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THE BEATTIE GOLD MINE, DUPARQUET TOWNSHIP

PROVINCE OF QUEBEC, CANADA

BUREAU OF MINES

Honourable J. E. PERRAULT, Minister of Mines

J. L. BOULANGER, Deputy-Minister A. O. DUFRESNE, Director

ANNUAL REPORT

OF THE

QUEBEC BUREAU OF MINES

FOR THE CALENDAR YEAR

1932

JOHN A. DRESSER, Directing Geologist

PART C

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By J. J. O'Neill

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THE BEATTIE GOLD MINE

DUPARQUET TOWNSHIP, WESTERN QUEBEC

By J. J. O'Neill

INTRODUCTION

The Beattie mine is the first of its character to be exploited in the Province of Quebec. It is primarily a large low-grade gold deposit containing values which a few years ago would not have been considered as making ore. Much interest is attached to this development as its success may mean a greatly enlarged scope to gold mining in Canada on deposits which formerly have been regarded as worthless.

Because of its potential importance as a pioneer in low-grade gold mining, it was decided to make a careful detailed study of the Beattie in the hope not only of assisting in its development, but of stimulating the search for similar essential geological conditions in other parts of the Province.

At the commencement of the field-season, a regional survey was begun along the east shore of Duparquet lake, but as Dr. A. H. Lang, of the Federal Geological Survey, was making a revision of the regional geology of Duparquet township, this work was dropped and the remainder of the season was spent on a detailed examination of the geology in the vicinity of the mine itself.

History of the Beattie Mine

The credit for the discovery of the Beattie deposit belongs to Mr. John Beattie, who has been interested in the district since 1910. He found gold in small veins in basalts on Beattie island, near the outlet of Duparquet lake, and did a considerable amount of work there, but the showings did not seem to warrant large-scale development. He then turned his attention to the mainland east of the lake, where a body of feldspar porphyry was discovered a short distance from the lake and values in gold were obtained at various places in its vicinity. The first zone opened-up at the north contact of the porphyry was thoroughly drilled by the Consolidated Mining and Smelting Company, but did not prove sufficiently attractive, so their option lapsed. Further work westward, towards the west end of the porphyry body, opened-up a wider zone in a similar position, and the assays from the trench-samples were attractive enough to warrant a new option, which was finally taken over by Ventures Limited. Ventures drilled this new area and obtained indications of a large tonnage of material with values considered to be commercial. The Nipissing Mining Company became associated with Ventures for a 40 per cent interest in the undertaking, and in 1932 a prospect shaft was sunk in the ore to a depth of 220 feet and the ore-body cross-cut at that level. The results were so encouraging that a major development was at once undertaken for an initial production of about 600 tons per day, with planned gradual expansion to 5,000 tons per day.

The Beattie gold mine is owned and operated by the Beattie Gold Mines, Limited, incorporated in December 1931 by Dominion charter, with an authorized capital of 5,000,000 shares without nominal, or par, value.

Location and Means of Access

The Beattie ore-body is situated two miles west and half a mile north of the centre of Duparquet township and approximately 22 miles northwest (N. 28°W.) of the town of Noranda.

Access to the property in 1932 was from La Sarre, on the Canadian National railway, by motor launch, following the La Sarre river, lake Abitibi, and Duparquet river to Duparquet lake and the Company wharf, which is connected with the mine by a motor road one mile in length. This route involves trans-shipment at Danseur rapid, on Duparquet river, over a portage about 600 feet in length; otherwise there are no obstacles to shallow-draft navigation. This route is about thirty miles in length, and some 2,000 tons of machinery and supplies were taken-in over it from La Sarre.

In the fall of 1932, a Government truck-road, about nine miles long, was cut from the Macamic highway to the Beattie mine, roughly along the east-west centre-line of the township; also a light narrow-gauge railway was laid, without ballast, from the C.N.R. tracks of the Rouyn-Taschereau line to the mine, and both these routes were used during the winter.

A semi-weekly aeroplane service was inaugurated from Noranda to the Beattie during the summer of 1932 and was maintained through the winter; it takes about twenty-five minutes for this trip.

Previous Work

The first general discussion of the geology, physiography, and topography of the region was published by M. E. Wilson in 1913 (1). His map shows a small area of sedimentary rocks, enclosed in Abitibi volcanics, extending a little south of east near the northeast shore of Duparquet lake into the Beattie property, but no feldspar porphyry was mapped at that time. The only prospect noted in Duparquet was the Beattie claim, of which Wilson states:

"A brecciated zone extends across a small island occurring at the north end of lake Duparquet, in which considerable quartz and some carbonate have been developed. It was reported that assays of $20 per ton had been obtained from the quartz of this deposit, but an average sample taken by the writer contained no gold when assayed by Mr. L. Leverin of the Mines Branch, Department of Mines".

In 1922, W. F. James (2) mapped the western and southern parts of Duparquet township, but with no additional detail in the vicinity of the present Beattie mine.

Cyril W. Knight (3) drew attention in 1922 to the close association of the known occurrences of gold ores in northern Ontario with two east-west belts of Témiscamian sediments which are roughly parallel and from 25 to 40 miles apart. "Occurring in or near the northern belt of sediments are the Dome and other mines, the

(1) *Kewagama Lake Map-Area, Quebec;* Geol. Surv. Can., Memoir 39, 1913.
(2) *Duparquet Map-Area, Quebec;* Geol. Surv. Can., Summ. Rept., 1922, Pt. D.
(3) *Lightning River Gold Area;* Ont. Dept. Mines, 33rd Ann. Rept., 1924.

nearby Hollinger mine, the Croesus, and the gold prospects of Lightning River area".

In 1924, Douglas G. H. Wright and Walter E. Segsworth (1) explored the eastward extension of this northern belt into Quebec and called attention to the fact that similar favourable geological conditions of structure, metamorphism, and porphyry intrusions, together with gold mineralization, extend across Duparquet and Destor townships, and concluded: "The widespread occurrence of gold, under such favourable geological conditions, justifies the intensive prospecting of this field, and encourages the hope that exploration would be rewarded by the development of an area of economic importance somewhere along the Quebec extension of Ontario's northern gold belt."

In 1925, B. S. W. Buffam (2) mapped this district in connection with a larger area investigated for the Geological Survey of Canada, and his map was published on a scale of one inch to a mile. Buffam mapped the mass of red feldspar porphyry east of Duparquet lake and, from observations near its eastern end, considered it to be pre-Témiscamian in age. His description of the porphyry is quoted, as he examined the whole mass, while the present report deals only with the western half:

"A large mass of purplish-red feldspar porphyry is exposed in Duparquet township close to the east-west centre line. This body of porphyry has a length of 3 miles and a maximum width of $^5/_8$ of a mile. It extends from ½ mile east of the north-south line [centre line of Duparquet] to within half a mile of Duparquet lake. In addition to this large mass, a few dykes of reddish porphyry were observed intrusive into the volcanics 1½ miles to the east, and also to the south, of the sedimentary series, adjacent to the Destor-Duparquet boundary. A megascopic and microscopic similarity seems to indicate that the smaller intrusions are of the same age as the large body of porphyry.

"The rock is highly porphyritic, with phenocrysts of feldspar up to one inch in diameter. These phenocrysts have good crystal form

(1) *Extension of the Porcupine Gold Belt into Quebec;* Eng. & Min. Jour.-Press, May 10th, 1924.

(2) *Destor Area, Abitibi County, Quebec*; Geol. Surv. Can., Summ. Rept., 1925, Pt. C., pp. 82-104.

and vary in colour from grey to green to pink, depending on the amount of alteration they have undergone. The matrix is variable as regards texture, but is usually fine grained and under the microscope is found to be composed of a felted aggregate of small plagioclase and orthoclase laths with indistinct outlines and generally much altered. The alteration products developed are small patches of carbonate, flakes of sericite, and occasionally a small, irregular grain of epidote. All the phenocrysts are clouded with kaolin and flakes of sericite. Pyrite and magnetite in small grains and crystals are common. The composition of the feldspar phenocrysts as determined by oil immersion is anorthoclase".

In 1932, all the known information about this district was included in a memoir on the *Geology and Ore Deposits of the Rouyn-Harricanaw Region, Quebec* (1).

Finally, a revision of the general geology was carried on during 1932 by A. H. Lang, of the Geological Survey of Canada; his report and map, on a scale of one inch to half a mile, is not yet issued.

Acknowledgments

During the field work, the writer was ably assisted by John T. Williamson. André Hone and Hélidore Dumont performed their work as junior assistants in a capable and satisfactory manner.

Grateful acknowledgment is due to Mr. A. J. Keast, General Manager, and Mr. Millenbach, Assistant Manager, of the Beattie Gold Mine, and to Mr. Train, of the Nipissing Mining Company, for their courtesy and co-operation in the work.

I am also indebted to Dr. F. Fitz Osborne, of McGill University, for the preparation and examination of polished sections of the ore and for the preparation of the photomicrographs which accompany this report.

General Statement

The physiography of the country and the general geology have been well described by Cooke, James, and Mawdsley, to whose report the reader is referred.

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(1) Geol. Surv. Can., Memoir 166, by H. C. Cooke, W. F. James, and J. B. Mawdsley.

The present investigation had to do with the detailed geology about the Beattie ore-body, to establish a basis for further detailed work as the property develops; the object being to determine, so far as possible, the geological conditions peculiar to an ore-body of this large low-grade type, as the Beattie is the first of its kind to be exploited in the Province of Quebec, and it is hoped the discovery and development of similar ore-bodies will be facilitated by making this information public. The report is therefore a preliminary compilation of a mass of data, much of which cannot yet be fully interpreted.

The area was mapped on a scale of one inch equals 30 feet and the map reduced to one inch equals 100 feet for this report of progress. Only the broader features appear on the accompanying map.

The mine is situated on a ridge which begins about half a mile east of Duparquet lake and rises about 150 feet to 175 feet above lake level. The ridge extends east and west; it is bordered by swampy ground to the north and west, and by sand and gravel terraces to the south, followed by swampy ground towards Dugros river. Outcrops are largely confined to the ridge, with only a few scattered exposures through the swampy area to the north and south.

The main ore-body is on the northwest side of the ridge. Feldspar porphyries are the main country rocks exposed on the ridge; only in trenches are the bordering Keewatin schists seen. The examination did not extend far enough east and southeast to include the Témiscamian sediments. It is planned to continue the work in this direction during 1933.

GENERAL GEOLOGY

Keewatin andesitic pillow-lavas, with some tuffaceous sedimentaries, are the oldest rocks in and around the Beattie mine, and are intruded by syenite porphyry and bostonite porphyry, apparently as small bosses. These are the only rocks in place in the immediate vicinity. Southeast of the area a short distance there are outcrops of sedimentary rocks, including conglomerate, greywacke, and slate, which are thought to be Témiscamian in age.

The surface material is of sand and gravel of probable post-Pleistocene age, deposited in a post-glacial lake.

The character of the porphyries, their general massive condition, and their relation to the Keewatin rocks, strongly suggest that the major regional folding was complete, or nearly so, before they were intruded. There is only slight structural unconformity in this region between the Keewatin and Témiscamian, and the major folding movements followed the Témiscamian From structural evidence, then, the porphyries are definitely later than the post-Témiscamian folding, and hence later than the Témiscamian sediments.

As noted above, Buffam concluded that the porphyries are older than the Témiscamian because of an apparent conglomerate lying below the Témiscamian rocks and made up largely of large and small blocks and boulders (?) of the feldspar porphyry. This would be in direct conflict with the structural evidence, and, in the light of similar effects produced by shearing in the porphyry near the Beattie, it is possible that the conglomerate noted may be a pseudo-conglomerate produced by shearing in porphyry, or by injection of porphyry into true conglomerate, followed by shearing. The writer was informed that Dr. Lang found a dyke of the feldspar porphyry cutting right across this apparent conglomerate near the Duparquet camp.

The sequence of geological events in this district seems, then, to have been as follows:

Post-Pleistocene gravels and sands

Great erosional unconformity

Period of mineralization.............................. { **Gold**, **Arsenopyrite**, **Pyrite** }

Intrusion of aplite dykelets and pegmatites

Intrusion of bostonite porphyry

Shearing

Intrusion of syenite porphyry

Major folding

Témiscamian conglomerate, greywacke, etc.

Broad open folding followed by some erosion

Keewatin pillow lavas and tuffaceous sediments

Summary and Conclusions

The mine area is largely underlain by a mass of syenite porphyry which forms the western end of the east-west ridge already referred to and extends easterly along its northern part. The southeast part of the ridge in this area is composed of bostonite porphyry which seems to be a multiple intrusion and parts of which occur in the syenite porphyry as dykes, and also are found near and at the north and south borders of that mass. It is evidently somewhat later than the syenite porphyry.

The main Beattie ore-body lies on the north border of the syenite porphyry in a sheared zone which is partly in the syenite porphyry and partly in the bordering bostonite porphyry, which is here brecciated and cemented by quartz. Outside the bostonite porphyry, to the north, is a series of chlorite and sericite schists with occasional thin sills of bostonite porphyry, but the valuable mineralization stops as soon as these schists are reached. In the 220 ft. cross-cut of the ore-body from No. 2 shaft, all but 16 feet of the total of 107 feet of ore is in sheared, brecciated and silicified bostonite porphyry: the 16 feet are of crushed and silicified syenite porphyry included in the bostonite porphyry.

The porphyries were sheared along an approximately east-west direction. This resulted in the development of closely spaced slips in the syenite porphyry along the direction of shear, while the bostonite porphyry broke into irregular pieces.

Silicification followed the shearing, recementing the rock and partly replacing it by cryptocrystalline quartz; the bostonite porphyry received most of the silica, probably because, being more highly fractured, the solutions had freer access to it. Dykelets or veinlets of quartz and albite cut silicified zones and are themselves cut and partly replaced by seams of carbonate and of sericite; the sericite apparently later than the carbonate.

Pyrite and arsenopyrite, in minute crystals, were developed later than the bulk of the sericite, and the gold, in extremely fine particles, is associated with the sulphides. Some carbonate, sericite, and quartz were apparently later than the sulphides.

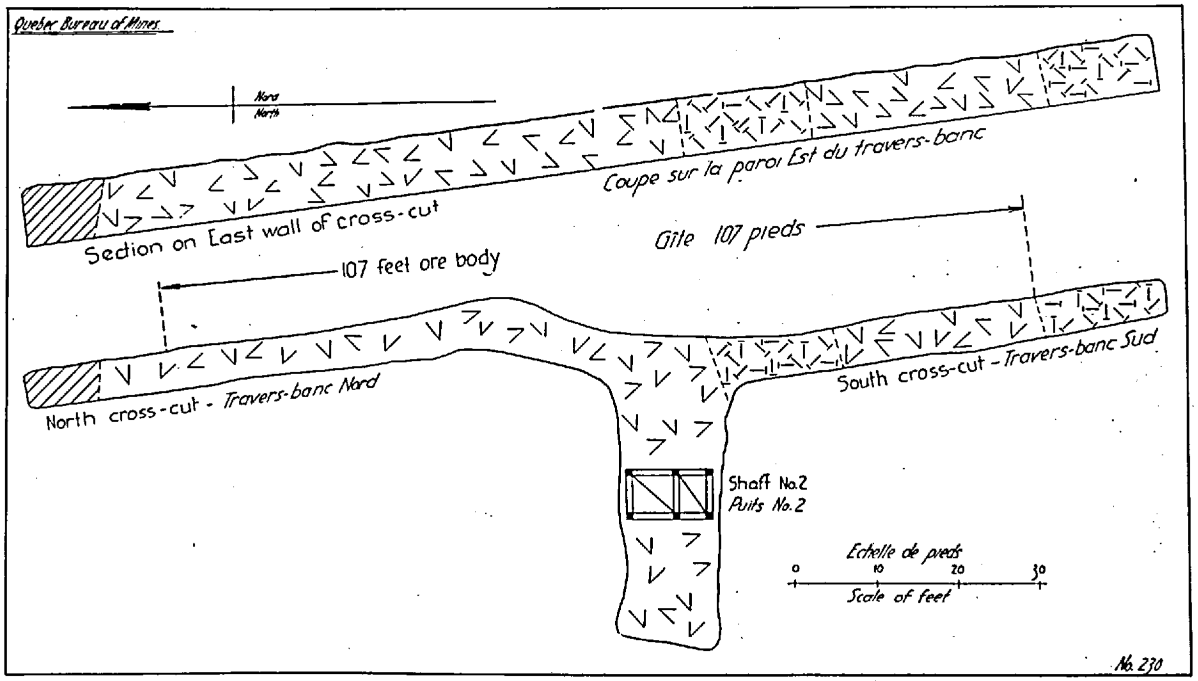


FIGURE 1.—Plan of the geology in the cross-cut of the main ore-body, on the 220-foot level, Beattie mine.

Legend.—Bostonite porphyry, pattern of angles; Syenite porphyry, irregular T;
Keewatin schist, diagonal lines.

Magnetite in minute grains was earlier than the sulphides, and chlorite was developed at early and intermediate stages.

It is probable that, after the first silicification and re-fracturing, the later minerals were more or less contemporaneous, some early ones continuing throughout the whole period, some developed at one particular stage.

Bostonite porphyry, sheared and silicified, seems to be the favourable host-rock for the ore; the syenite porphyry less favourable; and the Keewatin schists distinctly unfavourable.

The mineralization is of the moderate temperature type.

The Intrusives

Two distinct major intrusives are recognized in the Beattie area; they are essentially of the same mineral composition but are different in texture and appearance, and one is intrusive into the other. Somewhat later than the major intrusives, minute aplite dykelets, only observed under the microscope, cut both rocks; these are usually less than a millimeter in width but are widespread. Besides the aplites there are a number of short, curved lenses of pegmatite in some areas.

The earlier major intrusive is a syenite porphyry which occupies an area at least 1,500 feet wide and 2,300 feet in length—practically the whole west end of the Beattie ridge; it narrows abruptly to about 700 feet at the east end of this mass and continues eastward along the north half of the ridge for at least 2,500 feet.

The other major intrusive is a bostonite porphyry which begins where the syenite porphyry narrows, and extends eastward for at least 1,500 feet with an average width of about 700 feet, occupying the south half of the ridge. This intrusive appears as dykes cutting the syenite porphyry to the west, and it is also found on the north border of the syenite porphyry, at which place it is the host-rock of the main ore-body.

Although the evidence so far obtained is not conclusive, the suggestion is strong that the bostonite porphyry mass is a compound intrusion, and there is some reason to believe that the syenite porphyry also is of that nature.

Syenite Porphyry:

The normal syenite porphyry is easily recognized in the field, but along wide bands shearing and contemporaneous or later alteration have so changed the appearance of the rock that it bears very little resemblance to the normal type. In such areas, the impression one gets is of Keewatin greenstone schists injected by narrow sills of porphyry which have porphyritized the adjacent schists to a greater or lesser extent; in other words, the rocks over relatively large areas have the appearance of replacement porphyries. Greenish sericite and sometimes chlorite have been developed abundantly in these sheared zones along minute wavy lines, but the normal pinkish colour of the porphyry usually shows with the green, so that there are gradations from massive porphyry through so-called coarse and fine 'augen-porphyry'—where 'eyes' of porphyry lie in the schist, which in places resembles sheared conglomerate—to true schists which were mapped as greenstone schist, and even sericite schist or schisted tuffs. Much of the porphyry was mapped as 'hybrid porphyry', since it was apparently injected Keewatin rock. Under the microscope, however, there is no evidence of such injection or replacement, and even the 'sericite schists' referred to are clearly seen to be simply highly sheared and sericitized syenite porphyry. It is interesting to note that a dyke of bostonite porphyry, 18 feet wide, lies in the middle of such a highly sheared zone, 50 feet wide, in the syenite porphyry at the mill site, and that the bostonite porphyry is relatively unsheared.

This syenite is distinctly a porphyry, usually pinkish in colour, but sometimes grey; the weathered surface is generally a light grey with pinkish tinge, especially in sunlight. The pinkish colour is due to very minute hematite dust all through the rock. The abundance and size of the phenocrysts vary from place to place, often within short distances. Phenocrysts are all of feldspar and seem to be of two generations: the earlier ones are scattered through the rock and range from 12 by 6 mm. to 25 by 12 mm. in size; the later ones average about 2¼ mm. in length and are quite abundant. They are usually grey but sometimes pink in colour, probably due to alteration. The groundmass is finely crystalline, the average size of the crystals being 0.34 mm. by 0.18 mm. The ratio of length to width of both phenocrysts and groundmass crystals is approximately 2 : 1.

The texture is granitic and porphyritic. With the exception of a few small crystals of green hornblende—usually altered to chlorite and black iron oxide—and of apatite, the rock is wholly feldspathic.

The phenocrysts are microperthite and orthoclase usually, but occasionally albite. Although sometimes fresh, they are usually partly altered in a zonal arrangement—either the border zone is changed and the central portion clear, or the border is clear and the whole central part altered. The principal alteration product is sericite in minute flakes, sometimes accompanied by very fine carbonate and perhaps zoisite. This alteration gives a distinct green coloration to the part of the crystal affected and such phenocrysts have then the appearance of huronite (so-called). The pink crystals contain oxidized iron carbonate.

A brief description of two varieties of the syenite porphyry follows.

Sample No. 249.—A medium grained rock with large crystals of orthoclase in a groundmass of oligoclase with granitic texture. Scattered grains of black iron ore, crystals of apatite, nests of biotite, and some large crystals of sphene are also present. The phenocrysts contain much fine sericite, and there are a few patches of carbonate, chlorite, and quartz, all of which are secondary. There is some pyrite in the rock, some of it replacing sphene.

Sample No. 251.—A medium to fine grained variety with large crystals of turbid albite instead of, or together with, orthoclase. There are some patches of chlorite, apparently altered ferromagnesian mineral; chlorite also occurs in minute cracks. Carbonate is abundant but there is no recognizable sericite. The rock is veined by quartz and carbonate.

Bostonite Porphyry:

This rock has the same mineral composition as the syenite porphyry, but the texture is conspicuously different. The groundmass, instead of having a normal granitic texture as in the syenite, is distinctly trachytic. It is made up of slender laths of oligoclase (12An to 28An) which average about 0.37 mm. by 0.07 mm., so that the ratio of length to width is about 5 : 1 as contrasted with 2 : 1 in the syenite porphyry.

The phenocrysts are platy and in extreme cases comprise at least 70 per cent of the volume of the rock. They attain a length of 1½ inches but average about ¾ inch. The plates are relatively thin, rarely more than one-eighth of an inch in thickness, and they are arranged roughly parallel and standing on edge, with the result that the surface section shows long, slender laths of feldspar—hence the field term 'lath porphyry'. The phenocrysts are microperthite and orthoclase, commonly Carlsbad twins. Usually fairly fresh, they are sometimes saussuritized zonally, as in the syenite porphyry, and such green crystals are very conspicuous. The field term 'serpentine porphyry' has been used for rock containing such phenocrysts, whether in syenite or bostonite porphyry, and this practice has resulted in confusion.

The bostonite porphyry is not, as a rule, easily distinguishable in the field. Characteristically fine grained and, through hydrothermal alteration, presenting a great variety of appearance, it has been mapped as 'greenstone', 'rhyolite', 'andesite', 'feldspar porphyry', 'lath porphyry', all of which, under the microscope, are seen to be the same type of rock.

When comparatively fresh it has a pinkish colour, very like the syenite porphyry, but being very fine grained it resembles jasperoid when the phenocrysts are few. Very often, however, the rock is light or dark grey, or greenish, due to bleaching or to alteration products, and then it looks entirely different. Also, the light and dark greys may alternate, and the rock then has somewhat the appearance of a bedded sediment.

Dykes of this rock cut the syenite porphyry mass and also border it to the north. It is evidently a distinctly later intrusion, and the dykes usually occur in sheared bands of the syenite porphyry. There is no transition from the one porphyry to the other. It is true there is a suggestion of trachytic texture developed in the syenite in some places near the north border, but the rock exhibiting this feature may be part of an unexposed bostonite intrusion in that area.

STRUCTURE

Because of the scarcity of outcrops of bedded rocks in this area, the general structure is not definitely known. If we assume that the

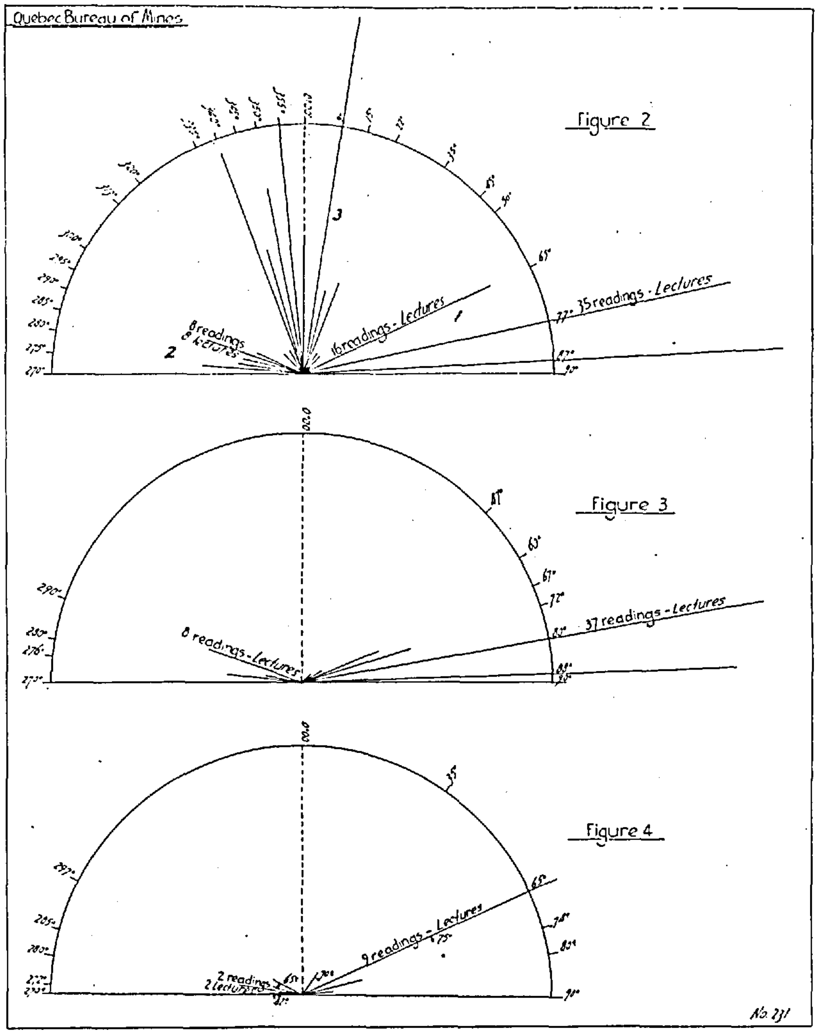


FIGURE 2.—Diagram showing strike of jointing on the Beattie property.

FIGURE 3.—Diagram showing strike of shearing on the Beattie property.

FIGURE 4.—Diagram showing strike of quartz veins and pegmatite dykes on the Beattie property.

Témiscamian conglomerates to the south of the porphyry occupy the centre of a synclinal, as seems plausible, then the porphyry bodies occupy a parallel anticline, since the bedded rocks on the north side of the porphyry dip 75° north. The few determinations of dip on the pillow lavas south of the bostonite porphyry average about 85° north also, so if this is an anticline, there is some overturning towards the south. No Keewatin schists have been found south of the porphyry similar to those cut in the drill-holes north of the porphyry.

Concerning the Témiscamian sediments, no instance of a repetition of beds has been recorded, although a band of slate was mapped on the extreme northern edge and shown to be quite distinctive and persistent along strike. It has not yet been definitely established whether the Témiscamian owes its preservation to folding or to faulting.

The regional strike of both Keewatin and Témiscamian rocks is roughly east-west, and the long axis of the porphyry conforms to this direction, as does the schistosity to a large degree.

The porphyries are strongly jointed and traversed by shears, which in places become narrow zones. The accompanying diagrams show the direction and dip of the principal jointing, shearing, and fissures (probably produced by tension) occupied by dykes and veins.

The jointing lies in two major systems nearly at right angles to one another. The average of the stronger system strikes about five degrees west of north, with 50 per cent of the dips steeply towards the west, 25 per cent steeply towards the east, and 25 per cent vertical. The second system has an average strike between five and ten degrees north of east; 60 per cent of the dips are steeply towards the south, 23 per cent steeply towards the north, and 17 per cent vertical. A third, minor system strikes on the average about ten degrees north of west; 18 per cent dip steeply south, 59 per cent steeply north, and 23 per cent are vertical.

The shearing is, on the average, parallel to the E.5°-10°N. jointing; 44 per cent of the shears dip steeply north, 37 per cent steeply to the south, and 19 per cent are vertical. A minor set of shear-planes average ten degrees north of west; these are individual slip-planes rather than bands as in the former case.

The major set of tension cracks filled with quartz or pegmatite has an average strike E.25°N., and a minor set averages W.12°N.; all these dip towards the south, with an average of about 75°.

Although movement has taken place along a number of shear planes, as indicated by offset minor structures or veins, the movement in each case noted was a matter of only a few inches. An apparent fault was exposed in the excavation for the foundations for the mill, but no indication could be obtained as to the amount or direction of movement.

The records from drill-holes suggest that a normal fault cuts the main ore-body roughly parallel to its strike and offsets it about 300 feet to the north. According to reports, the No. 1 shaft cut through a sheared or faulted zone at about 500 feet depth and penetrated the main ore-body below it. The fault runs nearly east and west and dips about 60° towards the north; this would give the northern ore-body a depth of about 900 feet, while the top of the southern or main part would be about 500 feet below the surface. There is no direct evidence of such a fault at the surface, but its projected outcrop would occur under a drift-covered part of the property.

Indications from the diamond-drilling along the narrower extension of the ore-body to the east suggest offsetting of about 25 feet at two or three places, along nearly north-south lines; these have not been checked and no evidence of them was seen at the surface. This lack of evidence may not be surprising in non-bedded rocks such as the porphyries, especially as a considerable part of the area is drift-covered.

Much more data must be obtained before the detailed structure can be worked out satisfactorily.

METAMORPHISM

In general, there is great variety in the rock alteration from place to place. The green hornblende of the porphyries is usually altered to chlorite and black oxide. Chlorite from the hornblende is irregular in form, while other occurrences suggest that the chlorite has been formed from solutions introduced into the rock and it then appears in fibrous, radiating crystals.

Carbonate is usually present in greater or lesser amount, and it seems to be of two types—the one an iron carbonate that takes on various tints of brown, pink, to purplish; the other, a clear carbonate. In one instance the iron carbonate was seen to be distinctly later than the clear variety.

Sericite varies greatly in amount from place to place; it may be even more abundant than the carbonates, or it may be entirely absent. It is common in the large phenocrysts, as already noted, and usually is abundant along fine shear-planes and in shear zones through the rock; occasionally it also is found scattered through the fine groundmass.

Sphene is very abundant in some places and especially in the bostonites; it is apparently an alteration or introduced mineral, or possibly both types occur. It replaces any of the other minerals and is often in good crystal form.

Biotite occurs in small amount and it may or may not be original.

A green mica occurs in small nests in crushed zones, and very rarely also as scattered flakes in unbroken bostonite.

Epidote is not so common as one might expect it would be; it occurs in nests of fine grains and was seen in only a few thin sections.

Tourmaline was observed in only one of the two hundred thin-sections examined; it occurs as dull green crystals in an altered bostonite porphyry. Black radiating crystals of tourmaline, about one-quarter inch in length, were also seen in a narrow quartz vein cutting one of the diamond-drill cores.

The feldspars in the porphyries are commonly turbid and in some thin sections they are almost opaque; they have the appearance of being highly kaolinized. Some turbid phenocrysts appear to have an aggregate polarization and with increasing size of inclusions from dust to fine grains the replacing material is seen to be carbonate. The phenocrysts in both porphyries are usually altered to fine sericite, which may form a narrow border to the crystal but usually occurs as a matte in the central portion; carbonate may or may not be present with the sericite. The sericite colours the crystals a serpentine-green and those crystals containing iron carbonate take on tints ranging from light pink to a brownish-red.

The oligoclase in the groundmass is not so highly altered, but it is replaced to some extent by carbonate in irregular grains and sometimes by chlorite.

Only in areas of considerable shearing does silicification occur, and not always there. It seems to be associated with the intrusion of innumerable minute aplite dykelets and occurs in irregular patches bordering or near these dykelets, usually spreading from small fissures. In the extreme cases, only small patches of the original groundmass or of phenocrysts remain, in a matrix of cryptocrystalline quartz, and, without the gradations to only slightly silicified rock, it would be impossible to determine the true character of this type of rock. Parts of the ore-bodies are of this highly silicified rock, but they always contain less fissured remnants which are only slightly altered.

On the whole, the metamorphism is intermediate to low grade and only approaches high grade in limited areas.

ECONOMIC GEOLOGY

General

The valuable mineralization at the Beattie mine is of the disseminated sulphide replacement type, formed at moderate temperature and pressure. Gold is the only metal of economic importance, although some allowance may be made if the process of extraction also recovers the small percentage of arsenic present. The gold is closely associated with finely crystalline pyrite and still more finely crystalline arsenopyrite. These minerals were deposited along sheared or fractured zones in silicified syenite porphyry or bostonite porphyry, particularly in the latter.

Early shearing of the syenite porphyry was followed or accompanied by intrusions of bostonite porphyry, often along the shear zones; renewal of shearing stress, along east-west lines as before, formed shear zones again in the syenite porphyry but brecciated the bostonite porphyry. The former usually sealed its fracture, but the latter offered easy passage to silicifying solutions which came in with aplite and pegmatite dykelets and which cemented the breccia and partly replaced the fragments. A certain amount of silica was deposited in the sheared zones also.

Later re-fracturing along the same general lines found these silicified zones brittle and easy to break, allowing ascending mineralizing solutions free and easy access to the rock. Carbonate was deposited, then sericite and chlorite, then pyrite, arsenopyrite, and gold, the last apparently precipitated about the same time as the sulphides.

The main ore-body is surrounded by 'assay-walls', as the values decrease outward, and arbitrary limits are set according to the grade of ore that can be profitably mined. Thus there is a compact mass, roughly 1,100 feet long by 100 feet broad, estimated to contain about 5,390,000 tons of ore averaging $3.07 in gold within 500 feet of the surface, and drilling indicates that the ore continues in depth. The grade can be raised by reducing the tonnage around the margins, or the tonnage may be increased by taking in more of the margins of the body should it be found that an even lower-grade ore will give a profit.

As already noted, it is thought by the management that the ore-body cut by the new shaft at about 500 feet depth is really the main ore-body, and that the present large ore-body is really a section about 900 feet deep faulted downward from the top of the new ore-body and moved laterally about 300 feet north and vertically about 400 feet down on a 60-degree fault-plane.

Besides the ore-bodies mentioned above there are narrower bodies of similar character extending eastward along the north contact of the syenite porphyry. These have been trenched and more or less thoroughly drilled at shallow depths.

Near the south margin of the syenite porphyry, a sheared silicified zone with low values in gold has been trenched for a few hundred feet. A narrow dyke of brecciated bostonite porphyry occurs in this zone, which is still within the syenite porphyry mass, and the zone deserves much further testing, especially as the main syenite-bostonite contact lies under drift a short distance to the south of part of it at least.

Other silicified zones are known, some in the syenite porphyry mass, some in the main bostonite mass to the east and south. In fact trenches extend almost continuously across the 700 feet of bostonite porphyry and the assays show some gold across a considerable part of this width, higher where shearing and silicification were more intense. No ore-body has yet been outlined in this area, but it has interesting possibilities, especially near the contact with the syenite porphyry, if shearing is present there.

The main ore-body shows remarkable continuity and uniformity in values across its width. There are certain bands of higher, and some of lower, values than the average, but the ore does not take on a streaky character until near the ends of the body, where certain bands carry on with good values, while intermediate ones are low. The sampling of the cross-cut on the 220-level illustrates the solid character of the mass. Channel samples taken independently on opposite sides of the cross-cut, broken away every three or four feet, showed a remarkable uniformity of values across a width of 107 feet, with an average value on each wall of $4.41 per ton in gold. Individual samples ranged from $2.60 to $7.00, with only two or three much higher; these were cut to the average. It is interesting to note that diamond drilling indicated an average grade of only $3.80 per ton at this place in the ore-body.

The evidence so far available shows that the ore favours the bostonite porphyry and is concentrated in sheared silicified and brecciated zones in this rock. Of less importance, but still valuable, are sheared silicified zones in the syenite porphyry, where the shearing was later than the intrusion of the bostonite. No ore has been found so far in Keewatin rocks, but that may be only because those exposed are unfavourable. There is no apparent reason why the Témiscamian sediments or brittle Keewatin rocks should not be hosts to the ore in favourable places—preferably in sheared and silicified zones near bostonite porphyry intrusions. It may be that the ore solutions followed the same lines as the bostonite porphyry in their ascent, and there may be a genetic relationship of common source.

A point of importance to note is that the intrusions of bostonite are apparently nearly vertical and the shear planes also are nearly vertical, a combination which should make for deep ore-bodies, other things being equal.

The Microstructure and Mineral Composition of the Ore

The gold ore from the Beattie mine consists of finely divided and disseminated pyrite, arsenopyrite, and magnetite in a gangue of brecciated and silicified bostonite porphyry cut by closely-spaced veinlets of quartz and aplite. The ore is not uniform in composition, but the proportions of the pyrite and arsenopyrite vary from specimen to specimen. Twenty polished sections were prepared of pieces taken from the ore-dump on the surface and from diamond-drill cores. It is thought that they give a reasonable notion of the composition of the ore. Some specimens are much richer in metallic minerals than others, but all have the same minerals in them.

The complex alteration and deformation of the bostonite porphyry has been pointed out in the previous section. In general, the direction of the shearing is found to be almost constant and about parallel to the strike of the ore-body. The composition of the rocks has been modified in places and the alteration has proceeded outward from the shear planes. The mineralizing solutions came up along the shear planes in the breccia, so the metallic minerals are found to be arranged irregularly along the shear planes, although they are not confined to them.

PYRITE:

Pyrite is by far the most abundant sulphide and is found in cubes, or in combinations of cube and pentagonal dodecahedron. In the softer parts of the country rock and along some of the shear planes, the crystals are larger than most of those found elsewhere in the rock, but the faces are rounded. In some places such anhedra form conspicuous aggregates. In the harder parts of the country rock, the crystals are smaller, not so rounded, and the cube form predominates.

Micrometer measurements show that most of the crystals of pyrite are between 0.012 inches (0.3mm.) and 0.003 inches (0.07mm.). The crystals of the larger size would just pass the opening in standard Tyler screen of 48 mesh to the inch, and the smaller size would just pass 200 mesh. A census of all the polished surfaces showed that thirty per cent of the pyrite crystals are larger than the opening of a 65-mesh screen, and seventy per cent are larger than 150 mesh. Relatively few of them are smaller than 250 mesh. Expressed in per cent by weight, most of the pyrite is larger than 65 mesh.

ARSENOPYRITE:

The arsenopyrite is in diamond-shaped crystals, showing the same distribution as the pyrite. In only one or two places may the crystals of arsenopyrite be seen with the naked eye, for the diameter of most of them is 0.0004 inches (0.01 mm.). In a few places, aggregates of the diamond-shaped crystals have formed clots as large as 0.002 inches (0.04 mm.). The aggregates show a branching form and resemble skeleton crystals but are composed of crystals with various orientations, probably twinned.

Analyses of some specimens of the ore show about 0.25 per cent arsenic, which corresponds to ten pounds of arsenopyrite per ton. If the size of the crystals is as given above, a simple calculation shows that in every ton of ore there are 200,000,000 such crystals. This gives some notion of the small size of the arsenopyrite, for all the sulphides together amount to only 5 or 6 per cent of the ore by weight.

MAGNETITE:

Magnetite is found in anhedra about the size of the crystals of arsenopyrite. In some places these are arranged irregularly in the country rock, but most of them follow the shear planes. No gold appears to be associated with magnetite.

GOLD:

Gold may be seen under the microscope only in the most favourable circumstance on account of its low tenor in the ore. Small pieces of gold were seen both with arsenopyrite and pyrite. Other data also indicate that the gold is associated with the sulphides. The amount in each has not been ascertained, but it is believed that practically the whole gold content of the ore is divided between these two minerals. Inasmuch as the particles of gold are smaller than those of arsenopyrite, very fine grinding would be necessary to recover the gold mechanically or to break the sulphides so as to expose the gold to the action of cyanide solutions.

PARAGENESIS:

The magnetite was the first metallic mineral to be deposited and may belong to an earlier mineralization than the pyrite and arsenopyrite. The pyrite was deposited next and then was replaced in part by arsenopyrite, showing that the latter is younger than the pyrite. The gold is probably contemporaneous with the sulphides. Some veinlets of quartz cut across the bands of the sulphides and are younger than them, as are also some veinlets containing carbonate.

Application to Milling:

The gold is apparently associated with both the pyrite and the arsenopyrite and both the latter minerals must be saved if all the gold is to be recovered. There is much less arsenopyrite than pyrite in the ore, and the gold may favour one or the other. Seventy per cent of the pyrite crystals will pass a 150-mesh screen, but the average size of the arsenopyrite crystals is about one-seventh that of the smaller pyrite crystals. That means there must be some gangue left with the concentrate even with the finest economical grinding, if much of the arsenopyrite is to be recovered; probably a 10 to 1 concentrate rather than a 15 to 1 concentrate such as might serve if the metallics were coarser. Regrinding of concentrate to extremely fine size would be costly, considering the tonnage, so that an economic balance must be struck between loss in tailing and cost in grinding. A close study of the ratio of gold with pyrite to that with arsenopyrite would give useful data. In the extreme case, if the gold were largely with the pyrite, it would seem feasible to make a high-pyrite separation with reasonable grinding, allowing the bulk of the arsenopyrite to remain in the gangue.

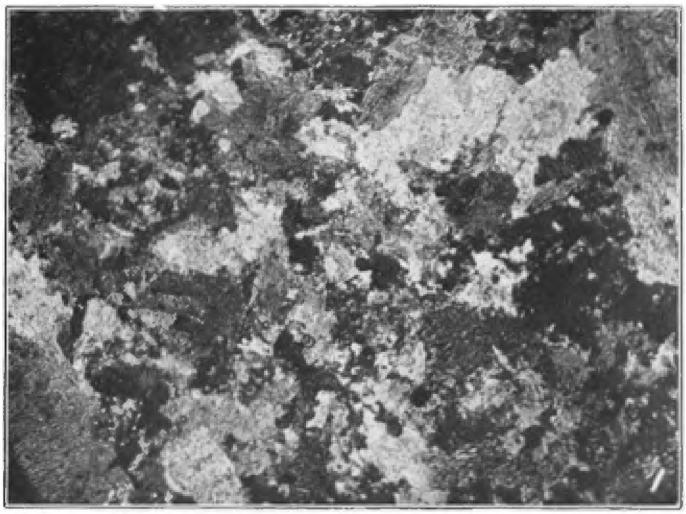
At present the concentrates are shipped to a smelter at Tacoma, Wash., until the tonnage increase warrants treatment at the mine; freight charges on gangue left in concentrate are therefore an important consideration.

Plate I

BEATTIE GOLD MINES, Limited.

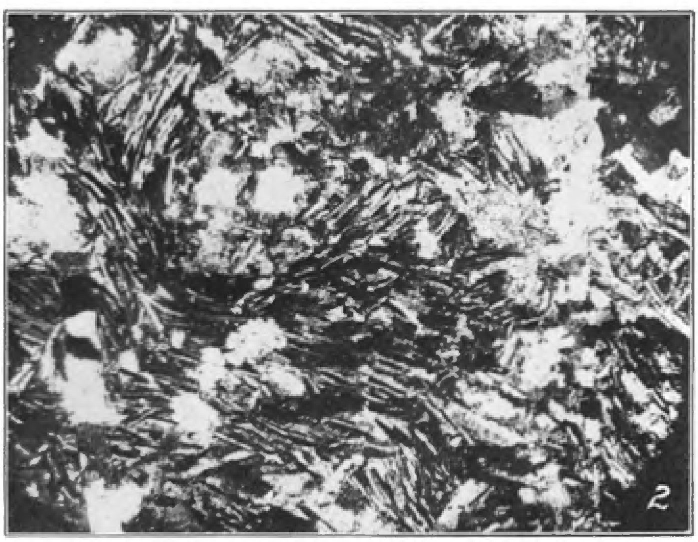
Concentrator of the Beattie mine. A dyke of bostonite porphyry lies under the mill site.

Plate II.—A



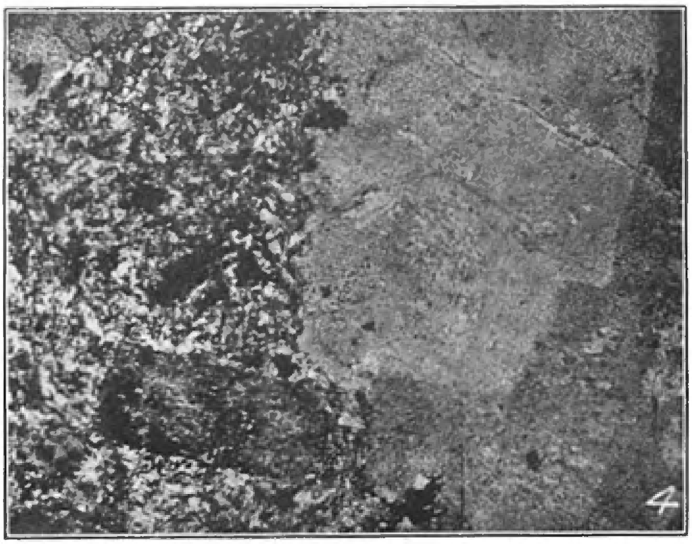
Typical syenite porphyry, from about 100 feet southwest of shaft No. 2, Beattie mine. Crossed nicols, × 28 diameters.

Plate II.—B



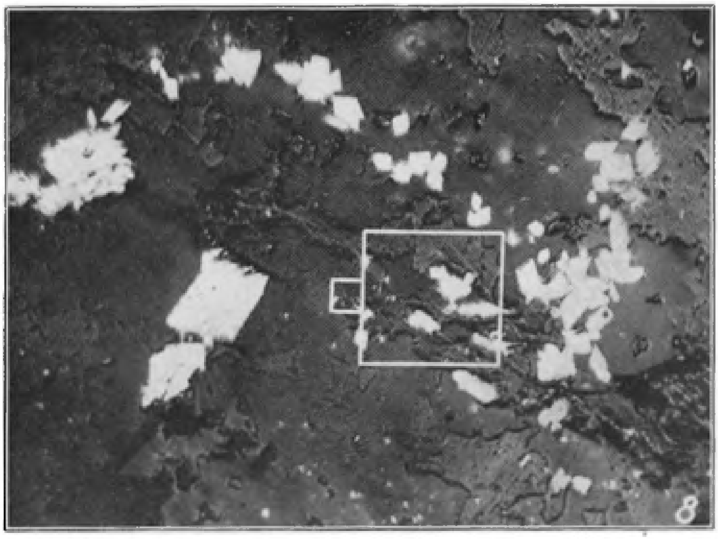
Typical bostonite porphyry, with trachytic texture, from main mass 30 feet from the north contact with syenite porphyry. Crossed nicols, × 28 diameters.

Plate III



Bostonite porphyry (so-called lath porphyry), from a dyke cutting syenite porphyry southeast of machine shop. Crossed nicols, × 28 diameters.

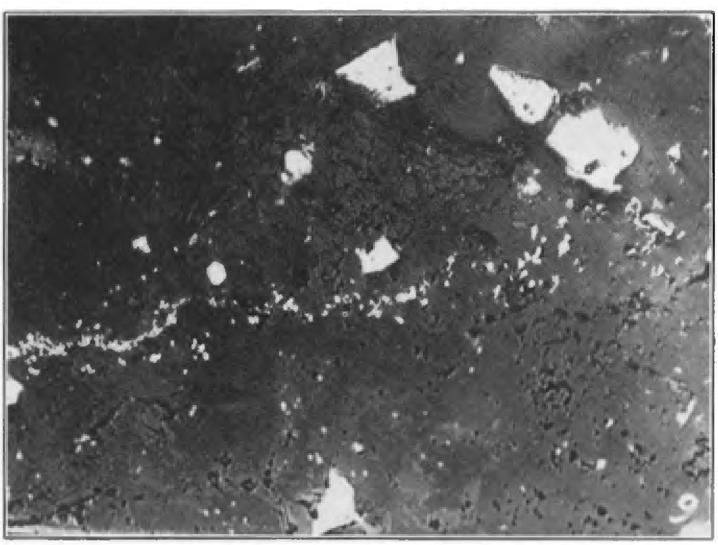
Plate IV.—A



Beattie ore, main ore-body. × 420.

The two large white crystals are pyrite; the small white crystals are arsenopyrite. The large square represents the opening in a standard screen of 325 mesh; the smaller square has a side of 0.01 mm. (0.0004 in.) enlarged to the same scale as the photograph.

Plate IV.—B



Beattie ore, main ore-body. × 160.

The large white patches are pyrite; the very minute white patches are arsenopyrite pyrite, and magnetite. The black spots are pits in the polished surface.