surprising if the reserves quarried were not fairly close to what was predicted, particularly for proven reserves.

Only proven and probable reserves are recognized by the SEC. Possible (inferred) reserves are extrapolated beyond drill holes or other data points and represent a lesser degree of certainty. Drill holes and other data are too far apart to assume continuity of the reserves. There is greater uncertainty regarding the deposit thickness, lateral continuity and geologic character.

Some authors prefer to classify these as mineral deposits and not a reserve, as defined above. This implies that there is not enough information to accurately decide if mining the deposit would be financially profitable. Simply stated, the tons quarried would probably not match the predicted reserves.

Quality

Aggregate quality is very important in reserve estimation. In nearly all cases, the higher the quality, the greater the market demand and opportunity to market the aggregate. In many states both physical and chemical quality are important. High demand for anti-skid aggregate for asphalt surfacing courses in central states makes the MgO content important in the analysis of the deposit reserves.

Samples for physical and chemical testing of stone deposits can be obtained by drilling core holes. The core is split-in-half, with one-half submitted to a laboratory and the other half retained for future reference. NQ (~2 in. diameter) is the standard size for coring. Laboratories need at least 50 lb. of material to perform the required L.A. Abrasion, Na2SO4 Soundness, Specific Gravity and Absorption tests. At about 1.75 lb./ft. for split NQ limestone core, 50 lb. of material is equivalent to about 30 ft. of split core.

Data for reserve estimation

The number of borings, trenches or other data points needed to prove a reserve depends on many factors, including project objectives, type of deposit (sand and gravel or stone), proximity to other aggregate operations, available test data, property size and shape, geologic character and water-well logs available from state agencies.

J.R. Dunn reports that a typical spacing for core holes is one hole per four acres, although a wider spacing may be justified where rock is homogeneous over large areas. The author has found that one hole per 20 acres is sufficiently close to prove stone reserves in Midwest carbonate deposits. To classify reserves in the probable category, a minimum of one hole per 40 acres may suffice. Sand and gravel deposits, owing to their less-certain depositional geometry and continuity of units, usually require at least twice as many holes to prove the reserves.

Conversion of acres to tons

The specific gravity is a number that expresses the ratio between a material’s weight and the weight of an equal volume of water. A limestone that has a specific gravity of 2.65 is 2.65 times heavier than an equal volume of water. A diabase that has a specific gravity of 2.95 is 2.95 times heavier than an equal volume of water.

One cu. ft. of water weight 62.4 lb. Since the limestone is 2.65 times heavier than an equal volume of water, 1 cu. ft. of limestone weighs about 165 lb. The diabase weighs about 184 lb./cu. ft.

An acre contains 43,560 sq. ft. and, at a thickness of 1 ft., contains 43,560 cu. ft. There are 2,000 lb. in a short ton. The limestone weighs about 3,600 tpa/ft. of thickness, or 3,600 tpa-ft. (165 lb./cu. ft. x 43,560 cu. ft./acre-ft./2,000 lb./ton). The diabase weighs about 4,000 tpa-ft. These are volume-tonnage conversion factors. A 100 ft. thickness of limestone and diabase contains about 360,000 tpa and 400,000 tpa, respectively, in the ground.

Tons in the ground

The acreage owned or leased cannot generally be completely mined. Legal setbacks from roadways and property lines, utility and other easements, slope angles, previously mined areas, excess overburden thickness, pinching or termination of strata, and non-mining areas set aside for the plant, stockpiles, ponds, ramps and roads all limit the actual acreage available for mining.

The net mineable acreage is calculated by subtraction of the non-mineable acreage. Tons in the ground are then calculated by multiplying mineable acres by the appropriate volume-tonnage conversion factor.

The in-ground reserve is probably not a meaningful calculation for a mine owner. Tonnage sold across the scale is usually less than the estimated in-ground reserves. This happens because dust from crushing and slimes from washing stone or sand and gravel are lost, material is used internally and never crosses the scale, bases for stockpiles grow, and poor-quality stone from joints and faults is wasted.
Prescreening of unwanted material and wasting of nonsaleable fines must also be considered. A loss factor of about 10 percent for stone and a minimum of 15 percent for sand and gravel is commonly used in the central U.S. At 3,600 tpa-ft. for limestone in the ground, sellable stone reserves are about 3,200 tpa-ft., or about 320,000 tpa for a 100-ft. thickness of limestone. At 2,400 tpa-ft. for sand and gravel in the ground, sellable reserves are about 2,000 tpa-ft., or about 100,000 tpa for a 50-ft. thickness of sand and gravel.

**Acreage requirements**

The number of tons mined annually is an easy number to obtain. The length of time a mine operates at a particular location is more difficult to answer. Twenty-five years is considered a minimum mine life, assuming there are sufficient mineable reserves. Multiply previous year sales by 25 to get an idea of how many tons are needed for a 25-year mine life.

If the mining operation is in a growth area, escalate sales annually for the 25-year period. If 1 million tons were sold last year, 25 million tons will be sold in 25 years, with no growth rate. More than 28 million tons are needed at a growth of 1 percent, 32 million tons at a growth of 2 percent, and nearly 36.5 million at a growth of 3 percent.

Divide the total tons needed by the tpa in the deposit to determine how many acres are required. A 1 million tpy quarry, escalating at 2 percent annually, will sell 32 million tons in 25 years, and consume about 100 acres of a 100-ft. thick limestone deposit (32 million tons/320,000 tpa). A 500,000 tpa-ft. per year sand and gravel pit, growing 1 percent annually, will sell about 14 million tons in 25 years, and consume about 140 acres of a 50-ft. thick deposit (14 million tons/100,000 tpa).

**REZONING AND PERMITTING MINEABLE ACREAGE ARE OFTEN BEYOND THE FINANCIAL AND TECHNICAL RESOURCES OF MOST LANDOWNERS.**

**Acreage value**

The value estimates derived from the Sales Comparison Approach generally provide the best indication of the market value of the property, says T.R. Ellis. In other words, the best indicator of value for undeveloped, non-permitted land containing mineable stone or sand and gravel is the price other mining companies have paid for comparable acreage.

Rezoning and permitting mineable acreage in many parts of the country are often beyond the financial and technical resources of most landowners. The mining company generally obtains the permits necessary to conduct mining on the property. The market value of permitted acreage may be greater than the value of the land plus the actual cost of obtaining the permit. Can undeveloped, non-permitted acreage be valued using the income approach? Can a landowner anticipate income, the principle upon which the income approach is founded, without the property being permitted to mine? Many believe that undeveloped, non-permitted acreage containing mineable stone or sand and gravel is worth a moderate premium above agricultural value.

Until the permitting process, and possibly rezoning, is complete, the highest and best use of mineral-bearing land in the central U.S. is usually agricultural. Permit denial by zoning boards and subsequent litigation by the mining company is becoming the rule, not the exception.

There are several misconceptions about the value of undeveloped land containing mineable stone or sand and gravel. A landowner commonly feels that the value of his property, i.e., the minerals, is related to the income generated from mining the property. The following hypothetical statements come to mind:

**Example 1:** "I have 15 million mineable tons of stone on my property and the stone sells for about $5.00/ton. My property is worth $75 million."

**Example 2:** "I have 15 million mineable tons of stone on my property and the company will mine the property for $5.00/ton. My property is worth $75 million."

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<th>Annual Sales (tons)</th>
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<th>Risk Rate (percent)</th>
<th>Total Sales (tons)</th>
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*Source: Associated Geologists Inc./Pit & Quarry*
pany makes $1.00/ton profit. My property is worth $15 million."

**Example 3:** "I have 15 million mineable tons of stone on my property and the royalty rate is $0.30/ton. My property is worth $4.5 million."

All three examples are simply not true, and overstate the value of the mineral-bearing land. Examples 1 and 2 overlook the fact that the landowner is not entitled to the income the operator generates. In Example 1, the landowner fails to realize the capital outlay, operating costs and risk associated with creating that ton of stone that sells for $5.00.

Multiplying mineable tons by average sales price provides the gross price of the reserves. D.W. Gentry and T.J. O’Neil say that "The [income] approach assumes that a purchaser would not be justified in paying more to acquire income producing property than the present value of the income stream to be derived from the property." Clearly, businesses are valued based on income, not gross or net sales.

Example 2 is more appropriate to the value of the mining enterprise or mining operation, not the property or mineral deposit. R.H. Paschall defines total property as, “… the sum of: (a) land, including that needed for roads, plant site and stockpiles, (b) the processing plant, and (c) mobile equipment, which may embrace a dragline or shovel, loaders, trucks, et al."

**Goodwill**

To this list of value elements the author would add “goodwill,” which is included in the Glossary of the Uniform Standards of Appraisal Practice as “an intangible asset category usually composed of elements such as name or franchise reputation, customer patronage, location, products and similar factors.” Clearly, the $1.00/ton profit contains several value elements, including the value of the land and mineral rights. The property owner, then, is entitled to a portion of the net income for the land and minerals.

Example 3 uses the correct methodology, but overlooks the fact that future income is always discounted to arrive at a present value. The logic for this is twofold.

First, an anticipated rate of return must be realized to interest a company in investing money in the mineral-bearing property. All income is discounted, year by year, at an appropriate rate, to guarantee that the purchaser makes money. This is the reverse of compounding interest, with additions to a sum with each successive time period.

Second, there is a risk in selling the predicted annual tons and having enough quality reserves to satisfy the market. In addition to market, reserves and quality risks, there are risks associated with regulatory compliance, with the actual operation and with management. Each of these factors contributes to the success, or failure, of the mining enterprise. The higher the risk, the greater the risk factor and the lower the value. The lower the risk, the lower the risk factor and the higher the value.

The farther into the future, the greater the discount factor, and the greater each year’s income is discounted. The 15 million tons in Example 3, if mined at a constant 500,000 tpy, with a nonescalating $0.30/ton royalty rate, has a present worth, after discounting at 11 percent, of about $1.26 million, or about $0.10/ton in the ground.

Table 1 demonstrates this relationship among annual sales, royalty and discount rates. The table assumes adequate mineable reserves are available, and neither annual sales nor the royalty rate escalate. This is usually not the case. Clearly, discounting future royalty income to estimate present value (market value) results in a lower value for the land and mineral rights than Example 3. The table also demonstrates that the more reserves you buy, the lower the value/ton.

Reserves planning requires an owner or lessee to understand the relationship among acres, reserves, annual sales and value. Is there sufficient drill hole or other data within the acreage to be certain or assume continuity of thickness and geologic character of the reserve? By knowing net acres available for mining, an estimate of the life of the reserves can be made. Future acreage requirements can then be evaluated.

Art Pincomb is a geologist and appraiser, and is president of Associated Geologists Inc. He can be reached at 630-845-0442.

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