Report on the Ores from
Dentonia Gold Mines, Ltd.

by

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defined in the granitic rock, whereas in the schistose rock the veins become disseminated into numerous parallel stringers. According to the statements made by the late R.W. Brock and others, the vein is considered to be mineralized by the ascending solutions, which, probably, were genetically related to the intrusion of Jurassic (?) granodiorite into the schistose series.

III. MINERALOGY

Two types of ore were available for examination and metallurgical treatment - the "high grade", and the "low grade". The first term refers to the ore filling a true fissure in granitic rock, while the second applies to the ore mined in the schistose portions of the mine. Only the "high grade" specimens were used for preparation of the polished sections and subsequent microscopic examinations.

Megascopically the ore shows dissemination of sulphides in quartz. The individual grains of some constituents are composed of a single crystal, which sometimes appear to be much coarser than the average grain-size of the ore, because of inclusions of different composition.

Several generations of mineralization are evident, with the result that the structural features of the minerals are different; the oldest minerals are fractured and cemented by younger ones, which appear under the microscope as veinlets cutting the older minerals at all angles. This fracturing accounts for the friability of the ore, which is especially displayed during preparation of the polished sections.

As a result of microscopic examination, the following metallic minerals, in order of their relative proportions, were found to be present in the ore:

1. Pyrite
2. Chalcopyrite
3. Galena
4. Sphalerite
5. Unknown grey mineral, "X"
6. Unknown blackish mineral, "Y", containing bismuth.

None of the free gold, gold-tellurides, or compounds of silver were found in the sections examined, although their presence is reported by the management of the mine and by some of the previous investigators.

Following are brief descriptions of each constituent of the ore.

<u>1. Pyrite</u>. This mineral was found to be the most abundant metallic constituent, being present as small and large crystallized grains. The latter frequently display characteristic striations parallel to the alternate edges. It invariably fills the fractures in a quartz gangue, and appears to be well distributed among the other sulphides. It is much fractured, and the fractures are filled with chalcopyrite, galena, the unknown "Y" mineral, and calcite. In well mineralized portions of the ore a great majority of the pyrite is closely associated with chalcopyrite, while in the lean

portions it shows a tendency to be segregated.

2. Chalcopyrite. Chalcopyrite appears to be present in anhedral masses, generally in a close association with pyrite, galena, and both undetermined minerals. While definitely healing the fractures in pyrite and cementing its larger remnants (see illustration #1), chalcopyrite tends, as a rule, to be intergrown with galena and the unknown mineral, "Y", although its occasional inclusions in the irregular bands of galena were noticed.

3. Galena. This is the third predominant metallic sulphide of the ore. It occurs as irregular anhedral masses in association with chalcopyrite, or fills the most fractured portions of the pyrite and quartz when present alone. Its inclusions in chalcopyrite were also frequently found. Characteristic triangular pitting and numerous lines of fractures at 90 degrees to each other are most prominently displayed in the masses of this mineral.

4. Sphalerite. This sulphide, apparently responsible for the traces of zinc in the assays of the ore, was found only on one section, where it fills the fracture in quartz. Its resin-colored internal reflection, hardness of 3, white powder on scratching, the negative etching reactions to all reagents but aqua regia (effervescence and black stain), left very little doubt as to its determination. None of the other sulphides were found in the immediate neighborhood of this minute veinlet of sphalerite.

as .002%.

6. Gangue. Quartz of the white milky variety, much fractured, and a very small amount of calcite were the only gangue minerals found in the sections examined. Megascopic examination of the "low grade" shipment of the ore, prior to the crushing, had shown the presence of a very limited amount of finely disseminated grains of pyrite, chalcopyrite, and galena in quartz veinlets, which cut what appears to be the chloritic type of the schistose "country rock". In the latter were found also some veinlets of calcite.

IV. PARAGENESIS

Following is the attempt to tabulate the order in which different constituents of the ore had been deposited:

1. Quartz
2. Pyrite
3. (Unknown mineral, "Y"
   (Calcite (?)
4. (Chalcopyrite
   (Galena
   (Unknown "X"

The oldest minerals are undoubtedly quartz and pyrite, for both tend to show crystal faces, and both are much fractured, the fractures being healed by the other sulphides. Because pyrite also fills the fractures in quartz, it is assigned the second place in the order of deposition. The unknown mineral "Y" was, presumably, the next mineral to be deposited; on section 2 it predominantly fills the fractures in the pyrite, and contacts the wide and irregular bands of chalcopyrite at the border of the fractured pyrite-field. Its intimate association with calcite on this particular section points to their contemporaneous deposition (?). Chalcopyrite and galena are always intergrown when present together, and both were found to fill the fractures in pyrite and quartz. These two facts tend to indicate their contemporaneous order of deposition, which follows those of quartz and pyrite.

Unknown mineral "X", on the evidence of illustration #2, may be contemporaneous with chalcopyrite and galena. No conclusion can be reached in regard to the order of deposition of sphalerite, because none of it was found in the actual contact with other constituents of the ore.

V. DESCRIPTION OF SECTIONS

Section #1.

On this polished section all principal sulphide constituents of the ore, some quartz, and microscopic grains of the undetermined "X" mineral are present. Characteristic relationships of different sulphides to each other are well displayed. Both the quartz and the pyrite show a tendency to form their crystal faces, and veining of the quartz by pyrite and of pyrite by chalcopyrite can be seen, as well as the intergrowth of the galena and pyrite. (See illustrations #1 & #2.)

Section #2.

This section is similar to section #1, but shows veining of the pyrite by galena. The fractures in very shattered portions of pyrite are filled with the unknown "Y" mineral and with calcite. Quartz inclusions in galena show good hexagonal crystals.

Sections #3, #4, #5, and #6.

All of these display a preponderance of fractured quartz gangue, the fractures being filled with pyrite, chalcopyrite, and galena. The small veinlet of sphalerite mentioned above was found on Section #6.

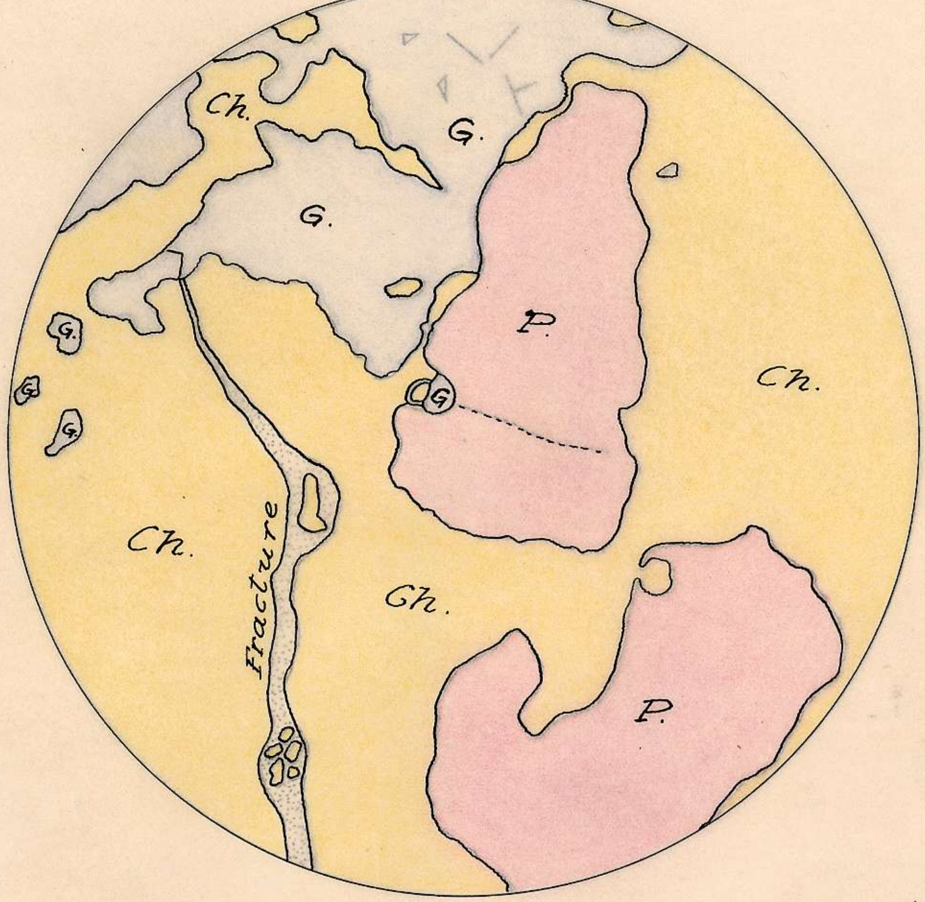
Sections #7 and #8.

Both show extremely fractured quartz, and the fractures are exclusively filled with galena. None of the illustrations were made from the sections 3 to 8 inclusive, because the nature of the contacts and fractures of the component minerals does not differ from that already established through study of sections #1 and #2.

DENTONIA ORE.

ILLUSTRATION No. 1
from section No. 1

Mag. 70 x

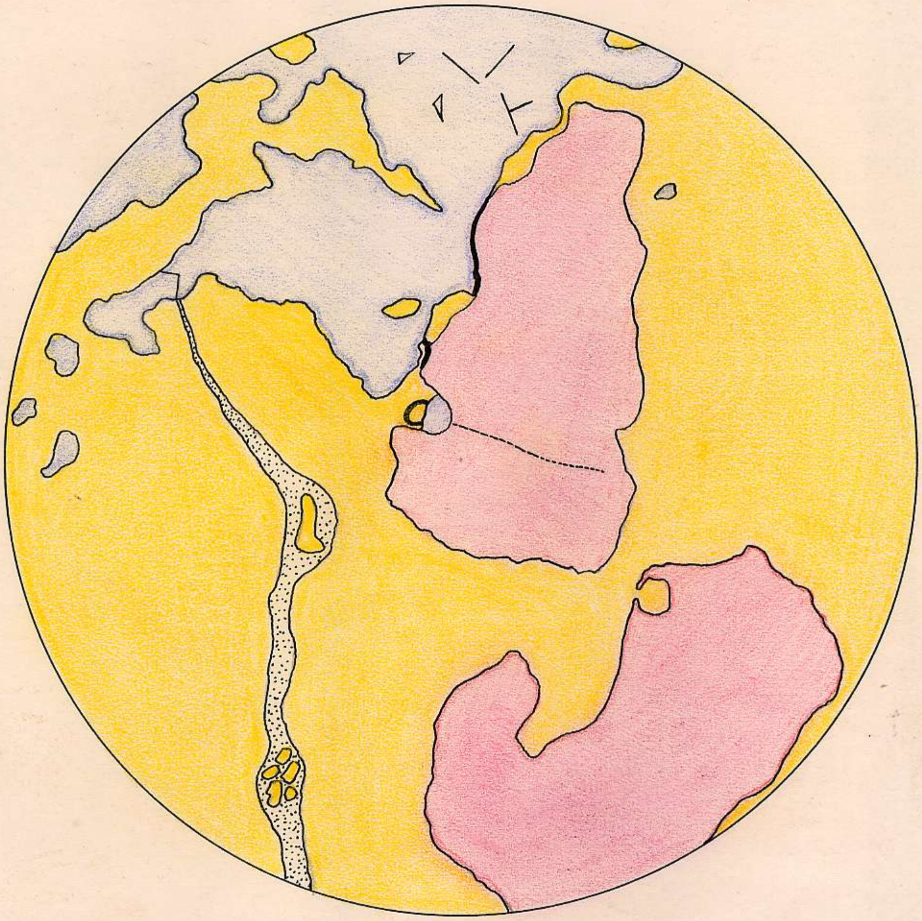


- General relationship of the principal sulphides -

DENTONIA ORE.

ILLUSTRATION No. 1
from section No. 1

Mag. 70 x

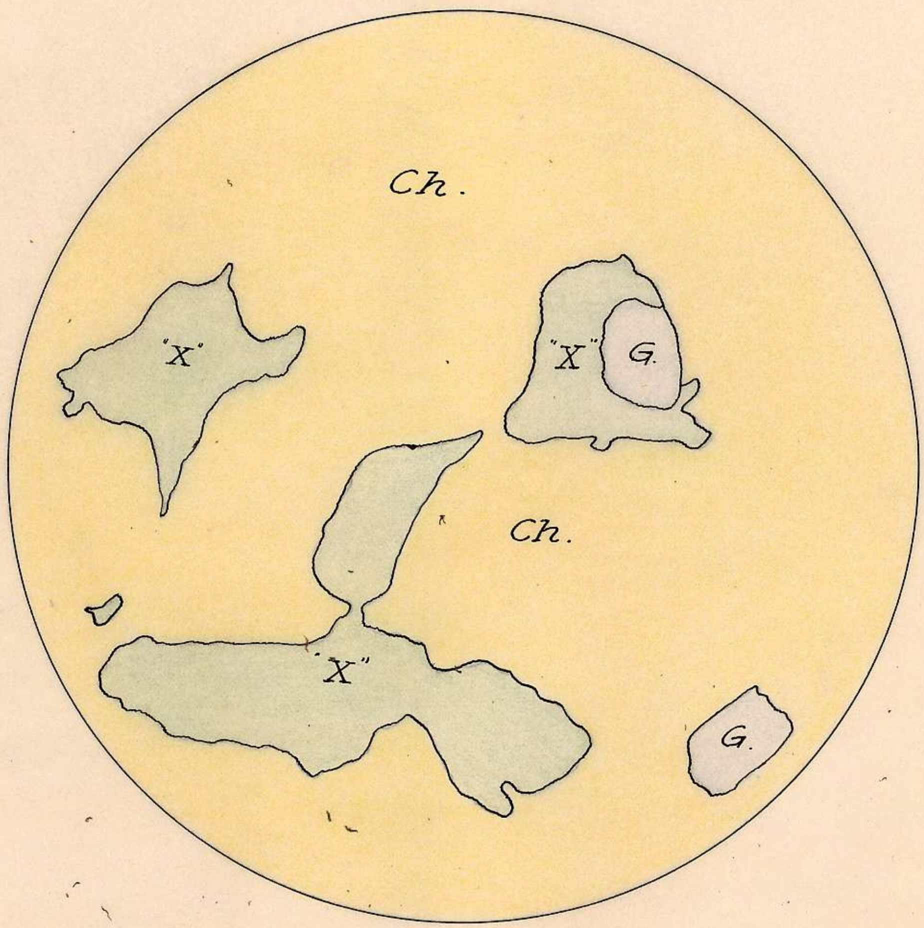


- General relationship of the principal sulphides -

DENTONIA ORE.

ILLUSTRATION No. 2

Mag. 360 x

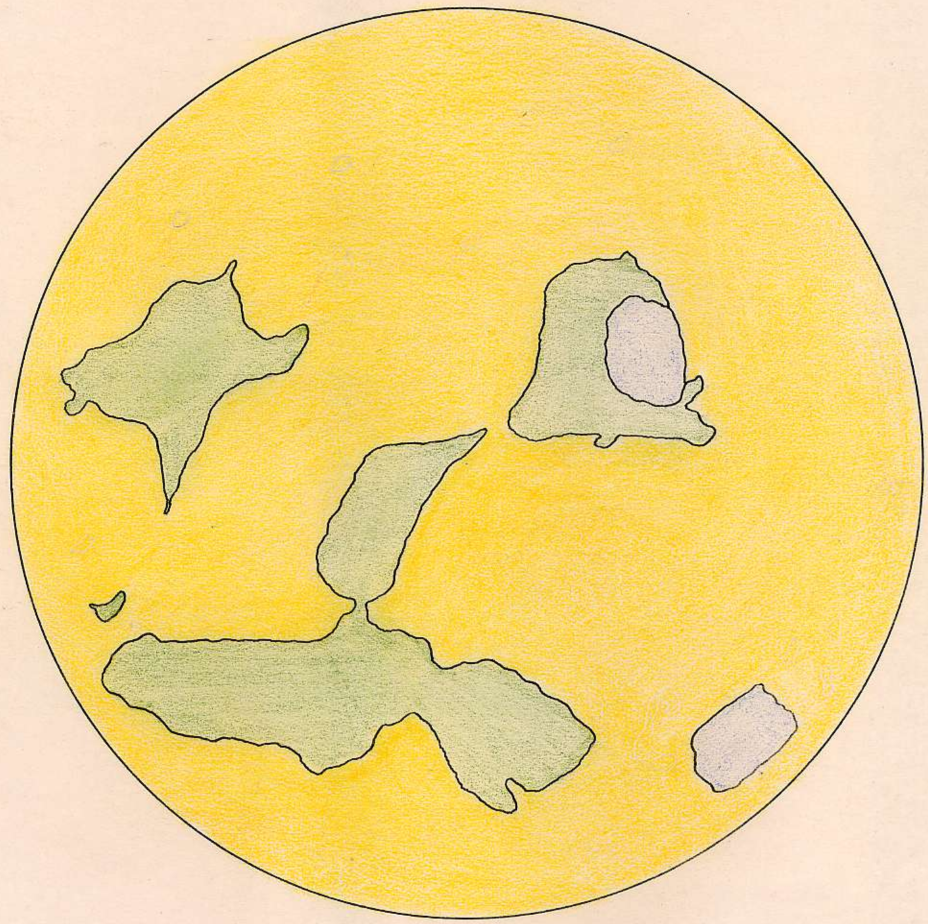


From polished section No. 1 showing the largest occurrence of the undetermined grey mineral "X" in the chalcopyrite.

DENTONIA ORE.

ILLUSTRATION No. 2

Mag. 360 x

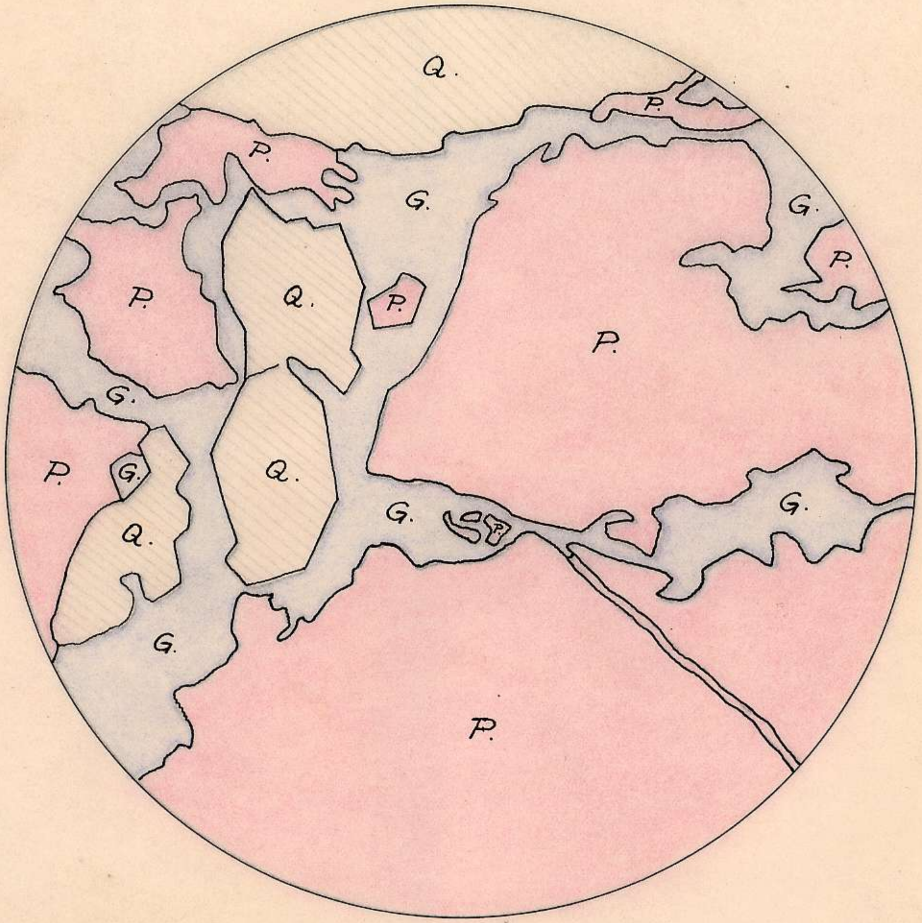


From polished section No. 1 showing the largest occurrence of the undetermined grey mineral "X" in the chalcopyrite.

DENTONIA ORE

ILLUSTRATION No. 3

Mag. 70 x

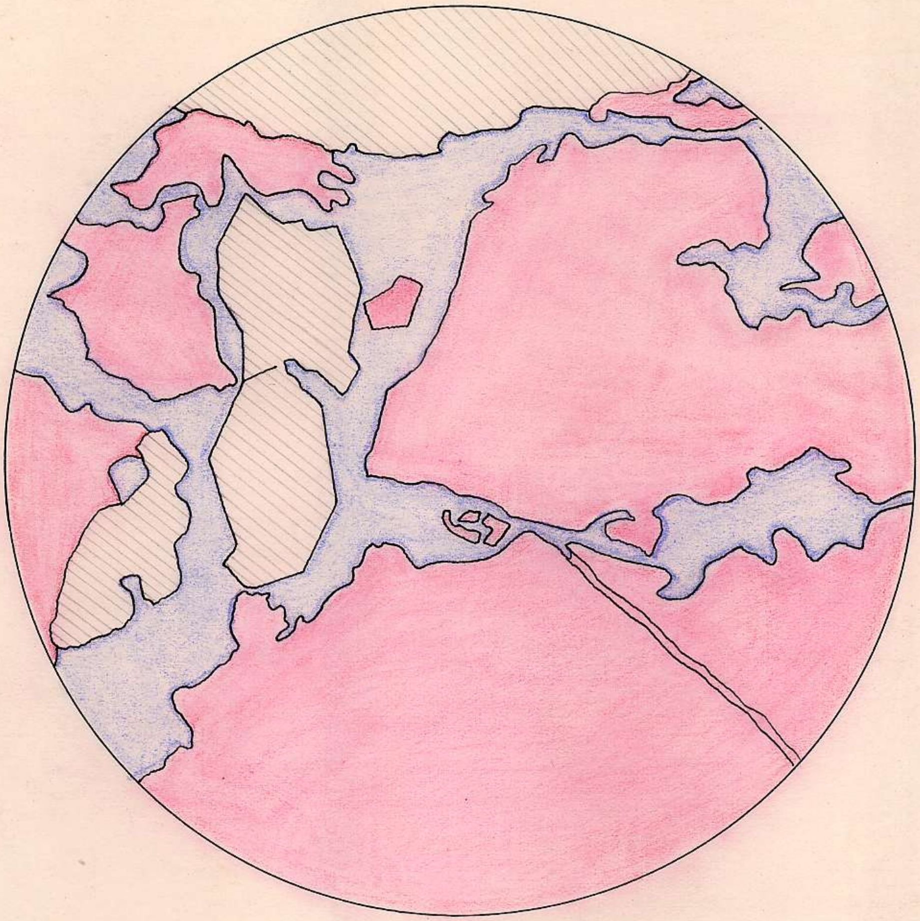


From polished section No. 2 showing veining of the pyrite by galena, and hexagonal crystals of quartz in galena.

DENTONIA ORE

ILLUSTRATION No. 3

Mag. 70 x

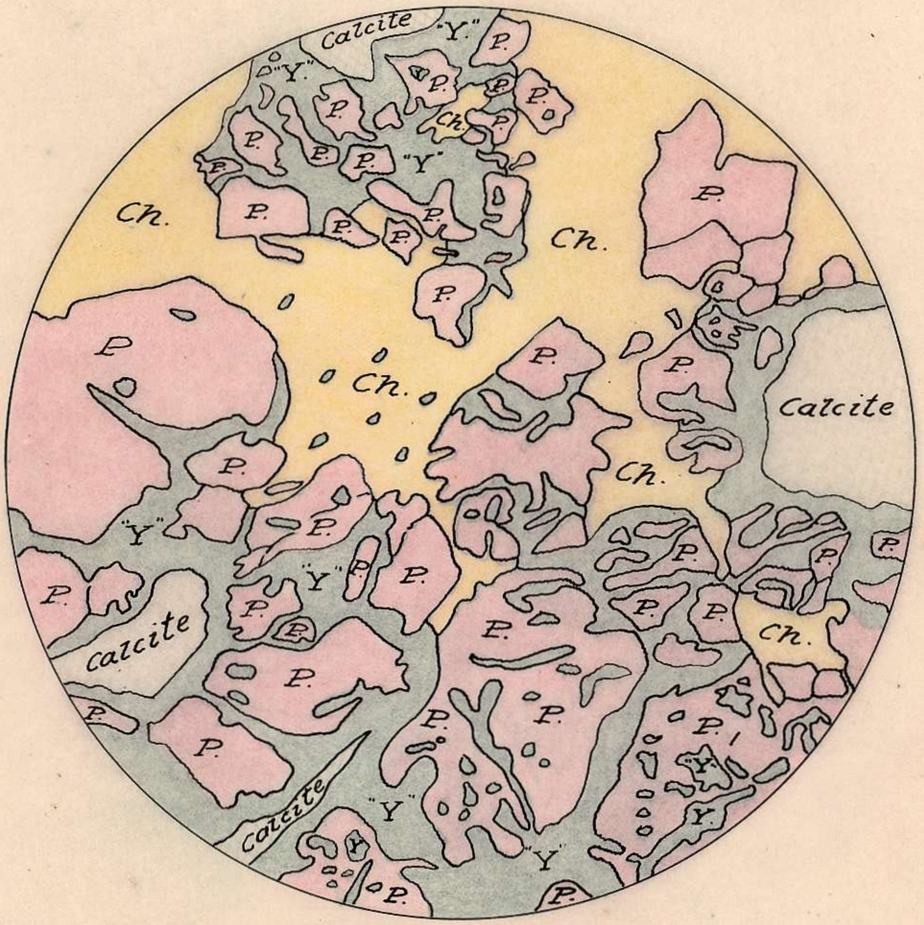


From polished section No. 2 showing veining of the pyrite by galena, and hexagonal crystals of quartz in galena.

DENTONIA ORE.

ILLUSTRATION No. 4

Mag. 70 x

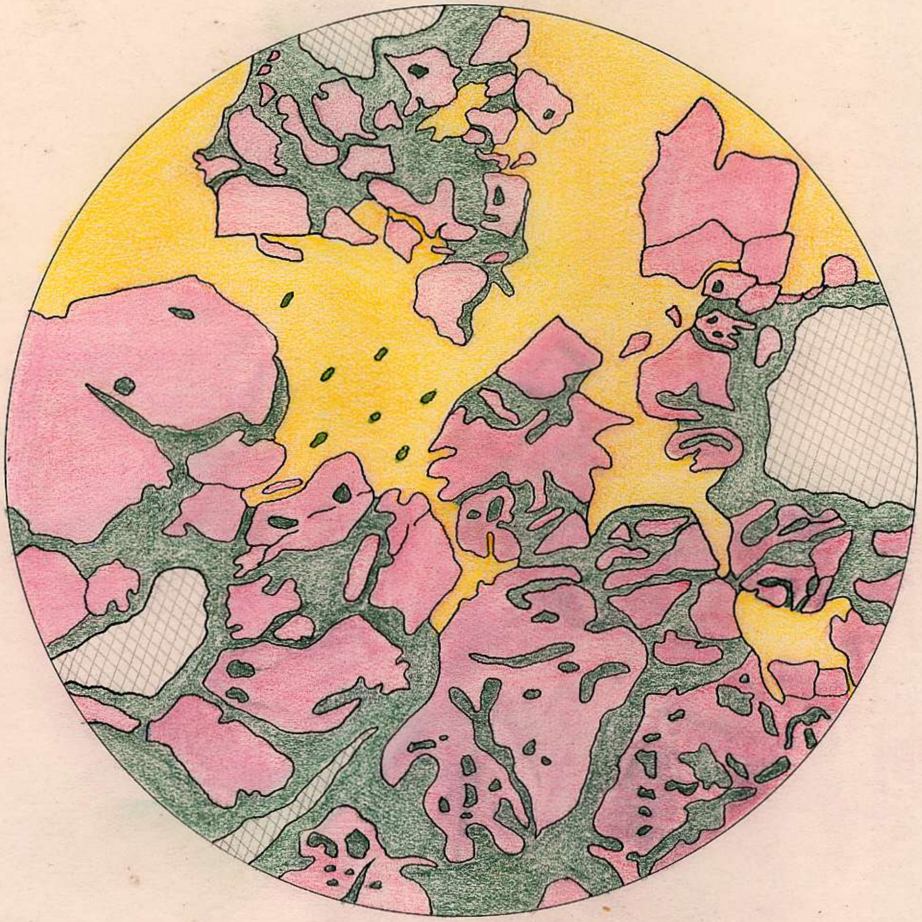


From polished section No. 2 showing fractures in pyrite filled with the unknown "Y" mineral, calcite and chalcopyrite. Characteristic relationship between "Y" mineral and calcite is well displayed.

DENTONIA ORE.

ILLUSTRATION No. 4

Mag. 70 x



From polished section No. 2 showing fractures in pyrite filled with the unknown "Y" mineral, calcite and chalcopyrite. Characteristic relationship between "Y" mineral and calcite is well displayed.

VI. DISTRIBUTION OF VALUES IN THE ORE

The failure to see free gold, gold tellurides, or compounds of silver has been already mentioned, and the next stage of investigation was carried into the field of metallurgical analysis, in order to establish the degree of association of gold and silver values with different sulphides in the ore. The opportunity was taken to make commercial assays for copper, lead, zinc, iron, silica, bismuth, sulphur, calcium carbonate, and insoluble matter at the same time, in order to ascertain the purity of the ingredients used. The result of the analysis is as follows:

Mineral	Au oz.	Ag oz.	% Cu	% Fe	% Pb	% Zn	% SiO_2	% $CaCO_3$	% Ins.	% S	% Bi	Total
Fractured FeS_2...	14.27	-	-	-	-	-	-	-	-	-	-	-
FeS_2...	5.78	16.42	2.2	45.2	1.48	-	-	Tr.	0.7	50.2	.002	99.88
$CuFeS_2$...	1.32	4.74	31.8	31.6	-	Tr.	-	-	1.64	35.7	-	99.97
PbS....	0.44	24.31	0.2	0.2	8.8	-	4.8	Tr.	4.9	13.8	-	99.89

Mineral	per cent distribution of sulphides			
	FeS_2	$CuFeS_2$	PbS	Insol.
FeS_2......	90.5	6.46	1.96	0.71
$CuFeS_2$....	6.8	91.9	Traces	1.64
PbS	0.38	0.57	94.2	4.95

Considering the results of these assays, the follow- conclusions are apparent:

1. The main gold values of the ore are largely associated with pyrite, while chalcopyrite is the secondary carrier of gold, and galena is only slightly auriferous.

2. The distribution of gold values in the pyrite is dependent upon the amount of fracturing and degree of crystallization of this mineral. This was inferred from the assays of the carefully selected grains of the fractured and well crystallized pyrite.

3. Galena is the principal carrier of silver values in the ore, with pyrite the secondary silver-bearing mineral, while chalcopyrite occupies the third place.

The first two conclusions are very suggestive of the deposition of gold from the solution upon the crystal faces of the pyrite or along the planes of its fractures. They also point to a deposition of gold approximately contemporaneous with that of chalcopyrite and galena, in which case gold displayed a marked tendency to be precipitated on the crystal faces of a mineral already crystallized. The presence of the unknown "Y" mineral in the fractures of the pyrite, however, may have something to do with the concentration of gold values, but no attempts to settle this question were made because of the insufficient quantities of this mineral. A failure to see any free gold undoubtedly may be accounted for by its occurrence in finely divided flakes, or by its association with other elements in the same form. It is more difficult to draw any conclusion in regard to a deposition of silver or its compounds. It seems to be of a deposition contemporaneous with that of galena and chalcopyrite, and, in such a case, high values of silver in association with pyrite tend to indicate its precipitation on the crystal faces of the latter in some combination with gold (gold - silver tellurides ?), or its association with the unknown "Y" mineral. Incidentally, the calculated "per cent distribution" of the sulphides among the picked "pure" mineral grains indicates that the true values of the gold and silver are somewhat lower in the chalcopyrite, and correspondingly higher in the pyrite and galena, due to the admixture of other sulphides.

VII. DISTRIBUTION OF SULPHIDES IN THE ORE

When the degree of association of gold and silver values with the predominant sulphides was established, further assays were made of "high", "low" grades and of the "mill heads", in order to determine the distribution of the principal sulphide minerals in the ore. These assays and the calculated results are as follows:

Attempted calculation of the percentage of pyrite in a low grade, using the total iron present as a basis for such a calculation, resulted in an apparent shortage of the available sulphur to satisfy the theoretical composition of the pyrite; that is, assuming that all iron left after satisfying the Fe content of the chalcopyrite amounts to 3.02%, it is necessary to have $\frac{(64)\ (3.02)}{55.8} = 3.46\%$ of sulphur available, while only $(1.60 - .08) = 1.52\%$ of sulphur is actually present. Hence, 1.55% of the iron is present as a constituent of pyrite, and the remaining 1.47% enter into some other chemical combination. Examination of the flotation tailings shows the presence of hard black mineral grains among the rejected gangue, and in the writer's opinion it is some iron mineral which is partially or wholly responsible for the additional amount of iron, as indicated by the analysis. Unfortunately, time did not permit any investigation in this direction.

VIII. LOSSES OF VALUES IN TREATMENT OF THE ORE BY FLOTATION

As has been mentioned above, the present mill practice is to recover the values from the ore by the bulk flotation of sulphides. This method of treatment appears to be quite justifiable in view of the comparatively simple composition of the ore, and of the fact that the principal sulphides - pyrite, chalcopyrite, and galena - all have gold and silver in association with them. Flotation practice, however, results in

Type of ore	Au oz.	Ag oz.	Cu	Fe	Pb	Zn	SiO_2	$CaCO_3$	Ins.	S.	Bi
High grade	2.84	22.61	3.24	10.80	7.80	0.13	64.9	1.5	65.0	13.0	–
Low grade	0.32	3.68	0.05	4.06	0.29	0.07	81.4	3.7	86.7	1.60	–
Mill heads	0.57	5.40	0.34	3.87	0.98	0.07	79.9	3.5	85.0	2.69	–

Type of ore	per cent distribution of sulphides				
	FeS_2	$CuFeS_2$	PbS	ZnS	Insol.
High grade	15.87	9.36	9.0	0.20	65.0
Low grade	2.88	0.10	0.34	1.00	86.0
Mill heads	4.26	1.00	1.05	0;92	84.7

Examination of the calculated results of the analysis points to the following conclusions:

1. Pyrite is a predominant sulphide mineral in the ore.
2. Chalcopyrite and galena are present in equal relative proportions.
3. Sphalerite chiefly occurs in the low grade of ore, thus displaying a tendency to be deposited in veinlets of quartz (disseminated through the schistose series) in preference to the well mineralized portions of the true fissure.
4. Some iron-bearing mineral is present in the low grade of the ore in addition to the minerals already mentioned.

comparatively low recovery of values, namely, between 88 and 90 per cent. Investigation has been conducted in the ore dressing laboratory with the purpose of increasing the recovery of gold from Dentonia ores in a flotation process of treatment, and also to ascertain the factors responsible for the loss of values in the present mill practice. A full report in connection with these tests is submitted to the Department of Mining and Metallurgy, and only the main conclusions in regard to losses and distribution of the values are incorporated in the present report. These are as follows:

I. (a) Failure to recover free gold which is liberated in the grinding circuit as minute flakes.

This appears to be the main source of losses, as indicated by the cyanidation of the tailings, whose gold content was thus reduced from 0.10 oz./ton to 0.03 oz./ton.

The surface of the liberated gold particles may be either contaminated through mechanical adhesion of foreign material, or may possess some film-coating, and consequently such free gold is made refractory to flotation. While some of the losses may be due to these reasons, a certain portion of free gold undoubtedly aggregates in the flotation cell with the grains of siliceous gangue, because of the opposite electrical surface-charges of gold and quartz particles. Such condition necessitates the use of some dispersing agent like sodium silicate, in order to float the gold. Confirmation of this fact was obtained during flotation tests, thus accounting for the increase in the overall recovery of over 3 per cent.

(b) Failure to recover all of the sulphides, because of the oxidized film-coating (limonitization) of the principal sulphides. It has been proven that employing sodium sulphide as a sulphidizing agent (after the first concentrate has been obtained) results in bringing up the greater part of the remaining sulphides as a second concentrate. This additional recovery amounted, on the average, to 2% by wt, carried up to 1-1.2 oz./ton, or 1.5-2% of the total gold. Such a small increase in the overall recovery shows that this factor is not the principal source of losses.

(c) Failure to recover probable compounds of gold such as tellurides, which do not respond to flotation.

II. Distribution of values in the ore is very erratic, as demonstrated by the calculated heads from the assays of the concentrates and tailings, which range from .50 to .60 oz./ton. This conclusion is in accordance with the fact already established, that more gold is in association with fractured pyrite, the spotty distribution of which has been noticed upon examination of the polished sections.