As an earnest of what might be done in making investigations of subjects of public wellfare, I would suggest that the Society, as such, might with propriety take up the question of artesian wells in Denver. Suppose that the President might appoint a committee of geologists, chemists and engineers. The geologist could examine the rocks passed through, their character, thickness and structural relations; the chemist may analyze the waters, and, if deemed necessary, the rocks; the engineer calculate the present actual supply derived from the wells; and then comparing results, or by combined investigations practical results as to the question of what may be expected in the future, and the precautions to be taken against wastage, may be obtained. Such investigations would naturally be comprised in the Report on the Denver basin, which is in preparation by the Geological Survey. But the two interests need not clash, inasmuch as the subject demands a more immediate attention than, owing to the press of other work, the Survey can give to it, and the Survey would be very glad to have so much of its work done for it in a way that would insure confidence in the results.

On the Estimation of the Capital requisite for Investment in Mining Properties, BY P. H. VAN DIEST.

It happens frequently that a really good mine does not answer the expectations entertained. The reason for this can be often ascribed to the fact that too large a sum was paid for the property, or that not a sufficient amount was appropriated for opening it.

I believe that in many cases reports on mining properties give principally general observations indulging too much in suppositions tending to a favorable opinion, or, if figures are used, they are often so dextrously grouped that, if they do not mislead, it yet remains difficult to use them for an appreciation of the value of the property.

Seldom is in a report the value of a property deduced from calculations based on facts ascertained with great care, wholly excluding all that is not known with certainty. In most cases, however, it is possible to estimate the value of a mining property according to certain rules. Amedée Bruat, La Cretelle and Albert Miller have treated this subject in professional papers, principally for the valuation of coal mines. Rossiter W. Raymond has, in a paper read before the Bullion Club, October 2, 1877, in his entertaining manner given some remarks on the valuation of mines, and hints as to how the complicated formulæ given by the above named authorities could be simplified and applied to the valuation of silver and gold mines in Western America.

P. van Dyk, mining engineer in the Netherland East India Colonies, many years ago gave some attention to the subject in his short paper entitled, "Iets over het kapitaal in eenige onderneming te steken met kans op voordeelige geldbelegging."

He expresses his ideas in a formula which, somewhat simplified, can be used in many instances in which an expert has to estimate the value of a mining property; that is, of a property which is developed to some extent.

To determine the value of mere "prospect" holes we can only make computations on the chances for speculation, and whatever sum is paid for a "prospect" is but a payment for the right to ascertain whether or not ore occurs in sufficient quantities to warrant continuous mining. Local indications of value must be compared with similar indications observed in other properties near by which have resulted well. As a rule, the price for such "prospects" must be in proportion to the chances, and be less when the uncertainty about principal points is greater.

When we have to deal with properties already opened and worked to some extent, the following points must be considered: The cost of breaking the rock; the average extent and value of the pay streak; the cost of transportation, smelting, etc.; in short, the maximum expenses and the gross receipts. There must also be estimated the amount of time and money needed to bring the mine to a state of maximum production, and lastly the number of years the property can be expected to hold out or to keep up a maximum production, for it must be always remembered that the principal difference between agriculture and mining is, that in agriculture the capital remains, and by improvement even increases, while by mining the capital is diminished.

These considerations can be expressed in the following formula for the calculation of the maximum capital to invest in a mining property.

$$X = \frac{R - E}{i + d + \frac{i}{(1+i)^{T} - 1}}$$

R represents the annual gross receipts, E the annual expenses, i the interest which the capital X pays previous to investing, T the number of years in which a sinking fund must be created equal to the capital X, and d the increase of interest which is expected of the new investment, and *without which there would be no reason to invest capital in a new enterprise*. In words this equation expresses, *that the annual net proceeds must equal the annual contribution to the sinking-fund plus the increased interest to pay on the capital invested.*

The yearly contribution to the sinking fund is calculated at compound interest, based on the principle of a mathematical progression, and is expressed by

$$\frac{X\,i}{(1+i)^{T} - 1}$$

X, the capital to invest, includes besides the cost price of the property, the necessary working capital.

To apply this formula, let us suppose that we have examined a mining property, opened by a shaft 200 ft. deep, and by drifts at 50, 100 and 150 ft. depth on each side, with a length of 200 ft. each; that we have observed and measured two or three ore chimneys of an aggregate length of 260 feet; that the pay streak over that extent, has, unbroken, a value of 50 ounces silver per ton, and that the average width of the pay-streak is 1½ feet. The first question to answer is, can the property under these circumstances pay? Or, if it can only meet expenses when worked on a limited scale, to what extent must it be developed to pay dividends?

The accounts kept by the mine owners of their expenses can be a guide, but as the expenses for the first 100 feet are considerably less than for deeper mining, it will be safer to take as a basis for calculation the highest figures for cost of working, drifting, stoping etc., obtained from statistics of mines worked on a large scale, say from 500 to 1000 feet in depth, in a similar kind of rock. Let these figures be:

for sinking, 60 cts. per cubic foot, including all supplies; for drifting, 50 cts., and for stoping, 30 cts., per cubic foot.

Sinking a shaft 12 ft. by 5 ft, to a depth of 200 ft. (12,000 cubic ft.) at 60 cts.	$ 7,200
Three drifts, each 400 ft. long, 7 ft. high and 4 ft. wide (33,600 cubic ft.,) at 50 cts.	16,800
Stoping over 260 feet in length, 100 feet in height and 3½ ft., in width, (that is, what remains) after deducting the amount taken out by drifts (99,190 cubic feet) at 30 cts.	29,757
All the ground broken, amounting to 144,790 cubic feet, at 12 cubic feet per ton, gives 12,066 tons of stuff to handle and hoist at $1 per ton	12,066
The vein surface in the ore chimney represents 36,200 square ft., and at a thickness of 1½ ft. pay-streak gives 54,300 cubic ft., which equals 4,525 tons, costing for sorting, $2 per ton	9,050
Salary for Superintendent. fuel, light, etc.	10,000
Repairs and unforseen expenses,	10,000
Total	$94,873

The revenue can be estimated as follows: 4,525 tons at an average value of 50 ounces can, according to experience at the mine, be sorted to 900 tons of an average of 170 ounces, leaving 3,600 tons refuse of an average of 20 ounces. Consider that this refuse ore can be concentrated, 10 tons into one, at a cost of $5.00 per ton, with a loss of 30 per cent.; then these 3,600 tons would produce 360 tons concentrate of 140 ounces per ton. These ores can realize the following prices, when we assume that silver is worth $1.10 per ounce; that transportation of a ton of ore to a smelting works is $15; that for treatment 10 per cent. loss is deducted and $20 charged for cost of smelting per ton. The ore of 170 ounces assay value will realize under these conditions (170 × 1.10)—18.70—20—15=$134 per ton, and concentrate of 140 ounces assay value (140 × 1.10)—15.40—20—15—50=$54 per ton.

900 tons at $134=	$120,600
360 tons at $54=	19,440
Total revenue	$140,040
Total expenses	94,873
Net proceeds or profit	$45,167

which shows that the mine can be made paying.

But it will be advisable to increase the capacity, because by more opening, more stoping grounds is accessible, more product is raised, while the general expenses for management, hoisting, pumping, etc., remain about the same, and thus the net proceeds per ton become greater.

Consider further that in a year the mine can be opened to twice the given depth and a double set of drifts run through the ore chimneys; that after this is done, stoping begins, and in future a nearly constant production of ore is kept up.

The figures for cost of drifting, stoping, sinking, etc., thus increase to $149,746, and keeping the general expenses at $20,000, the total will be $169,746. The receipts then become double what is given above, namely, $280,080, leaving $110,334 per year as net proceeds.

At the rate of sinking about 400 feet per year, in eight years such a depth will be attained that it will be impossible to go deeper, or only at an expense so great as to equal the returns.

The vein might be a blanket vein, which cannot be followed beyond the boundaries of the claim, or it might be that a deposit near the top of a hill limited in extent by slopes is to be worked. In either case the capital invested must be regained out of the net proceeds in a certain time.

For the example above chosen the yearly contributions to the sinking fund must create a new capital in eight years. Suppose that the present rate of interest on the money to invest is 6 per cent. a year, and that 14 per cent. more a year is desired, or an increased interest of 20 per cent. Suppose, also, that in eight years the loss of interest during the first year of opening must be regained, which would make the increase

$$\frac{20 \times 8}{7} = 23 \text{ per cent.}$$

We have now only to substitute the figures obtained in our formula, giving for $R-E$, $110,334; for i, 0.06: for $i+d$, 0.23; for T, 8 years; then we get

$$X = \frac{110.334}{0.23 + \dfrac{0.06}{(1.06)^8 - 1}} = \$363,500$$

This is the maximum amount of money to invest, but larger machinery and a working capital being needed, we have to deduct for these certain amounts, which we suppose to be (according to a careful estimation) about 100,000—leaving $250,000 as the price which can be paid for the property.

We assumed in our example that the ore left by sorting could be concentrated, but if, for instance, the gangue is heavy spar and the ore gray copper, both having nearly the same specific gravity, concentration is out of the question. Some ores can be amalgamated at greater profit than concentrated. For such cases we have to see if we cannot do better by sorting the higher for shipment to smelting works, and mill the lower grades near the mine. These different conditions we can again express in a simple formula and calculate to what value the ores must be sorted for shipment, and at what lowest value ores can be milled with profit. Consider that the cost of shipping ores to a smelting work is a, the loss by treatment b, the cost of smelting c; that the cost of milling is d, (including interest and amortisation on the capital invested in a mill), that the loss by milling is e per ton, and x the maximum value of a ton ot ore which will admit of milling at a profit over shipping to distant smelting works; then we have

$$x - bx - (a+c) = x - d - ex, \text{ or}$$

$$x = \frac{a+c+d}{e-b}$$

If, for instance, a is $15, b 10 per cent., c $20, d $17 and e 23 per cent., then x is $138 or 125 ounces, when an ounce of silver is worth $1.10, showing that in this case only ores under 125 ounces in silver can be treated in a mill near the mine with some profit.

More examples could be given to demonstrate how nearly all questions in connection with mining can be expressed in some algebraic form. But the foregoing, I hope, will be sufficient to show that experts and investors in mining properties can evade many deceptions by using formulæ similar to those given in this paper, and besides guard themselves against overlooking essential points when called on to estimate the value of a property.

MEETING OF FEB. 4TH, 1884.

Mr. Cross made some remarks upon the minerals of the cryolite group, found by him near Pike's Peak, and described in the American Journal of Science for Oct., 1883.

Mr. W. S. Ward presented specimens of "carbonate sand" ore, from the Morning Star and Evening Star mines at Leadville, Colo., accompanying the presentation with some remarks upon their occurrence in these mines.

He said that occasional nodules of quite pure embolite had been found in the Morning Star mine, directly imbedded in the cerussite sand, and that it was a noteworthy fact that the sand about these nodules was poor in silver.

In reply to a question from Mr. Ridgley as to the relative dimensions of the low-grade zone of cerussite sand and the embolite nodule enclosed thereby, Mr. Ward stated that only a few nodules had so far been found, and that they were near together in a mass of cerussite sand, all of which was poor in silver.

Mr. Eilers enquired if the embolite nodules occurred in parts of the workings near the surface, or remote from it. Mr. Ward replied that they were found at a point furthest (about 900 ft.) from the surface cropping of the ore body. He also said that the cerussite sands in both the Morning and Evening Star mines seemed to decrease in silver and increase in lead the greater the distance from the surface.

Mr. Pearce presented a specimen of crystallized gold from the Ontario mine, Summit co., Colorado, remarking that it occurred in a joint between porphyry and a slaty rock, that the crystals showed the combination of octahedron and rhombic-dodecahedron, and that when found the gold was coated with hydrous oxides of manganese and iron. Tellurium, bismuth and phosphoric acid were also found in this coating. On dissolving the latter in hydrochloric acid, chlorine had been evolved, which had attacked gold.

Mr. Ridgley asked if Mr. Pearce had frequently observed phorphoric acid in such association. Mr. Pearce replied that he had not sought for it in other cases, its detection here being accidental, while the tellurium had been specially tested for, as the mass resembled pseudomorphs of gold after sylvanite. Mr. Ridgley said that he had frequently found phosphoric acid in the gold-bearing telluride ores of