APPRAISAL AND VALUATION OF MINES

By Osborne Haydon

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of

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Definition and Purpose: The problem of the valuation of a mine resolves itself into two parts; first, the determination of the amount and value of the mineral contents of the orebody, and second, the profit that may be gained from placing the recovered material upon the market.

An orebody or mine may be valued for any one of a number of reasons. For the purpose of purchase the estimation of possible and probable ore reserves would not likely be as sanguine as those estimates made for the purpose of sale. It is only human nature to be a trifle more optimistic about the chances for good ore further on if you are making a valuation for selling purposes, and conversely a man buying will be cautious about the rosy prospects of unproved ore.

State and Federal governments also make valuations of mining properties for the purpose of taxation; these are apt to strike a happy medium, because the appraiser has no interest, though he is likely to be conservative in his estimates as it never seems quite fair to tax a man for something there is only a chance that he may have.

Mining companies of any size are in the habit of making continuous valuations of their property for development, to keep check on their workings, and to find out the quality of the ore being

taken out so that they may intelligently institute new workings.

Properties may also be valued for the purpose of consolidation in which case there are generally two valuations made of each property: one by a man from each concern, and an average of the two used as a basis for the merger.

General Considerations: There are a number of things which must be taken into account when valuing a property; these are quite general in character, but any one may often be the determining factor in deciding whether or not a mine will be worked.

The location of an ore deposit is of prime importance; a high grade deposit of iron ore would be of no present value if situated in the middle of the Sahara Desert because transportation costs to market would eat up all the profit, while a deposit of gold would be just about as valuable there as anywhere else as the ratio between its value and bulk is large.

An adequate fuel supply must be available, because fuel is absolutely necessary for the generation of power, and sometimes, when it is necessary to ship in fuel, transportation costs are prohibitive.

Labor is sometimes bothersome, but it is hardly a problem for an appraiser to consider, unless there are some extraordinary conditions which complicate matters.

Excessive ground water may necessitate so much pumping as to make profitable mining impossible when the margin of profit is small. Also the absence of water for drilling and power developement may absolutely stop development.

Poor climatic conditions never make it impossible to work a property, but they can add materially to the cost because they cause a high labor turnover.

The political stability of the country in which the deposit is located may not be overlooked. Mexico furnishes an example of a country where political turmoil caused the virtual abandonment of numerous properties for a considerable length of time.

Unless specifically indicated to the contrary by the client, the examiner should learn the condition of the title; where possible this should be done with the aid of reliable local attorneys who should also pass on all deeds, transfers, and escrows.

According to [1]Winchell there are two theories relating to

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[1]H. V. Winchell, Sec. 24 - Mining Laws. Mining Engineers Handbook. John Wiley and Sons.

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the acquisition of mining claims: "That in which the state or a private owner of mining property has the right to grant concessions or leases to individuals or corporations at discretion or under certain general restrictions", and "That in which any individual has the right to locate on discovery or otherwise certain limited areas of ground, and under certain conditions to hold, work, or dispose of the same. This is the 'Claims' system". The latter is the one in use on public domain in the United States and has led to unlimited litigation and trouble. "Under the law of 1872, lode claims may have a maximum length of 1500 feet, and maximum width of 600 feet, in no case exceeding 300 feet at each

side of the vein at the surface. The owner of valid location is also given all other veins of which the tops or apices lie within the exterior boundaries of his claim, provided they were not adversely claimed on May 10, 1872." "As in case of lode claims, a discovery of valuable mineral in place is necessary before location of a placer claim - - -." (For complete discussion of apexing, prior locations, and overlapping locations, see H. V. Winchell cited above.)

The necessary forms for deeds, transfers, bonds, etc., can be found in any lawyer's office; moreover no important contract would ever be signed without expert legal assistance. Such forms as are needed in the field can generally be developed by the examiner himself, unless the company he is working for has standardized forms.

The equipment needed varies greatly, of course, but Westervelt* gives the following list as a basis.

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*W. Y. Westervelt, Mine Examinations, Valuations, and Reports, Sec. 25, Mine. Eng. Hand. John Wiley and Sons.

General	For Sampling
Pocket aneroid barometer.	6"x12" and 14"x20" canvas sampling sacks.
Brunton pocket compass.	Twine for tying above.
50' metallic tape in leather case.	Sample envelopes with flexible mettalic mouth.
Pocket lens.	6'x6' canvas, ticking, or enamel stock, sampling sheet.
McNeils code.	Jones sample splitting outfit.
Drawing instruments with pencil, paper, etc.	Large iron mortar with pestle and canvas cover.
Fountain pen and ink in travelling filler bottle.	Galvanized iron screwtop cans of glass jars for moisture samples.
Soft and indellible pencils.	Adhesive tape for above.
Colored crayons.	Whisk broom.
Loose leaf note book.	Single and double hand hammers.
Triangular scale of 6 scales (1"-20' to 1"-60')	

1' steel folding rule.	Miner's pick.
Pocket adding machine.	3/4" moils, 6" to 18" diamond point.
Kodak.	Gold pan and vanning placque.

Additions For Placer Sampling

100' steel tape on reel.	Mercury.
Level and rod.	Annealing cups.
Carpenters pencils.	Nitric acid.
Magnet.	Alcohol and lamp.
Portable gold balance.	Short handled shovel.
1"x3/8" bottles with covers for gold colors.	Gummed labels.
	Retort stand with alcohol stove.

Geology: To intelligently set about placing a value upon a property, it will be of considerable aid to have the general geology of the region in mind. This can be gained from geological maps and from other mines which have been worked in the district. In little known or explored countries this will be impossible, and original geologizing must be done; it must be done in any case as a check upon other maps.

Where other mines have been worked it is possible to learn what conditions may reasonably be encountered such as the general nature of the ore body, the depth to which oxidation extends, degree of exhaustion with depth, ground water conditions, and amount and nature of faulting, fracturing, folding, and jointing.

Ries places all ore deposits in one of two classes: contem-

Henrich Ries: Economic Geology, 4th Ed. John Wiley and Sons.

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poraneous or syngenetic, and subsequent or epigenetic. The syngenetic deposits are not of very great consequence; they are divided into two groups - magmatic segregations of minerals within the magma, and interstratified sedimentary deposits, which have formed by similar processes

as those forming the enclosing rocks. Of this type, placer deposits are probably the most important.

The epigenetic class is divided into deposits from magmatic emanations, pegmatite dikes, high temperature veins, contact metamorphic deposits, deposits formed at intermediate depths, deposits formed at shallow depths, and deposits formed at surface by hot waters.

Ore bodies are quite likely to be faulted, and a thorough understanding of the degree and nature of faulting is necessary; a lost vein may often be picked up by a study of the fault, obviating the necessity of extensive prospecting.

At some depth below the surface every ore body will either play out or become unworkable; many will show a zone of higher values which can profitably be worked while the rest of the orebody may have no present value. According to the nature of the deposit, the depth of profitable working can in some measure be inferred from a general knowledge of similar deposits.

At Butte, Montana, [r]Douglas states that the copper has

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[r]Douglas, James The Copper Resources of the U. S., Trans, AIME., Vol. 14, 1891, p693. After Ries.

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apparently been leached out of the upper 400' and concentrated in a zone of secondary enrichment of some 200'. According to [r]Lindgren

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[r]Lindgren, W. The gold-quartz veins of Nevada City, and Grass Valley, Cal. 17th, An. Rep. U.S.G.S. pt 2, 1896, p128 After Ries.

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at Grass Valley, California, the gold-quartz veins have been decomposed

to a depth of about 50 meters and contain "from $80 to $300 per ton, while the average tenor in depth is from $20 to $30." These two cases illustrate how the ore may vary in richness, and they also give some idea as to how to choose a basis for calculations. From the nature of the ore body some idea of size may be had. A vein of gold-quartz cannot be expected to continue indefinitely; by its very nature it is limited in one direction. The meteroric water deposits of lead and zinc, on the other hand, are much larger; must be, in order to make their working practicable.

Maps and Models: Where detailed geologic maps have already been made they should be checked with other maps and by actual field work; if such maps have not been made, original geologizing must be done; the extent to depend upon the good judgment of the examiner. In addition to geological maps, mine maps, surface maps, assay maps, and vein maps are of value.

[r]Mine maps show the extent of workings on each level, in general, on a scale of 40'=1". These maps should show the nature of the rocks, structural features, mineralization, and anything else which may be of value.

[r]Sec. 19, Mining Engineers Handbook.

Assay maps show the exact location of each sample taken, and the assay value. They are of value in indicating the trend of the ore tenor, and in directing development work.

Surface maps show the topography of the country, property

lines, and surface openings; they can often be combined with the geologic map, but are clearer alone.

Mine models and vein models are of value chiefly for purposes of illustration; there are a number of various modifications depending upon what is to be shown.

Determination of Average Metal Contents of Ore: In those mines which have been previously worked for a number of years an examination of mill or smelter reports is often the best means of learning the metal content of the ore; however, ore in the ground must be authentically tied up with these reports else they are of no value. In the same manner, test parcels are theoretically ideal, but they must represent ore from all parts of the mine in order to avoid giving a false impression.

The method most commonly employed in the valuation of a mine is that of sampling, which is based on the theory that the values obtained by taking a large number of small samples from all parts of a large body will give a representative value for the whole.

Samples may be required from ore lots in the process of shipping or other handling, from dumps, from placer deposits, and from actual mineral exposures underground.

To obtain samples from ore lots being handled it is most convenient to select a portion from each unit, as each carload, wheelbarrowload, or shovel full; the size of the sample depending on the size of the unit sampled.

In sampling dumps, one of several methods may be used: trench sampling, which consists of cutting a series of trenches in the dump; by pit sampling, and by drill sampling, which, though not so satisfactory as pit sampling is less expensive and therefore a larger and more representative number of samples may be taken.

Placer deposits are sampled by drill holes or pits; noting the depth to bed rock, its strike and dip, and the depths at which values are obtained.

For underground sampling two methods may be employed; chip, and interval channel sampling. Chip sampling is employed on those deposits whose hardness and toughness makes the taking of channel samples too arduous. The sample consists of chips mailed off of a line.

Interval channel samples are made by cutting a series of channels at regular intervals along the face of the exposure. Care must always be taken to avoid salting one's self; exposures must be thoroughly dusted; chips prevented from flying away from the sample, and extraneous material of all kinds kept out.

After samples are taken they must be tagged indicating the precise place from which they come, the sampler, his assistants if any, the date, and anything else of interest. It is often possible to reduce the size of the sample immediately to a few pounds by coning and quartering on a sample sheet.

Samples must be kept in such a way as to avoid tampering and salting; especially those from gold and silver mines which are

easy to salt. A mail bag with locks and keys makes a convenient holder but even these may be salted by injection, therefore, it is advisable to include a few samples known to be barren in the lot.

No one who has not the complete confidence of the examiner should be allowed near the samples after they have been taken and points from which samples are to be taken must not be marked until the time of sampling.

Notes should be taken in loose-leaf metal backed note books; they can then be filed directly from the note book each night, and there is then less chance for confusion and loss.

Assay maps are the most graphic and probably the best method of indicating sample returns. They show at a glance where the richest ore is to be found, where it is petering out, and where it is growing richer.

Perhaps the most difficult part of sampling is obtaining a workable portion after the sample is taken. The main sample is usually between ten and twenty-five pounds while the part run by the assayer will generally not be as many ounces. Coning and quartering, or rolling and quartering, and vanners are used to advantage in reducing the size of the sample. The final crushing and grinding is done in the assay office where special machinery is employed.

When it is impossible to get surface exposures, and samples are desired, resort is made to the drill. There are three types of drills used: the diamond drill, the churn drill, and the long jack hammer drill.

The diamond drill is sometimes overstressed; it is valuable but it does not give infallible evidence of what will be found below. In general, diamond drilling is most suited to vertical surface holes, because underground every time the drill is set up a station must be cut out. Inclined holes do not always follow their intended path, and unless the position of the hole is determined at regular intervals by using tubes etched with[7] hydrofluric acid, or[11] glycerine bulbs, the hole

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[7] J. Parke Channing Curvature of Diamond Drill Holes. Proceedings of the L.S.M.I., Vol. 2, 1899.

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[11] E. E. White Surveying and Sampling. Diamond Drill Holes. Proceedings of the L.S.M.I., Vol. 16, p100.

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is not of a great deal of value.

The location of the hole is determined by the general conditions found in the field, and by the knowledge desired from the hole.

The core recovery varies widely depending on the formations encountered, and the skill of the operator; from as much as ninety-eight per cent. to as low as fifteen or twenty per cent.

After a diamond drill hole has been sunk it is of the utmost importance that the cores be taken care of properly, otherwise they are of no value. A core box some ten feet long by two feet wide, and thick enough for either one or two cores is very convenient. The box is sectioned so as to avoid mixing. The depth from which each section is taken is marked on the cores, and the depths between which the core was taken is marked on the box, also the exact hole from which the core came.

Sludge samples are quite as important as core samples. They may best be kept in screw top glass jars or tins, which are tagged the same as the cores.

Churn drills, though not so valuable as diamond drills, give good results for shallow, vertical, surface holes. They give no core, and consequently but little idea of the structures passed through as the sludge is recovered by bailing, which takes place only every ten feet or so. The sludge is cared for just the same as the sludge from a diamond drill hole.

The long jack-hammer drill, recently developed by a Denver firm, is very good for underground work. It is cheaper to operate than a diamond drill, because stations do not have to be cut for it. There is practically no deviation to the hole, because the bit is essentially solid, and for short depth holes it is extremely valuable.

After samples are taken assays are made either by the examiner or a reputable assaying concern. Their returns are checked by sending duplicates to another concern. Checks are sometimes made upon samples by including a known blank sample in those intended for assaying, so that any attempt at salting will be brought to light. After assay returns are secured, the values obtained are plotted on an assay map so that the value and amount of ore may be determined.

Determination of Quantities of Ore: [1]Hoover places all ore in one of

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[1]H. C. Hoover, Principles of Mining.

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three classes:

1. Proved ore: Ore where there is practically no risk of failure or continuity.
2. Probable ore: Ore where there is some risk, yet warrantable justification for assumption of continuity.
3. Prospective ore: Ore which cannot be included in the above classes, nor definitely known or stated in any terms of tonnage.

Ore of the first class can be definitely valued within a small limit of error. [1]By applying the prismoidal formulae the volume can be found and after this is found the tonnage of ore can be estimated from the specific gravity, the determination of which presents still another problem.

[1] H. C. Hoover, cited above.

It is possible to arrive at some approximation of the density of the whole mass by taking small pieces and determining their specific gravities, or by taking a whole mill run and weighing it up. The most accurate method is to determine the relative amounts of every mineral in the ore, and then from tables of the specific gravities of minerals to determine the specific gravity of the whole by proportion.

After the weight and assay value of the ore is known, it is only simple arithmetic to place a value upon a block of ore. The correctness of that value will depend upon the degree of care with which the work has been done and the good judgment of the examiners in weighing the different classes of ore.

Probable ore can be estimated in the same manner as proved ore, except that a certain degree of uncertainity is present. The ore is <u>probably</u> there, but no one can say for certain until it has become proved

ore. The accurateness with which these determinations are made depend solely upon the canniness of the appraiser, and the will of God. In the final summation this ore is given a value, but a value somewhat less than that of proved ore.

Prospective ore presents probably the knotiest problem of them all when it comes to setting a definite price for a property. It cannot be ignored any more than a definite value may be placed upon it. It is up to the appraiser to assume from past experience and a knowledge - great or small - of ore bodies and mines, that the ore he can see as proved or probable, will persist to a certain extent, and upon the soundness of his assumption will the ultimate profit of the mine to owner rest.

Recoverable percentages of Gross values: It cannot be assumed that the assay value of the ore can be recovered in actual practice; there is a certain recoverable percentage that cannot be exceeded with profit. It would be theoretically possible to recover all the values carried by the ore, but the cost of so doing would be far in excess of the returns, and so a happy medium is struck.

If the ore is to be shipped from the mine to a custom mill there is no problem involved, because the smelter will quote a price for the ore. However it is often expedient to do the milling and smelting at the mine with the company's own equipment.

There are two general methods for determining the method of treatment: first, by a comparison with similar ores which have been successfully treated elsewhere, and experimentally in the laboratory. If

a similar ore has been treated successfully elsewhere the chances are nine out of ten that a similar treatment will work on the new ore, unless it contains some interfering constituent, or for some other reason it cannot be done profitably. Treatments worked out in the laboratory are often very wonderful, but somehow fail to work in actual practice.

It is going rather far into the field of the metalurgist for an appraiser to attempt to say what process shall be used in the treatment of an ore. It may be noted here, however, that there are three rather broad classes of ore: the sulphides, the oxides, and the mixed sulphide and oxide group. Of the three, the last is the hardest to treat efficiently.

Cost of Production: The costs of production fall into two groups: operating cost, under which is included labor, supplies and power; and those variable factors which affect the operating costs as the size of the ore body, and the volume of output.

Operating costs are more or less fixed within certain limits. For so much labor so much money will have to be paid, and the same holds true for supplies, although, of course, large scale buying always commands better prices. The cost of power will not run up proportionately to the amount used. Depending upon the installation there is a point beyond which the cost cannot be lowered no matter how little power is used and as more power is used the cost per unit is less until the maximum output of the installation is reached.

In determining what sort of a power plant is to be used the average running capacity of the mine and mill must be considered. It

would not be good economy to put a hoist capable of operating three skips on a single skip.

The size of the ore body necessarily controls the volume of output for small mines, because the best returns could not be obtained from starting large workings on a small mine. It is a basic economic principle that the larger the total volume the smaller the cost of production per unit for labor. For those mines possessing tremendous ore reserves it is most profitable to get the ore out as quickly and on as large a scale as is possible.

Therefore, we may say that the operating costs are a constant for a given mine, and that the cost per unit of value produced will depend largely upon the scale of operations.

Market Price of Minerals Produced: Some value must be assumed for the product which is mined. In the case of gold this is simple - twenty dollars an ounce without any variation. For all other metals the price varies quite a good deal. If a certain price is assumed as the market price of the product, it may profitably be mined, but the assumed price may be only a high point in the general trend and not represent an average at all so that the mine really cannot be worked successfully at all.

In setting a price on which to value a property, the price of today, or last year, or two years ago, cannot be taken but a survey of the whole price curve must be made. The general market must be considered, whether or not there is going to be falling off in the demand for the particular metal mined, whether there is going to be an increased

demand for it because of some new process lately developed, and whether there are new deposits of it opened up that will affect the price in any way.

Generally, it may be said that the price for most of the staple metals such as copper, lead, or zinc, is gradually rising over a long period of years although there may be fluctuations which shoot the price way up or down. All anyone can do is to make a scientific guess based on the facts at his command.

Amortization of Capital and Interest: Unlike most industrial projects a mine is a wasting asset; that which is once taken out can never be replenished, and so in developing a mine allowance must be made for amortization of capital. That is, enough money must be set aside during the life of the mine, so much per year, that there will be enough accumulated to pay off the capital stock, bonds, and any other indebtedness of the mine.

After the mine has been worked out the remaining physical plant is almost valueless; mine workings assuredly are worth nothing, and such machinery as is left can only be realized on at a small part of its original value. It is seen, therefore, that ordinarily the life of the mine must be assumed as being for so many years, and provision made to take care of the invested money.

Tables can be found in any insurance handbook showing the amount that must be laid aside every year to accumulate a definite amount at a given rate of interest. The money set aside must be placed in safe securities and be available when the business of the mine is

finally wound up.

In addition to the amount needed for amortization enough must be earned to pay current expenses, provide for development work, and pay interest upon the capital invested.

Present Value: It must be remembered that the value of the ore in the ground is not the same as the value of the refined metal placed upon the market. Before saying how much a property is worth there are many things to consider. After the total tonnage and values per ton have been found it is necessary to consider how much it is going to cost to treat the ore, what the percentage of recovery of gross values is going to be, how much it is going to cost to market the product, and finally, how long before the product will be ready to go on the market. All of these factors except the last have been considered somewhat and so it is now time to speak of the present value method of valuation.

A dollar in the hand is worth more than a dollar which is to be paid one year from date, because the interest on that dollar is lost and it is worth just that amount less today. Following this same line of reasoning, Hoover has shown that the quicker a mine may be worked out, the more valuable it is to the owner.

It follows, therefore, that in placing a value upon a mine the time element is of the utmost importance. As in the case of amortization some value for the life of the mine must be assumed and the value of the whole calculated on this basis; again insurance tables contain all the desired information necessary. I think that it may safely be said that a mine which will take ten years to work out is just twice as valuable as one which will take twenty years - ten per cent. does not

seem an unreasonable rate of interest to expect as a return on mining stock. It is assumed that the other factors in the mines are equal.

Not all mines are successes; in fact the larger number of them are failures, and so it is not unreasonable to expect the returns from mines to be apparently very much larger than returns from other industrial enterprises, and in valuing a mine this must be remembered and a correspondingly higher rate of interest allowed for.

Reports: It seems to be the consensus of opinion that all the essential conclusions to be drawn from an examination should be placed upon the first page of a report, and followed by more detailed information in the body of the report.