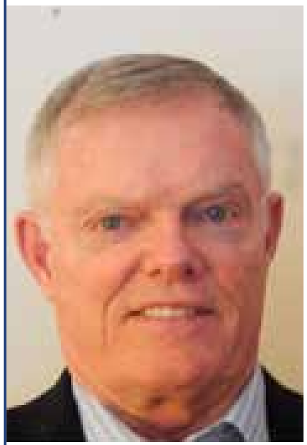
Mineral Appraisals: What is the Value of a Quarry or Mine?

Art Pincomb, ASA, CPG



Mineral commodities are classified as high-value, low-volume or low-value, high-volume. With current (2016) prices of about $1,100/oz. for gold, $14.00/oz. for silver and $800/oz. for platinum, precious metals are considered some of the highest value-low volume mineral commodities. Refined precious metal bullion is transported worldwide. Also falling into the high-value, low-volume category are the base metals like copper ($2.00/lb.), aluminum ($0.67/lb.), zinc ($0.67/lb.), and tin ($6.15/lb.), all concentrated at the mine site, refined and transported worldwide.

This paper looks at low-value, high-volume mineral commodities, mainly crushed stone and sand and gravel (aggregate), generally sold by the ton, fob quarry. Dimension or cut stone is generally sold by the cubic foot. Transportation costs limit the distance aggregates are moved to markets. According to the 2013 U.S. Geological Survey (USGS) 2013 Mineral Yearbook, 74% of crushed stone was transported by truck (74%) to local markets within about 30 miles of the open-pit quarry or underground mine. About 7% was transported by waterway and 4% by rail. The remaining 15% was processed and used onsite (cement plants, for example). Coal and industrial (frac) sand are also considered low-value, high-volume commodities, and can be transported greater distances by rail due to their higher unit prices.

Mine Operation Assets – What has Value?

The primary factors of production, to produce goods or services, include land, capital, labor and entrepreneurship. The land (resource) is a gift, not created by human effort. Capital includes the mining machinery and equipment, plus the processing plant, to produce a finished product. The raw ore is extracted by surface (open pit) or subsurface (underground) mining methods; processed to a marketable state; and delivered to the market. Labor includes all human effort, abilities and skills, both physical and mental, which goes into changing raw materials into a finished product. People are tangible, but the attributes of an assembly of people with special skills, team-working ability, pride of workmanship or loyalty can be a valuable intangible asset. The entrepreneurs are the individuals, commonly owners, who are the innovators, those who take risks in search of profit.

Mineral Property Ownership

Property in the Midwest and Eastern states is generally owned in Fee Simple, where the mineral and surface rights are not severed. In split estate situations, the surface and subsurface (mineral) rights for a property are owned by different parties. In these situations, mineral rights are considered the dominant estate, meaning they take precedence over surface ownership, including the right to develop the minerals.

Mineral Leases are common, where the operator leases the mineral rights from the property owner, generally paying a rental or royalty rate (per ton sold), during a set term, to the landowner (Lessor). Non-mined cropland is commonly farmed by the Lessee until overburden is stripped and mining commences.

A Surface Lease, where an operator leases the surface rights from the owner, may be required in some jurisdictions where limestone and sand and gravel are considered common variety minerals and are part of the surface estate.

A Mineral or Mining Property Defined

A Mineral Property encompasses all the land directly or indirectly used for mining, i.e., the highest and best use is for mining. As seen in the illustration below, mineral properties are usually required to have property line or roadway setbacks, to protect adjoining landowner's property from encroachment. The setback distance is commonly related to the thickness and angle of repose of the unconsolidated overburden overlying the ore. Dirt berms are frequently built on the setbacks from non-saleable overburden, and visually screen the mining and processing operation. Berms also protect fugitive dust from leaving the site and act as noise barriers for blasting, vehicles and equipment. Setbacks and other non-mineable tracts are part of the mining property and are not valued separately, for other uses.

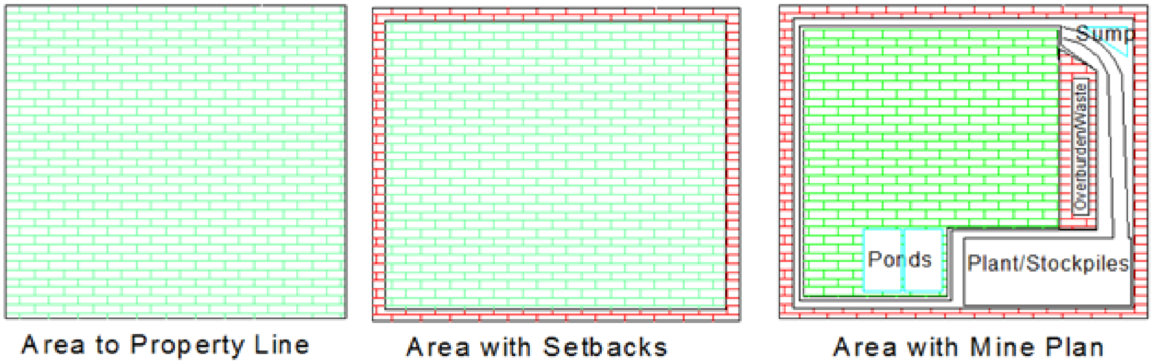
Economically mineable ore reserves may or may not underlie the entire property, and non-minable areas become locations for the processing plant and inventory stockpiles; the overburden stockpile area; wash water and settling ponds; and improvements. Non-mining areas may result from excessive overburden thickness, thin or absent formations, or low ore purity or quality. Many transportation agencies require crushed stone or sand and gravel to be free from clay or dust, requiring the aggregate to be washed before it is stockpiled and loaded into customer trucks. This clay and silt settles in the ponds before the water is re-used in the wash circuit of the processing plant.

Rights-of-way for powerlines, natural gas pipelines, utilities, roadways, along with their setbacks, may not be mineable.

In most cases, the zoning district for the property will be either Industrial or Agricultural. Mining is usually a permitted use in the Industrial District. If zoned in the Agricultural District, a Special or Conditional Use Permit for Mining, with or without blasting, may be required. Quarrying solid rock, like limestone and granite, requires blasting, whereas mining sand and gravel generally does not. Sand and gravel can generally be taken directly from the ground by a front-end-loader or excavator if above water, and by a suction or ladder dredge or dragline if below water.

Permitting a mining property, with or without blasting, is a time-consuming, expensive process, in most jurisdictions. It has become necessary to contract numerous experts, including mining and traffic engineers, hydrologists, blast vibration experts, land planners, air quality experts, wetlands and dust experts, and appraisers, for both highest and best use issues and impacts on housing prices. Permit denial at the local or county level is commonly followed by litigation to obtain a permit. Today, many quarries and mines are pre-existing uses (in operation prior to enacting zoning ordinances), court-ordered, or annexed into a city. Annexation is a tool used by municipalities to gain some control over grandfathered or court-ordered quarries. The quarry operator usually pays rent or a per-ton royalty to the municipality.

Figure 1. Diagram showing a Quarry Property



Mineral Reserves and Resources

According to the U.S. Securities and Exchange Commission (SEC) definitions, a reserve is a mineral deposit that can be economically 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, but the sites for inspection, sampling and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for proven (measured) reserves, is high enough to assume continuity between points of observation."

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, reserves 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.

The key words for proven reserves ae 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.

Mineral Resources are not recognized by the SEC. According to the SME Guide For Reporting Exploration Results, Mineral Resources, and Mineral Reserves (The 2014 SME Guide), "A Mineral Resource is a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade or quality, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling." Mineral Resources are generally 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.

Converting Acres to Tons *in situ* (in the ground)

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 weighs 62.4 lb. Since the limestone is 2.65 times heavier than an equal volume of water, 1 cu. ft. of limestone weights 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 lbs. in a short ton. The limestone weighs about 3,600 tons per acre per ft. (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.

The average specific gravity of sand and gravel is difficult to quantify, owing to variations in the degree of packing and water content. A factor of 111 lb. /cu. ft. is commonly used for sand and gravel, equal to about 3,000 lb. or 1.5 tons/cu. yd. This equates to about 2,400 tpa/ft. (111 lb. /cu. ft. x 43,560 cu. ft./acre-ft./2,000 lb. /ton). A 50-ft. thickness of sand and gravel contains about 120,000 tpa, in the ground.

The average aggregate thickness on a property is calculated by averaging the thickness of boreholes contained within the mineable acreage. Equal spacing of holes is important. A clay pocket or sinkhole is accounted for by either averaging the thickness of mineable material in the clay pocket with the rest of the holes, or by subtracting out the acreage contained in these anomalies.

Additional drill holes may be required to accurately quantify the acreage lost to clay pockets, karst, fault gouge or glacial scours. In estimating the thickness of a deposit, the top and floor of the deposit may need to be subtracted. Weathering commonly deteriorates surface rock to the point where it cannot be sold. A level quarry floor may require leaving some sellable stone.

Calculating 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, excessive 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 acreage 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 nonsaleable fines must also be considered. A loss factor of about 10 percent for stone and at least 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. mineable 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.

How Many Acres do You Need?

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 ton per year (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 tpy sand and gravel pit, growing at 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).

Rock and Mineral Quality or Grade

There are a variety of industry-standard purity and grade classifications to determine the unit value of rocks and minerals for reserve estimation. In nearly all cases, the higher the purity or quality, the greater the market demand, price and opportunity to market the mineral. At some lesser grade, the purity or quality of the material becomes too poor to market.

In many states both physical and chemical ratings are important to classify aggregate quality. Crushed stone and, to a lesser extent, sand and gravel, must meet strict state department of transportation requirements for aggregate placed in asphalt and concrete roadways and bridges. A combination of high resistance to physical and chemical degradation, low fluid absorption and moderate to high specific gravity is required for durable, long lasting highways. A low percentage of deleterious materials, like chert and clay, is also required. High demand for anti-skid aggregate for asphalt surface courses in central states, where only limestone or dolomite are available, makes the MgO content important in the analysis of the deposit reserves.

The demand for dimension stone is more a function of color, texture, compressive strength and workability. Much of the dimension stone used in the United States is a structural component, so beauty and strength are desired characteristics. Countertops are generally not cut from US quarries, being imported primarily from China and India.

Industrial sand, particularly "frac" or proppant sand, is used for recovery of oil and gas by fracturing the formation through water injection, then "propping" open the formation by pumping sand into the open fractures. The highest purity "frac" sands, found primarily in Illinois, Minnesota, Missouri and Wisconsin, are of Cambrian or Ordovician in age (450 million years old), rounded, equigranular, and are between 20 and 70 mesh.

Thermal coal is burned in power plants. Its quality depends primarily on its heating value (Btu per pound), volatile matter, and moisture, ash and sulfur content. The higher the Btu value and lower the moisture, ash, volatile matter and sulfur concentration, the more marketable and cost of the coal.

Transportation Costs may Limit Your Market

Aggregate per-ton haulage rates are directly related to the hourly trucking rate and roundtrip time to load and deliver a given quantity of aggregate to the customer. The maximum gross weight limit that States must enforce on the Interstate System is 80,000 pounds, or 40 tons. The typical truck load is 22-25 tons of aggregate, depending on the stone density. At $100.00/hr. trucking rate and a 1-hour roundtrip, including loading, travelling and delivering to the site, and returning to the quarry, the transportation cost is about $4.00/ton for a single, 25-ton load. If the truck travels 10 miles to the site, the haulage rate is $0.40/mile. Twice the distance halves the haulage rate. Since the time to load at the quarry and unload at the delivery site does not vary significantly, the rate per mile depends primarily on the distance between the quarry and jobsite and time it takes to travel that distance.

Trucking costs are generally $0.17 to $0.30/ton mile. Generally, the cost of the aggregate f.o.b. quarry doubles at a distance of 30 miles from the quarry. The 30-mile figure is commonly used as a distance limit for a quarry.

Modern rail cars hold about 100 to 120 tons of coal. A 120-car train unit holds about 12,000 to 15,000 tons of coal. Costs are $0.12 to $0.25 per ton mile. Conveyor belts $0.07 to $0.13 per ton mile. A typical jumbo barge holds 1,500 tons, 15 times more than a rail car and 60 times greater than one trailer truck. Costs are $0.09 to $0.20 per ton mile.

A large quarry in Chicago reports shipping 1 ton of product on the Chicago River 542 miles with one gallon of fuel. There are also fewer emissions and few incidents on waterways.

Quarry and Mine Appraisals

Mineral properties are valued using the sales comparison, cost or income approaches to value, according to Standard 2 of the Uniform Standards of Professional Appraisal Practice (USPAP). Some mineral appraisers may defer to USPAP Standard 10 to value mining operations, which includes the market, asset-based (cost) and income approaches to value. The valuation methodologies used for the two standards are similar.

The Summation Method, where the minerals are valued separate from the land, must be avoided, especially where surface mines or quarries are being valued. According the Uniform Appraisal Standards for Federal Land Acquisitions (UASFLA), the existence of minerals is a factor of value to be considered in determining market value of a property, but the landowner is not entitled to have the surface value of the land and the value of the underlying minerals aggregated, or summed, to determine market value. The charge of valuing the minerals separate from the land is commonly made in legal settings when mineral appraisers mention the value of the minerals in situ, or in the ground, usually per ton, cubic foot, ounce or other unit value.

Sales Comparison Approach - if the deposit to be appraised is undeveloped and non-producing, that is, is raw land, the sales comparison method is preferable, according to Robert H. Paschal, former ASA Mines & Quarries appraiser. 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.

If recent comparable sales data is available, the sales comparison approach is usually considered the best evidence of value. The courts prefer comparable sales. Sales of property permitted for quarrying, however, are extremely rare. Until the permitting process, and possibly rezoning, is complete, the highest and best use of mineral-bearing land in the central and eastern U.S. is usually agricultural. If discovered, sales of permitted mining properties are commonly used to support values obtained using the cost or income approaches. Sales adjustments must consider the volume, quality and life of reserves, permit renewal status and environmental pressures, ease and mode of access and distance to customers, competitors, mining costs and competing land uses.

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 commonly exceed the value of the land plus the actual cost of obtaining the permit, because permits are so difficult to obtain.

Comparable sales for operating mines and quarries are extremely difficult to find throughout the United States. First, sales of operating mines and quarries are rare. Secondly, the rare sales usually involve multiple quarries in differing locations, asphalt or ready mix concrete plants, and supply and/or non-compete agreements.

Cost Approach - The Cost Approach is rarely used for quarry and mine appraisals. The cost approach combines the value of the land assumed to be vacant and then factors in the costs of replacing or reproducing property improvements with deductions for property obsolescence and depreciation. The land is valued using the sales comparison or income approaches to value. Any improvements to a mining property are usually fully depreciated and do not add to value, so the Cost Approach becomes redundant. The processing plant, the scale and scalehouse and most structures are commonly portable and not considered improvements. The Cost Approach may be used when railroad spurs, ports or when newer improvements are present. Underground mine shafts or declines may be valued separately during early stages of development.

When valuing a quarry or mine business, the cost, or asset-based approach overlooks the fact that intangible assets of a going concern business enterprise, including synergistic values, reputation, customer patronage, location, skilled workforce, innovation and other factors contribute to the value.

Income Approach - Mineral properties are purchased for the production of future income. Can undeveloped, non-permitted acreage be valued using the income approach? Can a landowner anticipate income, the principle upon which the income approach is based, without the property being legally permitted to mine? Many believe that undeveloped, non-permitted acreage containing mineable stone or sand and gravel is worth a premium above agricultural value.

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 statements come to mind:

Example 1: "I have 15 million mineable tons of stone on my property and the stone sells for about $8.00/ton. My property is worth $120 million."

Example 2: "I have 15 million mineable tons of stone on my property and the company makes $1.50/ton profit. My property is worth $22.5 million."

Example 3: "I have 15 million mineable tons of stone on my property and the royalty rate is $0.50/ton. My property is worth $7.5 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 $8.00.

Multiplying mineable tons by average sales prices provides the gross price of the reserves. D.W Gentry and T.J. O'Neil state that "The [income] approach assumes that a purchaser would not be justified in paying more to acquire an 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 the value of the mining enterprise or mining operation, not the property or mineral deposit. R.H. Paschal 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." The $1.50/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, has a present worth, after discounting at 10 percent, or about $2.27 million, or about $0.18/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 in Example 3. The table also demonstrates that the more reserves you buy the lower value/ton.

Table 1. Royalty Discounted Cash Flow Variables

Annual Sales (tons)	Life (years)	Royalty Rate ($/ton)	Risk Rate (percent)	Total Sales (tons)	Value ($)	Value ($/ton)
500,000	25	$0.50	10 percent	12,500,000	$2,269,260	$0.18
	25	$0.50	12 percent	12,500,000	$1,960,785	$0.16
	25	$0.75	10 percent	12,500,000	$3,403,890	$0.27
	25	$0.75	12 percent	12,500,000	$2,941,177	$0.24
	40	$0.50	10 percent	20,000,000	$2,444,763	$0.12
750,000	25	$0.50	10 percent	18,750,000	$3,403,890	$0.18
	25	$0.50	12 percent	18,750,000	$2,941,177	$0.16
	25	$0.75	10 percent	18,750,000	$5,105,835	$0.27
	25	$0.75	12 percent	18,750,000	$4,411,766	$0.24
	40	$0.50	10 percent	30,000,000	$3,667,144	$0.12
1,000,000	25	$0.50	10 percent	25,000,000	$4,538,520	$0.18
	25	$0.50	12 percent	25,000,000	$3,921,570	$0.16
	25	$0.75	10 percent	25,000,000	$6,807,780	$0.27
	25	$0.75	12 percent	25,000,000	$5,882,354	$0.24
	40	$0.50	10 percent	40,000,000	$4,889,525	$0.12

About the Author

Art Pincomb, ASA, CPG is a geologist and mineral appraiser, and is president of Associated Geologists, Inc. Art can be reached at 630-845-0442, mobile 630-248-5314, email artpincomb@sbcglobal.net, website www.mineralvaluation.com.

Professional Certifications
American Society of Appraisers, Accredited Senior Member, 1994, Reaccredited to December 12, 2018
Certified Professional Geologist, States of Illinois, Indiana, Kentucky
State Certified General Real Estate Appraiser

Areas of Expertise
Mineral Property and Mining Operation Appraisals
Feasibility Studies and Due Diligence Investigations
Industrial Minerals Investigations
Mineral Deposit Reserve Estimations and Quality Investigations

Mr. Pincomb's experience includes 30 years in aggregates and industrial minerals and 10 years in precious and base metals and energy minerals. He routinely performs mineral property and mining operation appraisals, plans and implements drilling, geological and geotechnical core logging projects, mapping and reserve and quality analyses. He is an Accredited Senior Appraiser with the American Society of Appraisers, Mines & Quarries Discipline. He has acted as an expert witness in numerous condemnations, tax appeals and zoning hearings involving mines, quarries and mineral properties. He is a State Certified General Real Estate Appraiser.

Mr. Pincomb determines fair market value of mines, quarries and mineral properties at sites throughout the United States. More than 500 appraisals of mining properties, mining operations and mining companies have been performed in since 1990. Condemnation cases, securing bank financing, county tax disputes, permit or zoning appeals, sale or purchase of property, divorce and estate settlement, asset worth, and bankruptcy cases. Appraisals include reserve and quality analysis, life of the deposit and market studies. Clients include mineral producers, attorneys, banks, insurance companies and individual mineral property owners.