

The Mispickel Gold Ores of Deloro, Ont.

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Near the village of Deloro in Hastings Co., Ontario, there is found a belt of metamorphic rocks in which occur a series of gold-bearing veins. For the past two months I have been experimenting on gold ores from this district in the Mining Laboratory of the Kingston School of Mining, and the paper, which I have the honor of bringing before you this evening, contains a few of my results.

The country around Deloro consists of low, rounded hills, the most striking feature being a large irregular mass of granite, whose longer axis lies in a north and south direction, and which is known as the Huckleberry hills. Surrounding this granite mass and conforming to its general outline, there is a series of metamorphic rocks of the Hastings series, consisting of dolomitic schists, talcose schists and quartzites. The talcose schists are of the most interest, as in them are found veins carrying quartz, dolomite, mispickel and gold. The veins are parallel to one another, and have usually been considered to be bedded or segregated veins as they follow the strike of the schists. Most of them are found close to the contact of the granite with the schists. A similar occurrence is found in Barrie township, in the County of Frontenac. This is the Weber mine, which is found in rocks of the Hastings series, near the contact with the Grenville series. The veins at Deloro seem to be similar in character, and a description of the Gatling vein, which is now being worked, serves for all.

This vein has an average width of from seven to ten feet, and runs nearly due north and south with a dip of 30° west. It is composed of vitreous quartz, grey arsenical pyrites or mispickel, dolomite or "bitter spar" and in some places biotite is found. The mispickel is generally fine grained and compact, but large silver-white, striated crystals, prisms of the Rhombic system, are often found. Native gold

is sometimes seen adhering to the faces of the crystals. Analysis of the mispickel made some years ago by Thomas Thomas and J. H. James, of Swansea, Wales, gave the following results:—

	Fine grained varieties.	Coarsely crystalline.
Peroxide of iron	54 00	56 00
Silica	0 57	0 03
Sulphur	19 31	18 13
Arsenic.....	25 70	23 00
Nickel	trace	trace
Silver (per ton of 2,000 lbs.).....	trace	\$6 50
Gold " " "	\$306 95	\$2,920 67

The mispickel often contains a trace of cobalt, which may be detected by blow pipe tests. I also found several perfect crystals of zircon imbedded in the dolomite and associated with the mispickel.

Assays of the ore recently made in the laboratory of the School of Mining gave the average gold contents as \$30 per ton. For the sake of comparison, I append assays made by ex-Prof. Chapman of Toronto University. Sample No. 19, \$38.65 per ton; sample No. E, \$24.87 per ton; sample No. F, \$36.60 per ton; sample No. G, \$24.74 per ton.

The gold bearing veins in the Hastings series are found in schistose rocks, chiefly talcose, and are generally parallel with the strike of the rocks. Hence they have been called bedded veins. It is doubtful, however, as pointed out by Phillips in his work on ore deposits, whether there is any difference in origin between many veins of this class which occur in highly metamorphosed rocks and those which are called "true fissure veins." Metamorphic rocks were considered by the older geologists to be derived from sedimentary material, and for this reason the schistosity was compared to bedding. Of late years, however, many of the most strongly schistose varieties have been proved to be altered igneous rocks. While many of the members of the Hastings series are undoubtedly of sedimentary origin, such as the metamorphic conglomerates and calc-schists, there is as yet

no proof that or not metamorphism have been produced which were afterwards represented by the vicinity of many kinds, chiefly dykes of these dykes is now occupied of the formation apart, thus giving true fissure veins igneous rock of the mine in the dyke which, I district, and I of the rock. level of the on the side of the first level. to belong to nearer the edge sections from consist of plagioclase and other mineral contain orthoclase two specimens acid and basic and some of by their metamorphism. Thin sections in the vicinity of the

The contact point. Some panning and

no proof that other members, such as the talc and mica schists, are not metamorphose igneous rocks. The schistosity in these latter may have been produced partly or wholly at the opening of the fissures, which were afterwards filled with the metalliferous matter and are now represented by the gold bearing veins. The schists in the immediate vicinity of many of these veins are cut through by dykes of different kinds, chiefly diorite and more basic rocks. And at the Deloro mine none of these dykes cut at one time across the rocks before the space which is now occupied by the gold bearing veins was formed. At the time of the formation of the fissure this dyke was broken across and pulled apart, thus giving the ore deposit. It seems to me the character of a true fissure vein just as much as if it cut through a large mass of igneous rock or across the strike of the schists. During my visit to the mine in the latter part of December, I obtained specimens of this dyke which, I believe, has not been referred to by other writers on the district, and I have since made a microscopic examination of sections of the rock. Specimens were obtained in a cross-cut on the lower level of the main shaft, and on the hanging wall some distance from the side of the vein and from a "horse" near the foot wall of the first level. On microscopic examination both specimens were found to belong to the same rock. Although the material of the horse being nearer the edge of the vein, was much metamorphosed. The thin sections from the specimen on the lower level showed the rock to consist of plagioclase, orthoclase, biotite and some quartz together with other minerals in less quantity. The section from the horse showed it to contain orthoclase, plagioclase, a little biotite, muscovite and talc. The two specimens resemble each other very closely in the proportion of acid and basic minerals, with the exception that most of the black mica and some of the feldspar of that from the lower level is represented by their metamorphic equivalents, muscovite and talc in the horse. Thin sections were examined from other dark-colored dykes in the vicinity of the vein. They are similar to those described.

The condition of gold in the mispickel seems to be a debatable point. Some of the gold undoubtedly occurs free, as may be seen by panning and in certain specimens showing native gold. But it is the

invisible gold which causes the discussion. This is either chemically combined or in a mechanically fine state of division. Ex-Professor Chapman of Toronto University believed the gold to exist as an arsenide, but his reasons have not been published as far as I know. I made a series of experiments to ascertain the real state of gold in the mispickel and the results, though not settling the question by any means, throw light on a few points. The experiments in favor of the "combined" theory are as follows:

(1.) Mispickel rich in gold was crushed to 70 mesh and treated in a hand arrasta. The mercury refused to extract the assay value of gold.

(2.) A gold button was treated with hydrogen sulphide for nine days. A brown coating was formed on the button, which refused to amalgamate, showing that a coating of sulphide of gold had been formed.

(3.) Gold foil was fused with mispickel in absence of air. A dark grey powder formed around the button, which became brittle and refused to amalgamate due to formation of arsenide or sulph-arsenide of gold.

(4.) Gold foil was fused with arsenic trisulphide, a brownish-red powder formed, button became brittle and refused to amalgamate.

(5.) Mispickel known to be rich in gold was examined in thin sections, with highest powers of the microscope. No trace of gold was seen.

(6.) Gold was digested with strong solution of caustic potash and found to be insoluble. Trisulphide of gold (Au_2S_3) was digested with solution of caustic potash and found to be soluble. I also digested mispickel with solution of caustic potash, reasoning that if I got gold in the potash solution the gold must be in a combined state as a sulphide. I obtained a black precipitate from the acidified solution by hyd. sulphide which was proved not to contain iron, copper. I also failed to get good tests for gold by stannous chloride, ferrous sulphate or blotting paper tests. This, however, may be due to the small amount of precipitate obtained.

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The reasons in favor of the "free" theory are as follows:

(1.) The gold may be in the allotropic form which is known to resist the action of mercury.

(2.) Failure to amalgamate may be due to a coating of sulphides around the gold arising from decomposition of pyrites.

(3.) The particles of gold may be so embedded in the pyrites that only chemical means will free the gold.

(4.) The particles of gold may be invisibly fine so that the highest powers of microscope cannot detect them.

It is commonly stated in text books that if gold exists in a combined state in an ore, it is dissolved out by treatment with nitric acid. This I found to be an erroneous statement with regard to arsenide of gold and the ordinary sulphides. The arsenide is decomposed by nitric acid, giving free gold and forming arsenic acid ($H_3 As O_4$). The sulphides are not attacked by nitric acid. I digested pulverized mispickel with nitric acid and found no trace of gold in the solution. The residue on the filter paper was tested for gold and gave excellent purple colors in the blotting paper tests and also good result with stannous chloride.

Gold was first discovered in the Marmora district in 1865 and numerous attempts have since been made to extract the precious metal. The first attempt consisted of treating the ore by raw amalgamation in primitive stamp mills. The ore became refractory when the water-line was reached in the shafts and failure ensued.

A few years later the Canada Consolidated Co. commenced operations, and a large mill was constructed to treat the roasted ore by the barrel chlorination process. The ore proved refractory even by this process and the works were shut down. In connection with this, it will be interesting to know that the modern chlorination plant in our Mining Laboratory was successful on two different occasions in extracting gold from mispickel. Over 90 per cent. of the assay value was extracted in each case.

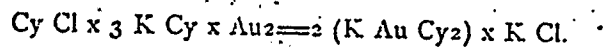
The next scheme was tried by the Hastings Mining and Reduction Co. in 1892. They proposed to treat the pulverized and roasted ore with mercury vapor, condensing and passing over copper and silver

plates to catch the amalgam. The process, experimentally successful, proved to have too many working parts and work was soon stopped.

And now a new process has entered the lists against the hitherto victorious mispickel.

This process, known as the Bromo-Cyanide, was invented by Mr. Sulman, and has been successful in Australia. It seems in many respects to be a combination of the cyanide and chlorination processes. The solvent used consists of the ordinary cyanide with a small proportion of one of the haloid compounds of cyanogen, viz: Chloride, iodide or bromide. The bromide is mostly used as it is cheap and portable.

The solvent is claimed to be particularly successful in extracting gold from refractory ores, such as arsenical, antimonial, manganiferous and copper compounds. The ordinary cyanide fails to extract gold satisfactorily from such ores. According to Mr. Sulman, this is due to: (1.) The oxidization of iron and other base sulphides with consequent destruction of the cyanide; (2.) the production of caustic potash as a necessary reaction product of the solution of gold. These defects are got rid of by adding haloids which cause no hydrolysis and take up the potassium set free. The chemical reaction is expressed thus:



This equation also shows that the solvent power is not due to liberation of oxygen from decomposition of water by free chlorine since the stable chloride of cyanogen is used.

Comprising this reaction with that of the cyanide process, viz:

$4 \text{ K Cy} \times \text{Au}_2 \times \text{H}_2 \text{O} \times \text{O} = 2 (\text{K Au Cy}_2) \times 2 \text{ K O H}$, it may be seen that the fatal defect (necessity of a good supply of oxygen) is entirely obviated.

This solvent was tried on refractory ores of all kinds by the inventor and other chemists, with surprising success. He claims the solvent is over 100 times more rapid on free gold than the cyanide, and he ascribes the results to:

(1.) The enormously accelerated solution of the gold, wherever its particles are easy accessible, by having potential cyanogen always

ready at hand to combine with the soluble double

(2.) The avoidance of being quite inert as in the case of the insoluble compounds.

To illustrate the process by the inventor:

"A shaking tank made with 0.3 per cent. Br Cy. Half an ounce (7 dwt. of gold), yielding 22 grains, and with a solution of 44 per cent. ammonia about the same as the ordinary solution of potassium cyanide in a tank, and addition of 2 of potassium cyanide crushed dry to absorb the solution from the tank. The gold is extracted. The solution is then treated by zinc fume, i.e.,

The Canadian Mining Institute, consisting of a number of men and chemical laboratories, is the efficiency of the process.

It is to be hoped that the mining district is rich

ready at hand to effect the formation of aurous cyanide necessary for the soluble double salt of gold and potassium.

(2.) The avoidance of production of caustic potash, the product being quite inert as regards the further formation of cyanide destroying compounds.

To illustrate this rapidity of solution, I quote an experiment made by the inventor:

"A shaking test upon a sample of Canadian arsenical pyrites was made with 0.3 per cent. K Cy and 0.3 per cent. K Cy x 0.12 per cent. Br Cy. Half an hour's agitation of the ore (which originally assayed 7 dwt. of gold), yielded, with cyanide alone, tailings assaying 3 dwt. 22 grains, and with our solvent, 1 dwt. 20 grains of gold, or extractions of 44 per cent. and 74 per cent. respectively." The plant required is about the same as used in the ordinary cyanide process. A dilute solution of potassium cyanide is used and to the contents of the storage tank, and addition of the bromide of cyanogen is made in proportion 2 of potassium cyanide to 1 of bromide of cyanogen. The ore is crushed dry to about 70-mesh fineness, treated in leaching vats with the solution from the storage tank for a few hours till the gold is all extracted. The solution is then filtered off and the gold precipitated by zinc fume, *i.e.* finely divided zinc purified by the ordinary means.

The Canadian Gold Fields Ltd., is now erecting a large plant consisting of a mill for the crushers, rollers, and leaching tanks, assay and chemical laboratory, shaft houses etc., for the purpose of testing the efficiency of the solvent on a large scale.

It is to be hoped the venture will prove successful, as the Hastings district is rich in auriferous mispickel veins.