MINERALIZATION AND WALL ROCK ALTERATION

FLIN FLON AREA, SASKATCHEWAN

A

THESIS

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by

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ABSTRACT

This thesis comprises a field and microscopic study of certain gold and copper deposits in the Flin Flon area. The gold deposits occur in gold-quartz-sulphide veins. These veins have been classed as: (1) gold-quartz veins, (2) quartz-sulphide-carbonate veins, (3) quartz-sulphide veins, and (4) quartz-arsenopyrite veins. One copper deposit was studied and it was classed as a sulphide replacement deposit.

The mineralization occurs along fissures in volcanic rocks of the Amisk group and in post-Missi intrusions. The minerals were deposited from hydrothermal solutions. Metallic mineralization and wall rock alteration took place at intermediate to high temperatures and is related in age to the granodiorite or the Kaminis granite.

The type of wall rock alteration accompanying the mineralization depends on the nature of the hydrothermal solutions and on physical conditions, such as temperature and pressure.

INTRODUCTION

General Statement

This thesis comprises a petrographic and metallographic study of certain mineral deposits in the Flin Flon area. The deposits were investigated during the summer of 1952. The investigation consisted of detailed mapping of the local geology with particular attention being given to structure and alteration of the rocks surrounding the mineralized zones. Samples of the rocks were collected to illustrate the varying degrees of metamorphism adjacent to the mineral deposits. Microscopic examination of thin sections and polished ore sections of these specimens was later conducted at the University of Saskatchewan. The points stressed were the identification of metallic minerals and their mutual relationship, the type and degree of wall rock alteration and their interdependence on rock-type and type of mineralization, and the paragenesis of the ores.

Location

The area investigated lies west and south of Flin Flon and between the Second Meridian and the Saskatchewan-Manitoba boundary. The mineral deposits studied lie along a belt approximately 2½ miles long extending from the south end of Bootleg lake north to Bomber lake which lies north of the Denare Beach-Flin Flon highway. Map 1 shows the geographic location of the mineral deposits and their location relative to the geology of the district.

General Character of the Area

The area exhibits the general physical features of the Precambrian Shield. Outcrops are numerous and the relatively flat surfaces of volcanic rocks are well exposed due to the area being swept by a number of forest fires.

The intervening areas between outcrops are occupied by muskeg, swamps and patches of shrubs, alders and some timber. Timber is relatively small and consists mainly of spruce, jackpine, birch, and poplar.

Previous Work

The earliest reports published on the area are by E. L. Bruce (1914, 1915, 1916, 1918) who made a reconnaissance geological investigation for the Geological Survey of Canada from 1914 to 1918. J. F. Wright (1932) published a summary report on the Amisk Lake area which adjoins the Flin Flon area on the west. J. F. Wright and C. H. Stockwell (1933) published a summary report on gold occurrences of the Flin Flon district. T. L. Tanton (1941) mapped the area in 1938. More recent work was done by C. H. Stockwell (1946) from 1943 to 1945, and at present A. R. Byers is working in the area for the Saskatchewan Department of Natural Resources.

Acknowledgements

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The author is indebted to Dr. A. R. Byers, Associate Professor of Geology at the University of Saskatchewan, for assistance and constructive criticism rendered in the identification of minerals and interpretation of textures in the laboratory.

In the field, able and willing assistance was rendered by Mr. Don Gavelin.

Mr. Ernie Hawkins of the Department of Geology, prepared the thin sections for petrographic study.

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GENERAL GEOLOGY

General Statement

The bedrock in the area is of Precambrian age. Direct correlation with the rocks in eastern Canada is impossible due to separation by wide expanses of granites, but lithological and stratigraphic similarities exist in the two regions.

The following discussion of the regional geology and the table of formations shown below have been taken from Stockwell's (1946) report on the Flin Flon area. Detailed megascopic and microscopic descriptions of some rock types within which mineral showings occur have been included by the writer.

TABLE I

Table of Formations

YOUNGER INTRUSIVES:	Kaminis granite. Boundary intrusives Granite, granodiorite Diorite, gabbro.
INTRUSIVE CONTACT	
MISSI SERIES:	Greywacke and arkose Greywacke, arkose and pebble beds Conglomerate
UNCONFORMITY	
OLDER INTRUSIVES:	Cliff Lake granite Meta-diorite, meta-gabbro.
INTRUSIVE CONTACT	
AMISK GROUP:	Quartz porphyry Rhyolite Bedded tuff and breccia Porphyritic andesite breccia Andesite breccia Porphyritic andesite Andesite, basalt, flow breccia, and dacite.

Amisk Group:

Stockwell (1946) has divided the Amisk group into seven mappable units. The first five divisions consist of dark-green andesitic and basaltic lavas with flow breccias and associated pyroclastics. Many of the flows are amygdaloidal and may also show pillow structure, while others are massive. Some lavas grade into flow breccias composed of irregular rounded masses of andesite in a matrix of andesite.

Megascopic examination of andesitic rock (Specimen No. 44)(1), from the vicinity of the Newcor mine, shows it to be medium to dark grey-green on the fresh and weathered surfaces. Feldspar phenocrysts of about 3.0 millimeters are embedded in an aphanitic groundmass which possesses a closely spaced weak foliation.(2) The distribution of the phenocrysts is sparse and they can only be detected by careful inspection. Silicification and pyritization occurs along the foliation planes. Microscopic examination shows a high degree of alteration, mostly by hydrothermal solutions. The rock now consists of 30 per cent quartz, 44 per cent chlorite, 24 per cent calcite, and other minerals such as pyrite, undeterminable feldspar, sericite and saussurite in traces.(3) Quartz is present throughout the rock and it replaces the feldspar. Feldspar phenocrysts are altered to sericite and are chloritized. Saussurite appears to have been driven out by the quartz to areas rich in chlorite. Chlorite, mostly penninite, may be attributed in part to

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(1) All specimens described in this section were thought to be relatively unaltered.

(2) Billings (1949) defines foliation as the ability of rocks to break along approximately parallel surfaces.

(3) Traces mean presence in amounts less than 1 per cent.

PLATE 2

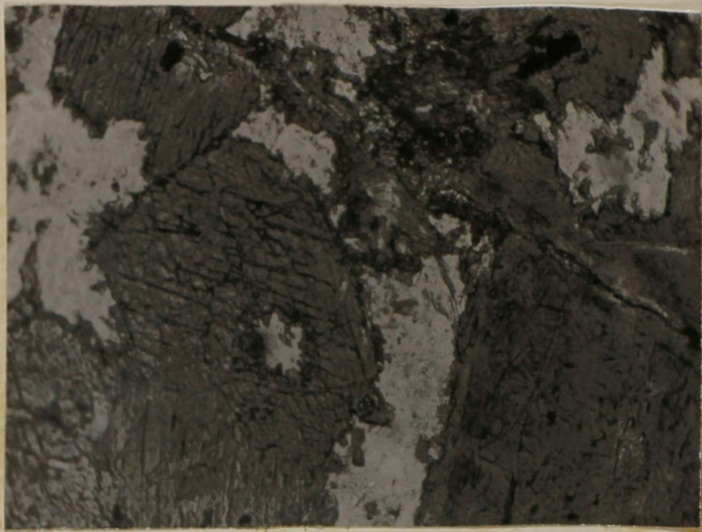


Fig. 1 Specimen No. 1(b) Meta-diorite. Hornblende (dark grey) shows recrystallization by changing from a brown to a green variety (darker grey patches are green variety, lighter grey are the brown variety), and by resorbed splintery boundaries. Intersertal oligoclase (light grey) is altered and has recrystallized along hornblende cleavage. X-nicols. X100.

Fig. 2 Specimen No. 8. Diorite. Oligoclase saussuritized and replaced by chlorite and quartz. (Rhombohedral shaped grain in right half is oligoclase, dark masses are chlorite and the finer-grained masses within and around the grain are saussurite). Chlorite along hornblende cleavage (left half). X-nicols. X100.

deutric alteration of ferromagnesian minerals and partly to hydrothermal replacement. Most of the carbonate is introduced. The texture is metamorphic due to the foliation. All the minerals are elongated and aligned along the foliation planes and possess either sutured or sharp boundaries between each other. The porphyritic andesite breccia (Specimen No. 17) (Plate 1, Fig. 1) north of Henning-Maloney mine is medium to dark grey-green on the fresh and weathered surfaces. Subangular porphyritic fragments varying in size and averaging about 8.0 millimeters in diameter, are embedded in a porphyritic dark green matrix. The phenocrysts in the matrix about 1.0 millimeter in size, weather light grey and are elevated on the weathered surface. Microscopic examination shows a composition of 25 per cent hornblende, 15 per cent quartz, 15 per cent zoisite, 2 per cent sericite, and a trace of carbonate. Oligoclase (An 28) is present to the extent of 30 per cent, and it is intensely saussuritized. The phenocrysts are composed of plagioclase and some of them are zoned. Quartz occurs as irregular masses throughout the rock and also as stringers. The high quartz content is thought to be due to hydrothermal solutions. The rock possesses an altered clastic texture.

The upper two divisions of Stockwell's Amisk group consist of rhyolite, quartz porphyry and quartz porphyry breccia. The quartz porphyry is fine-grained light grey weathering, with phenocrysts of quartz and commonly of feldspar. The quartz porphyry and breccia are probably largely flows, but some may be intrusive equivalents of the lavas.

PLATE 1

Fig. 1 Specimen No. 17. Porphyrytic andesite breccia showing intense saussuritization. Irregular fragment (lower half) nearly all replaced by quartz (light grey masses), and zoisite (dark grey to black). Irregular masses of quartz scattered throughout altered matrix (dark grey) consisting mostly of hornblende and saussurite. X-nicols. X100.

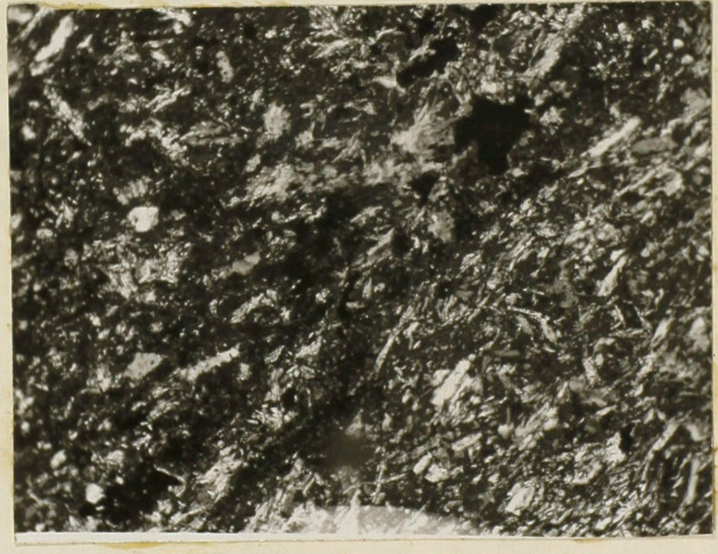


Fig. 2 Specimen No. 2. Dacite showing trachytic texture. Alignment of plagioclase and amphibole laths. Amphibole altered to chlorite. X-nicols. X100.

Microscopic examination of a thin section of Stockwell's rhyolite (Specimen No. 2) from the east shore of Bootleg lake, shows an approximate composition of 50 per cent of a mixture of potash feldspars n and oligoclase (An 15) in indefinite proportions, 37 per cent chlorite, 10 per cent opaque mineral, and a trace of quartz. The original composition is thought to have resembled a dacite more closely than a rhyolite. The texture is trachytic with indications of probable feldspar phenocrysts (Plate 1, Fig. 2). Grain size varies from 0.35 millimeters down to very small particles.

Older Intrusive Rocks

Dikes, sills and irregular bodies of meta-diorite and meta-gabbro are present. These are similar in appearance to some of the massive flows and possibly are closely related, but possess chilled margins and cross-cutting relationships.

Megascopically the meta-diorite (Specimen No. 1(b))is dark grey-green on the fresh surface, and weathers a medium grey-green. Usually it is fine-grained, varying from 0.25 millimeter to 1.0 millimeter and averaging 0.5 millimeter. Occasionally it may possess a few medium-grained phenocrysts of amphibole.

Microscopic examination shows the meta-diorite is composed of 60 per cent hornblende, 35 per cent altered oligoclase (An 25), and the remaining 5 per cent is penninite, epidote, carbonate, zoisite, sphene, apatite, pyrite, and titaniferous magnetite. The hornblende appears to be in a state of recrystallization from a brown to a green variety. Resorbed, splintery boundaries of the hornblende also show recrystallization (Plate 2, Fig. 1). Indications of the hornblende altering to penninite and carbonate are present, but these are few. The oligoclase is extremely saussuritized, and it also shows evidence of recrystallization along the hornblende cleavage. Epidote and zoisite replace hornblende and also occur as stringers associated with penninite. The apatite, sphene and opaque minerals may either be accessory minerals, or due to hydrothermal replacement. The meta-diorite possesses a recrystallized or sutured texture.

The Cliff Lake granite porphyry is an oligoclase granite, characterized by opalescent quartz eyes. It is probably older than the Missi series, as boulders of a granite similar to it are found in the Missi conglomerate.

Missi Series

The Missi series lies unconformably on the Amisk group. Stockwell has divided the series into three units. Conglomerate is prevalent at the base and also occurs at several other horizons within the series. Material contained in the conglomerates gives evidence for its derivation from the older volcanics. The conglomerate passes directly into greywacke and arkose with scattered pebble beds and lenses. Cross-bedding is characteristic of the three subdivisions of the Missi series.

Younger Intrusions

Diorite and gabbro are facies of granite and granodiorite and pass gradationally into these rocks with no sharp contact existing between them. These intrusions are seen to cut the Missi series. The diorite is medium grey-green and weathers a light grey. It possesses a weak foliation and ranges in grain size from 0.20 to 3.0 millimeters. Thin sections of diorite, specimens (8) and (20), show a composition

PLATE 3

Fig. 1 Specimen 25(b). Diorite. Plagioclase grain bent and twinning strained. Alteration to sericite (fine white masses) and saussurite (dark grey bodies). X-nicols. X100.

Fig. 2 Specimen No. 390. Kaminis granite porphyry. Microcline phenocryst with plagioclase inclusions. Groundmass (fine-grained aggregate along left edge) consists of potash feldspars and quartz and minor amounts of plagioclase. X-nicols. X100.

of 80 per cent plagioclase, varying from (An 27) to (An 32), 2 per cent amphibole, 6 per cent quartz, 5 per cent chlorite, 2 per cent epidote and zoisite, 2 per cent ilmenite and minor amounts of apatite, opaque mineral, potash feldspar and carbonate. The plagioclase is sericitised and in places this is masked by heavy saussuritisation to the extent of 75 per cent saussurite (Plate 2, Fig. 2). Some of the twin laminae are bent and show straining (Plate 3, Fig. 1). Amphibole is highly altered to chlorite. The quartz content has been increased over the primary composition by its introduction along fractures and also it occurs as an alteration product of the plagioclase. Stringers of carbonate and chlorite, also epidote and zoisite are present. Originally the texture was probably hypidiomorphic but now it is sutured mosaic.

The granite and granodiorite are characterized by pink feldspar, and are medium to light pinkish-grey on both the fresh and weathered surfaces. Several large masses are present with the gradational facies of diorite and gabbro occurring along the contacts. Foliation is present, but it varies in intensity and massive rock is common. The principal minerals are feldspar, quartz, hornblende and biotite.

Boundary intrusives cut the earlier intrusions in the Flin Flon area. They comprise a great variety of types ranging from acidic to ultrabasic. These are found to grade into one another, but more commonly acidic rocks intrude more basic types.

Granite possessing large feldspar phenocrysts has been called the Kaminis granite. There appears to be two different types of granite porphyry which may be related, and their related dikes intrude the granodiorite and cut the boundary intrusives.

The typical Kaminis granite is characterized by phenocrysts of microcline larger than one inch. Its total potash feldspar content is about 60 per cent. Oligoclase (An15) comprises 25 per cent, quartz 10 per cent, and the remaining 5 per cent consists of biotite, chlorite, sphene, apatite and opaque minerals.

The other type of granite porphyry consists of smaller phenocrysts of oligoclase, averaging about half an inch in size. Oligoclase makes up about 65 per cent of the rock, potash feldspar 10 per cent, quartz 20 per cent, and other accessory minerals 5 per cent. Both types show that stresses have been active. Feldspar phenocrysts are fractured and quartz is crushed and strained. Evidence of stresses is also shown by the presence of bent biotite laminae.

Dikes of Kaminis porphyry are probably more varied mineralogically. Microscopic examination of a Kaminis porphyry dike (Specimen No. 390) shows the rock to be comprised of 62 per cent potash feldspar, 24 per cent quartz, 10 per cent oligoclase (An 21), 8 per cent biotite, and traces of chlorite, carbonate, sericite, epidote and zoisite, hornblende, apatite, and sphene. The phenocrysts are composed of mainly potash feldspars, but there are a few oligoclase phenocrysts. (Plate 3, Fig. 2).

ECONOMIC GEOLOGY

GROUP A (1)

Henning-Maloney Gold Mine

Location and Development

The Henning-Maloney Gold Mine is about 1100 feet east of the south end of Bootleg Lake and about 4½ miles southwest of Flin Flon. The location of the mine is shown on Group A map and on Map I.

In July 1931 the claims were staked by P. J. Maloney and A. J. Henning. Mining operations started in the late thirties and ended very soon after. Detailed gological mapping of the ground was undertaken by J. F. Wright and C. H. Stockwell in 1933. The mineralization was explored by a shaft and a number of trenches.

Geological Setting

The mineralised zones are in diorite a short distance east of its contact with tuffs. This diorite is a facies of a larger mass of granodiorite which occurs further east. The diorite and granodiorite have been described under the heading of younger intrusions in the section on general geology.

Zones of shearing occur in the diorite. These zones are mineralised along the shear planes by stringers and veins of quartz several inches wide. The shear zones strike in two directions. One strikes north 20 to 30 degrees east and dips 65 to 80 degrees southeast, and the other strikes anywhere between north 53 to 70 degrees east and dips steeply to the southeast. Definite planes of movement occur within and parallel to the shear zones.

...mineralized zones have been grouped and are designated by ...r locations relative to the geology of the district and ...eatures are shown on Map I.

A shaft has been sunk on quartz veins in a principal shear zone trending north 20 to 30 degrees east. Diorite outcropping north of the shaft is sheared and cut by quartz. Seven pits and trenches are located along shears trending in the two directions. Trenching has also been done in the overburden to the south of the shaft, but no exposed bedrock was seen. However, strongly sheared and altered material on the sides of the trenches indicates that the principal shear zone at the shaft continues beneath the overburden to the south.

Mineralization

The diorite adjacent to the mineralization has been altered to varying degrees depending on the distance from the mineralized zones. An outer zone of alteration farthest from the mineralization is marked by agreyish-green diorite, darker than the normal unaltered rock. This outer zone is characterized by chlorite which is more abundant than anywhere else. As the zone of mineralization is approached the diorite either becomes bleached-looking by the presence of epidote and zoisite or remains the same green chloritic rock but with increase in the amount of carbonates. The diorite within the mineralized zone is hard and fine-grained due to silicification, and is bleached-looking due to the presence of sericite. Carbonate is also present, but less than in the intermediate zone. The gold bearing vein was not seen in place due to a covering of overburden and waste rock, but gold ore found in the loading chutes consists of dense, dark greenish quartz which possesses a cherty appearance. A slight amount of sericite and carbonate are present in this ore.

The following table gives the approximate percentages of the minerals present as determined by microscopic examination with increasing alteration to the right.

TABLE 2

	Unaltered		Low-		Medium-		High-Alteration			Ore	
Specimen No.	8	20	25(b)	25(a)	26(b)	28(a)	25(a)	31(a)	32(a)	32(b)	33
Hornblende	3	1	15	9	-	-	-	-	-	-	-
Chlorite	5	6	18	12	35	15	23	-	tr	tr	tr
Quartz	4	8	tr	1	tr	tr	33	6	69	64	95
Carbonate	tr	-	tr	4	15	35	tr	59	20	2	-
Plagioclase	80 An27(a[illegible])	80 An32	66 An46	70 An47	50 An37	tr	33 An31	4 An26	-	-	-
Epidote-Zoisite	3	1	tr	tr	tr	-	7	-	-	-	-
Opaque	tr	1	tr	4	tr	7	2	tr	8	33	tr
Ilmenite	4	-	tr	-	-	-	tr	-	-	-	-
Apatite	tr	1	tr	tr	-	tr	-	-	-	-	-
K-feldspar	-	2	-	-	-	-	-	-	-	-	-
Sericite	15 of plag.	(some masked)	15 of plag.	30 of plag.	30 of plag.	49	40 plag.	30	2	tr	2
Saussuritization	45 of plag.	70 of plag.	25 of plag.	low	20 of plag.	-	low	-	-	-	-

PLATE 4

Fig. 1 Specimen No. 32(b). Crushed quartz with carbonate. Carbonate (mottled grey, upper left corner) shows straight line boundaries with quartz and also occurs along quartz fractures. Maybe simultaneously deposited with quartz or after the crushing. Sericite replacing quartz. (Fine white laths, lower right corner). X-nicols. X100.

Fig. 2 Specimen No. 28(a). Sericite lath (center) replacing chlorite (medium grey, irregular mass at center) and carbonate (light grey making up most of micrograph). X-nicols. X352.

Deuteric[1] alteration of minerals and regional metamorphism have produced some of the alteration products. Specimens of diorite not affected by mineralising solutions show the feldspars altered to sericite and saussurite, and the ferromagnesian minerals to chlorite and pyrite.

During and following a period of fracturing mineralising solutions migrated along the fissures and altered the mineralogical composition of the wall rock. Quartz and carbonates were deposited. The association of the carbonates with the quartz, and also since straight line boundaries occur between the grains of the two minerals, suggests that they were simultaneously deposited. However, some of the carbonates surround quartz grains and suggest that they were deposited after the quartz. The carbonates were therefore deposited during or shortly after the silicification. (Plate 4, Fig. 1). Most of the carbonates are unfractured and appear to have been deposited after the main movement, but some grains are fractured and show that movement continued after the carbonisation. A period of chloritisation followed which was post-carbonatisation. Stringers of chlorite cut across carbonate stringers and irregular masses occur where quartz is fractured. The textural and structural relationships of the chlorite do not indicate the age of its initial deposition, therefore it is possible that it began at the same time as the silicification and carbonatisation. Epidote and zoisite are associated with the chlorite and replace it with increasing alteration. Laths of sericite replace all the non-opaque minerals (Plate 4, Fig. 2). The initial deposition of the sericite, as in the case of chlorite, is not known and may also date back to the period of silicifi-

(1) Deuteric alteration is a term applied to alteration in an igneous rock produced by the consolidating magma during the later stages of its consolidation.

PLATE 5

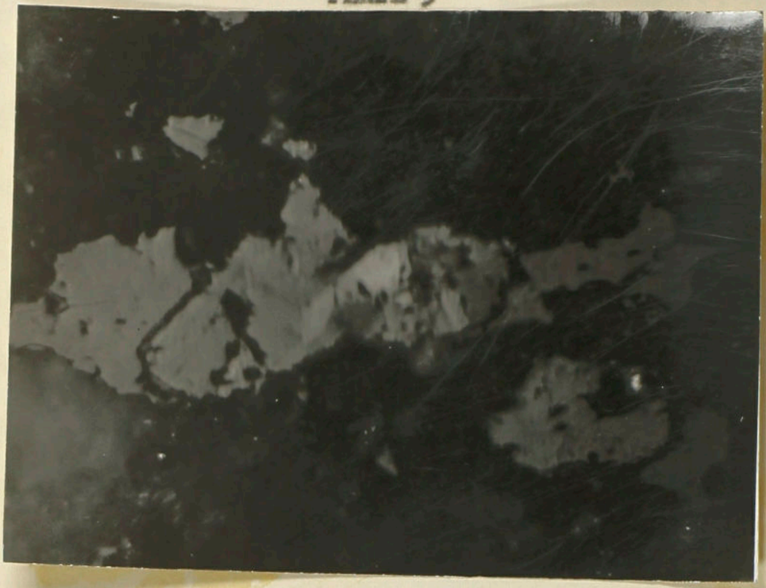


Fig. 1 Specimen No. 33. Arsenopyrite masses replacing non-opaque minerals (dark grey) along fractures. The lighter grey patches are variously orientated arsenopyrite grains. X-nicols. Metallographic microscope. X132.

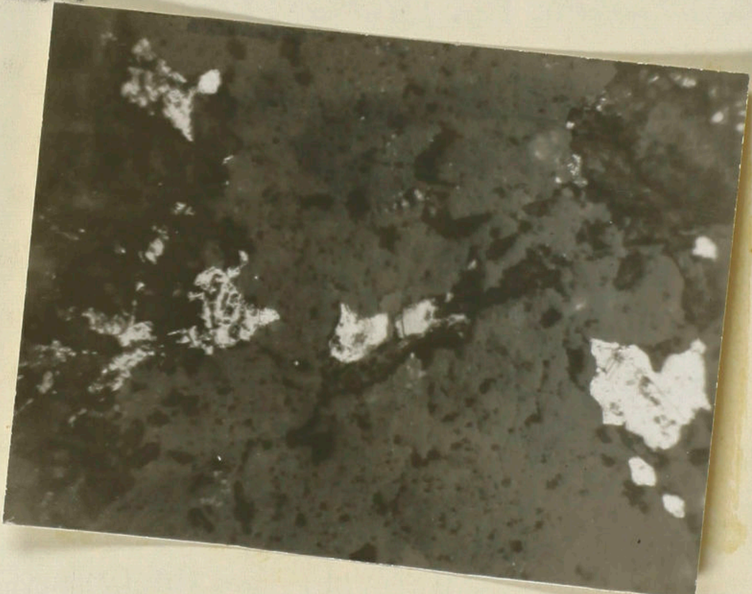


Fig. 2 Specimen No. 33. Gold and molybdenite in quartz. (Medium grey is quartz, darker grey is carbonate). Gold replacing carbonate and quartz. Plain light. X132.

cation.

The quartz containing free gold also possesses minor amounts of sulphides. Microscopic examination shows that chalcopyrite is most abundant and it occurs as stringers and irregular masses. Irregular pyrite masses are next in abundance. Arsenopyrite is found as masses of variously orientated grains either within the pyrite or alone. (Plate 5, Fig. 1). Molybdenite and gold are found in subordinate amounts. The gold appears as irregular masses or poor cubic shapes near the molybdenite. (Plate 5, Fig. 2).

Polished sections of mineralized rock taken from the dump probably depicting underground mineralization, and of mineralization in one of the trenches, show the presence of chalcopyrite, pyrite and pyrrhotite. Chalcopyrite often forms along stringers and pyrite usually occurs as irregular masses in quartz. The pyrrhotite is found in very minute quantities and is always present replacing the interior of pyrite. (Plate 6, Fig. 1).

Traces of what appears to be free gold have also been found in a number of thin sections of the diorite. Positive identification is impossible due to its presence in minor amounts. The gold occurs as fine "wisps" cutting across strained quartz and plagioclase. Gold occurring in this manner was noticed in the diorite from the outcrop 90 feet east of the shaft and in the wall rock of a trench north of the northwest corner of the waste dump.

Sulphides and free gold replace non-opaque minerals and were the last to be deposited. Pyrite is the oldest sulphide and relatively unstrained quartz within the masses shows that pyrite probably dates back to the period of silicification. In the high grade gold ore, pyrite

PLATE 6

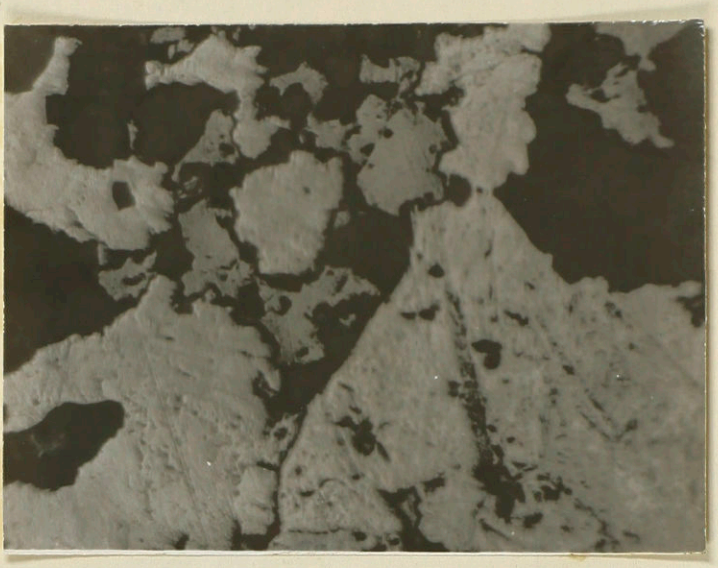


Fig. 1 Specimen No. 32(b) Irregular masses of pyrite (lighter grey) and chalcopyrite (darker grey). (Quartz is black). Plan light. X132.

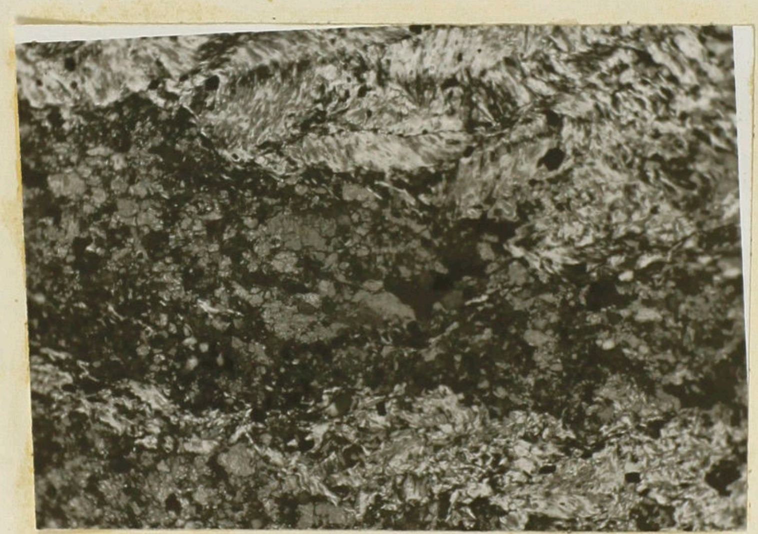


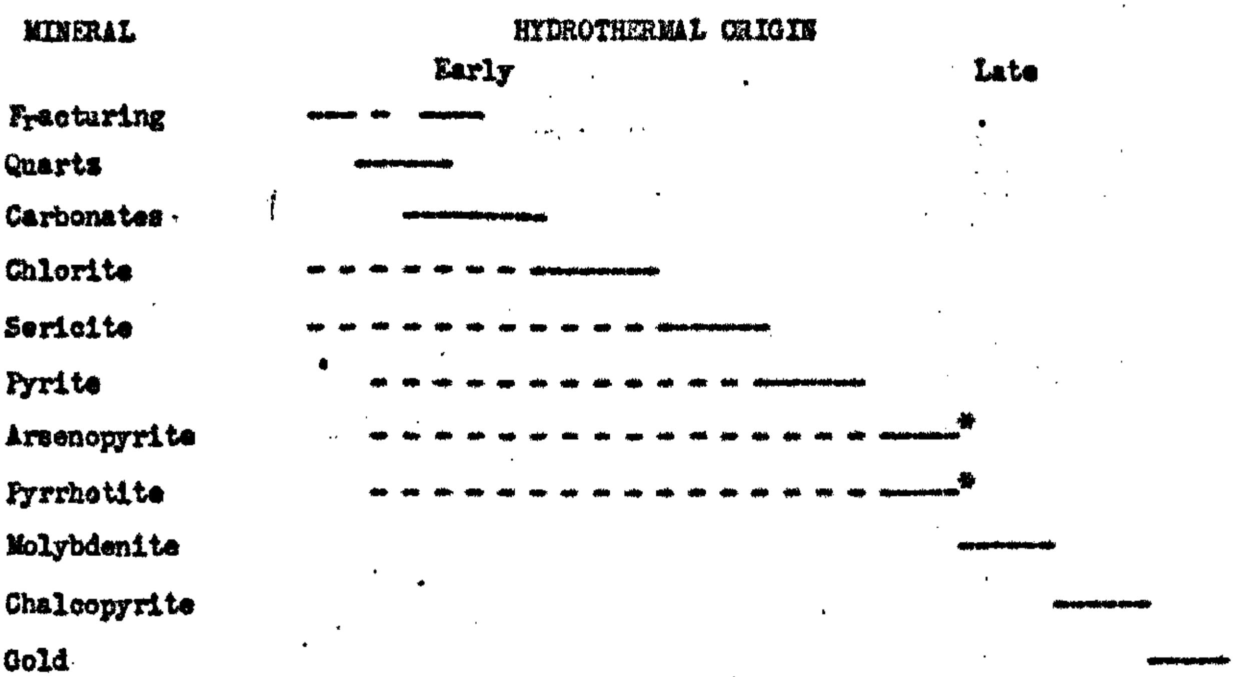
Fig. 2 Specimen No. 16. Sericite (light grey, wavy and fibrous bands) along shear planes. Carbonate bands between the sericite. (Dark grey rounded grains making up band across the middle of micrograph). Sulphide (fine, black grains) most abundant along sericite bands. X-nicols X100.

is replaced by arsenopyrite, molybdenite followed and was replaced by chalcopyrite. Gold, occurring in minute amounts, was not seen to replace the metallic minerals, but it may be inferred from other gold deposits in different areas that it was the last metallic mineral deposited. Mineralisation in the trenches shows that pyrite was replaced by pyrrhotite, then later it was replaced by chalcopyrite.

Paragenesis

The following paragenetic diagram shows the sequence of mineral deposition.

DIAGRAM 1



Note: Minerals are shown from top to bottom in the order in which their deposition appears to have begun.
Only the relative positions of the lines are significant.
Dashed lines indicate inferred deposition.
* These minerals replace pyrite only and therefore their relative age relationship cannot be determined.

North Trenches

Geological Setting

The north trenches are about 2,000 feet north of the Henning-Maloney Gold Mine as shown on Maps I and A. At the north end of the Map A area, approximately north trending andesite breccia, basic lavas and tuffs are cut by a fault trending north 58 degrees east. This fault offsets the volcanics, but the amount of movement is not known. Subsidiary faults branch off at about north 30 degrees east, and approximately east-west trending Kaminis porphyry dikes, about 8 feet wide, are displaced along these fault planes. Exploration pits and trenches are found where the Kaminis porphyry dikes are fractured near the fault; in the subsidiary faults; and on the main fault.

The fault zone consists of sheared and crenulated volcanic rocks. The crenulated appearance is produced by fine, wavy graphitic bands ranging from paper-thin up to 1/8 of an inch thick, interbanded with cherty wall rock and lensy ribbons of quartz. A main zone of movement is marked by intensely schistose rock about 6 to 18 inches wide. Quartz in the form of numerous stringers and veins up to 4 feet wide occur in this intensely sheared zone.

Mineralization

Quartz in the larger veins is practically barren but sulphides are found disseminated in the silicified wall rock. Ankerite is associated with the quartz stringers and veins and occurs in large quantities. The high iron content of the ankerite imparts a rusty appearance to the weathered surface of the whole zone. Sericitization is abundantly developed along the shear planes and this gives the unstained rock a light grey silky look. (Plate 6, Fig. 2).

The following table gives the percentage of minerals in the country rock and also in the mineralised zone as determined by microscopic examination.

TABLE 3

	Unaltered	Altered Wallrock and Mineralized Fault Zone			
Specimen	Porphyritic Andesite Breccia #17	Andesite Breccia (Wallrock) #6(b)	Andesite #16	Andesite Breccia (Fault-zone) #19(a)	Vein in Andesite #18
Hornblende	25	-	-	-	-
Chlorite	15	7	-	-	-
Quartz	15	tr	29	51	40
Carbonate	tr	45	40	48	20
Plagioclase	30 (An28)	23 (An8) + K-feld	-	-	-
Epidote-Zoisite	15 (Zoisite)	-	-	-	-
Opaque	-	2	1	tr	15
Apatite	tr	-	-	tr	-
K-feldspar	-	23 K-feld + (An8)	-	-	-
Sericite	2	-	30	tr	25
Saussurite	heavy	20	-	-	-
Biotite	-	3	-	-	-

A significant feature of this mineralisation is the removal of ferromagnesian minerals and the replacement of the rock by quartz, ankerite, sericite and sulphides. Two zones of alteration are apparent. Ankerite and calcite form a zone farthest away from the main mineralization, then with increasing alteration this grades into a silicious-ankerite zone

PLATE 7

Fig. 1 Specimen No. 19(a). Carbonate grains fractured and fine-grained carbonate grains between fragments. X-nicols. X100.

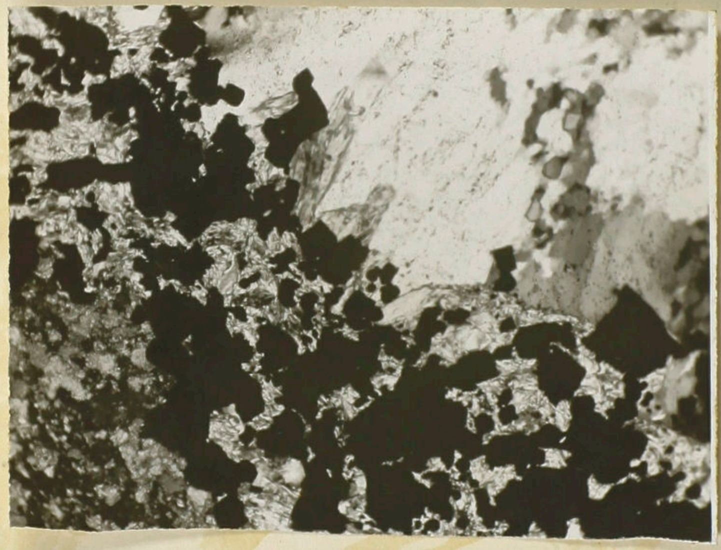


Fig. 2 Specimen No. 18. Pyrite cubes (black) along crushed quartz-sericite band. Carbonates (lower left corner) and quartz (upper right corner) replaced by pyrite to a lesser degree. In quartz pyrite forms larger and better automorphic grains than in sericite-quartz band. X-nicols. X100.

with an addition of sericite. The main mineralized zone is highly silicious with a decrease in the amount of ankerite.

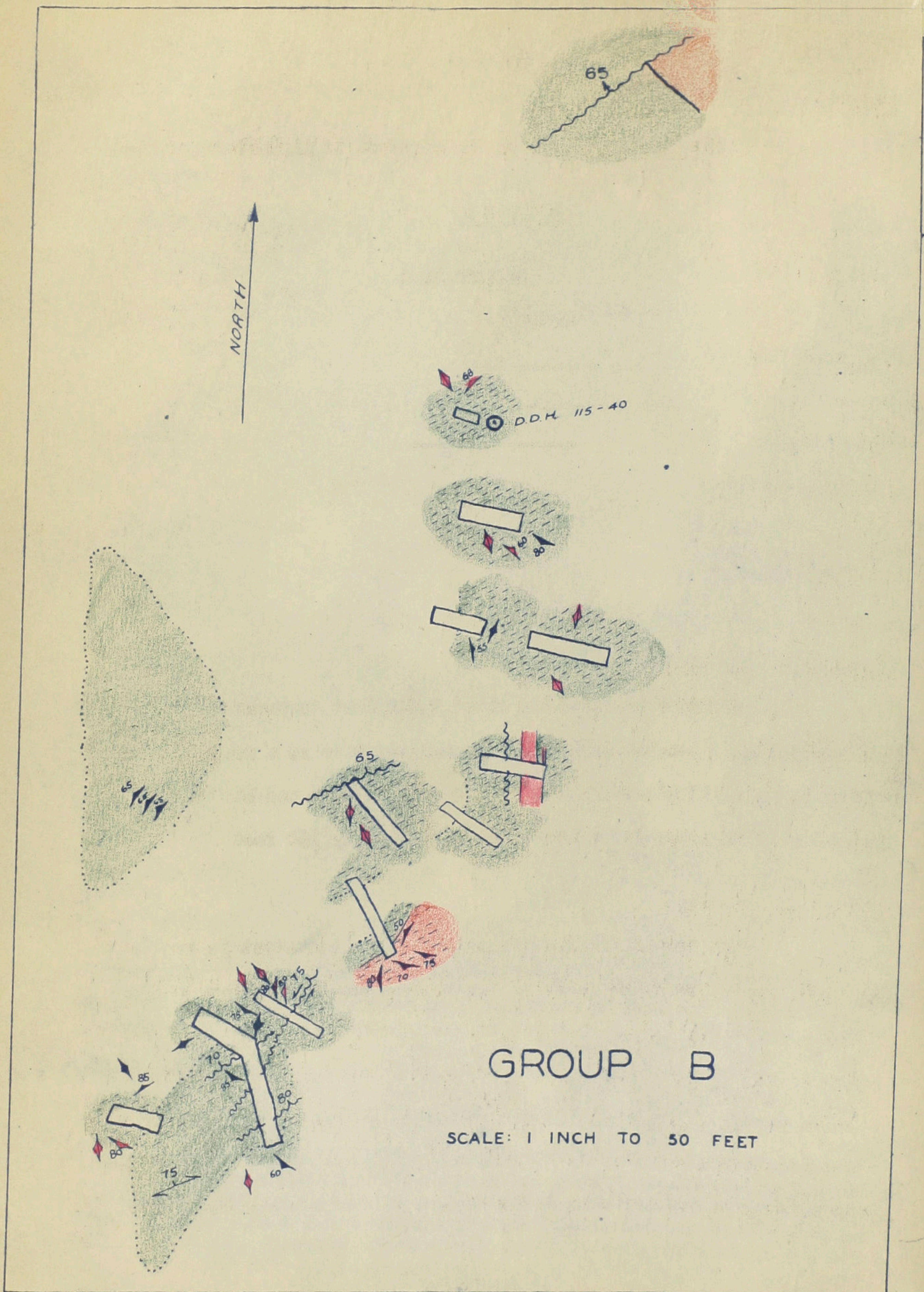
Textural relationships of the quartz and carbonates are similar to those described occurring at the Henning-Maloney Mine. The silicification and carbonatization are related, and since some of the quartz and carbonate grains have been fractured while others have not, a recurrent period of movement along the fault after the deposition of these minerals is suggested (Plate 7, Fig. 1). Sericite occurs along planes of movement and replaces crushed quartz, therefore it could have been deposited during and after the fracturing.

Examination of thin sections and a polished section (Specimen No. 18) shows that pyrite is the only sulphide present. It occurs as guided replacement (1) along shear planes and forms automorphic grains replacing quartz it forms better automorphic grains. (Plate 7, Fig. 2). Pressure shadows (2) are not present along the pyrite boundaries suggesting that the pyrite formed after the main crushing, or that the movement after pyritization was not pronounced. Where pyrite replaces sericite bands the grains show poor crystal form. This is probably due to minor stresses being capable of producing movement along these bands more easily than in the quartz, therefore hindering the formation of large pyrite cubes.

---

(1) Replacing minerals are often found along structural or textural features that would naturally be expected to guide penetrating solutions, such as fractures, bedding planes, schistosity, contact between mineral grains of the same or different species, mineral cleavages, and mineral partings and twinning planes. Minerals in this mode may be described as occurring as guided replacement (Bastin, 1950, p. 33).

(2) Pressure shadows are borders of any mineral partly surrounding or surrounding crystals of pyrite, arsenopyrite, or any other mineral that would fracture rather than recrystallize under strain. The minerals forming these borders usually show a preferred orientation with respect to the faces of the crystal which they border. (Plate 8, Fig. 2).



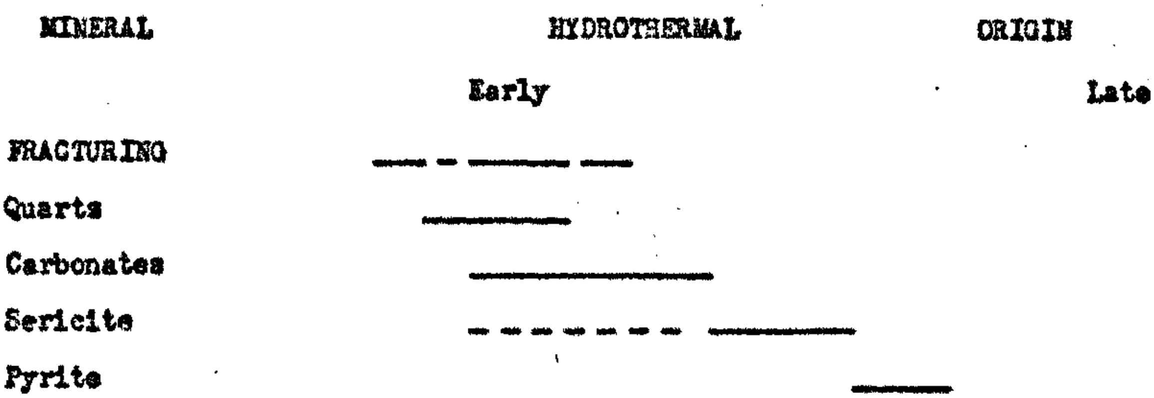
GROUP B

SCALE: 1 INCH TO 50 FEET

Paragenesis

The following diagram shows the sequence of mineral deposition.

DIAGRAM 2



GROUP B

Location and Development

The Group B trenches are about 2,500 feet southeast of the southeast end of Douglas lake. The mineralized zone is a continuation of the north fault mineralization of the Group A map, and has been explored by 11 trenches for a length of approximately 350 feet.

Geological Setting

Two en echelon faults are present. The southwest fault is a continuation of the north fault of the Group A map, and it cuts across massive or amygdaloidal andesite and andesite flow breccia. These volcanic rocks strike at north 25 degrees west and there is a suggestion of pillows facing southwest. A dike of feldspar porphyry is cut off by this fault and is seen only on the southeast side of the fault. This southwest fault does not continue to the northeast, but another fault, 250 feet to the northwest trending at north 53 degrees east and dipping 65 degrees northwest, does continue and follows a contact between granodiorite to the southeast and volcanic rocks to the northwest. There are two sets of subsidiary faults. One set parallels the main faults and strikes at north 53 degrees east, and dips from 65 to 80 degrees northwest. The main southwest fault may be represented by these minor faults, or anyone of them may be the main fault. Another fault set varies in strike from north to north 30 degrees east and also varies in dip from vertical to 75 degrees southeast. The two sets of subsidiary faults occupy the position between the two main en echelon faults, and all of the exploration work has been conducted on the subsidiary faults and on the main southwest fault.

Three sets of joints are present. One set strikes north 30 degrees west and dips vertically or steeply southwest, a second set strikes about north 60 degrees west and dips from 60 to 80 degrees southwest, and the third set strikes north to slightly east of north and dips vertically to 50 degrees west.

The wall rock is cut by quartz stringers varying in width from 1/16 to ½ inch. A vein up to 10 feet wide is also present. Most of the stringers occupy the joints which strike north 30 degrees west.

Mineralization

The following table shows the percentage of minerals in the altered wall rock and in a mineralized quartz vein.

TABLE 4

MINERAL	WALL ROCK Specimen No. 30 (a)	VEIN Specimen No. 30(b)
Quartz	10	96
Carbonate	69	-
Plagioclase	10 (unalt) (An8)	-
Sericite	10 (from plag alt.)	tr
Opaque	tr	3

The andesite wall rock is altered to a light grey, dense, cherty rock by hydrothermal solutions which deposited quartz, carbonate, sericite, and metallic minerals. The wall rock is also cut by quartz-ankerite stringers. Weathering of the ankerite stains the rock to a rusty color. Carbonates replace the wall rock most easily and, depending on the degree of alteration, they are present for varying widths along the strike of the zone. Textural relationships of the quartz and carbonate are similar to that occurring at the Henning-Maloney Mine, t[illegible] and [illegible]e silicification and carbonatization are probably related. Carbonate stringers across quartz and carbonate grains indicate that there was recurrent movement after the period of carbonatization and silicification with more carbonates being deposited. Sericite replaces carbonate and quartz, but its initial period of deposition cannot be determined and it may have commenced during the period of silicification.

The metallic minerals consist of pyrite, galena, sphalerite,

PLATE 8

Fig. 1 Specimen No. 30(b). Pyrite cubes and pressure shadows formed in quartz. Orientation of pyrite cubes and alignment of pressure shadows. X-nicols. X100.

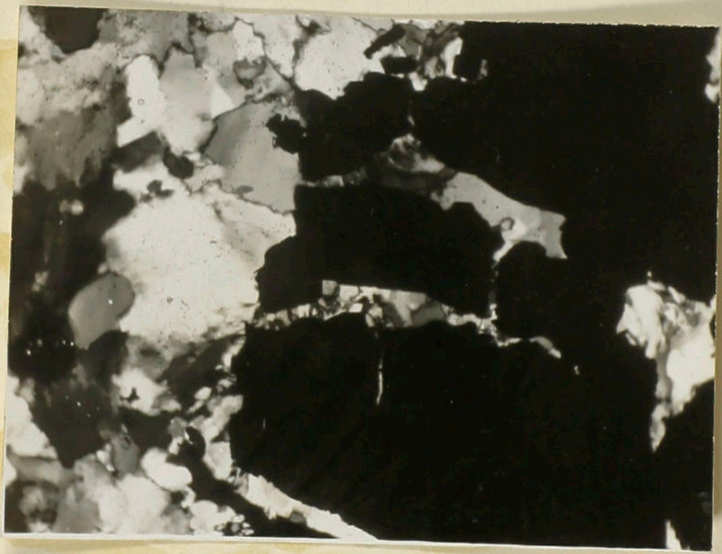


Fig. 2 Specimen No. 35(a). Arsenopyrite grains (black) fractured and quartz recrystallized within fractures. Sutured textures of quartz grains (left side of micrograph) indicates crushing and recrystallization. X-nicols. X100.

chalcopyrite, and native gold. Sphalerite was only observed in the hand specimen and not in the polished section. Native gold was detected only by the microscopic examination of polished and thin sections of the wall rock.

Pyrite occurs as well developed cubes with striated sides. The cubes range in size from 0.01 to a maximum of 0.6 millimeter, with an average of about 0.1 millimeter. The pyrite occurs in the fine-grained silicified wall rock and not in the coarse-grained quartz stringers. Pressure shadows surrounding pyrite grains show recrystallization of the quartz after pyrite was deposited. The pyrite crystals and related 'pressure' shadows show a preferred orientation. (Plate 8, Fig. 1). Cubes of pyrite are also deformed thus indicating post-pyritization movements. There is evidence of quartz replacing pyrite, probably during the time of recurrent movement, as this was the last period of quartz recrystallization and pyrite fractured by the stresses would be easier to replace than at any other time.

Galena was readily visible in the hand specimen, but only very minor amounts were seen in the polished section. Here the galena replaces pyrite.

Sphalerite, visible in the hand specimen, was not seen in the slide, but by inference, it probably formed prior to the chalcopyrite and after the pyrite and galena.

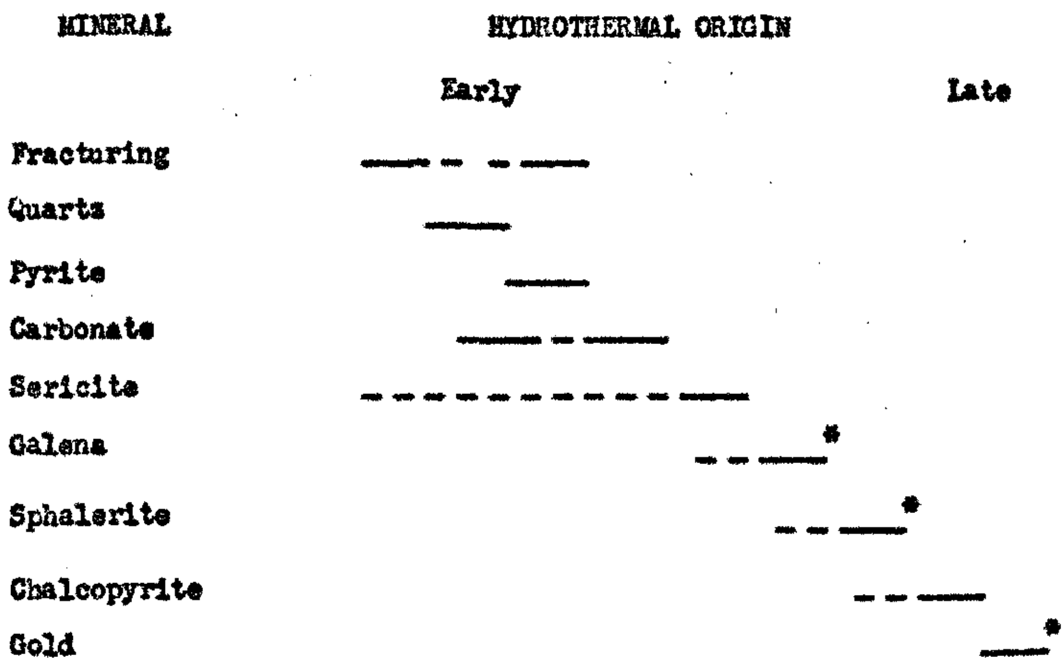
Chalcopyrite occurring in very minute amounts replaces the pyrite and is also present along fractures in the quartz.

The age relationship of the gold was not determined as it occurs in minute quantities, and is only in contact with quartz. However, by comparison with gold deposits in other areas, it may be inferred to be the youngest metallic mineral deposited in this mineralization.

Paragemesis

The following paragenetic diagram illustrates the sequence of mineral deposition as determined by microscopic examination.

DIAGRAM 3



* Age relationships inferred.

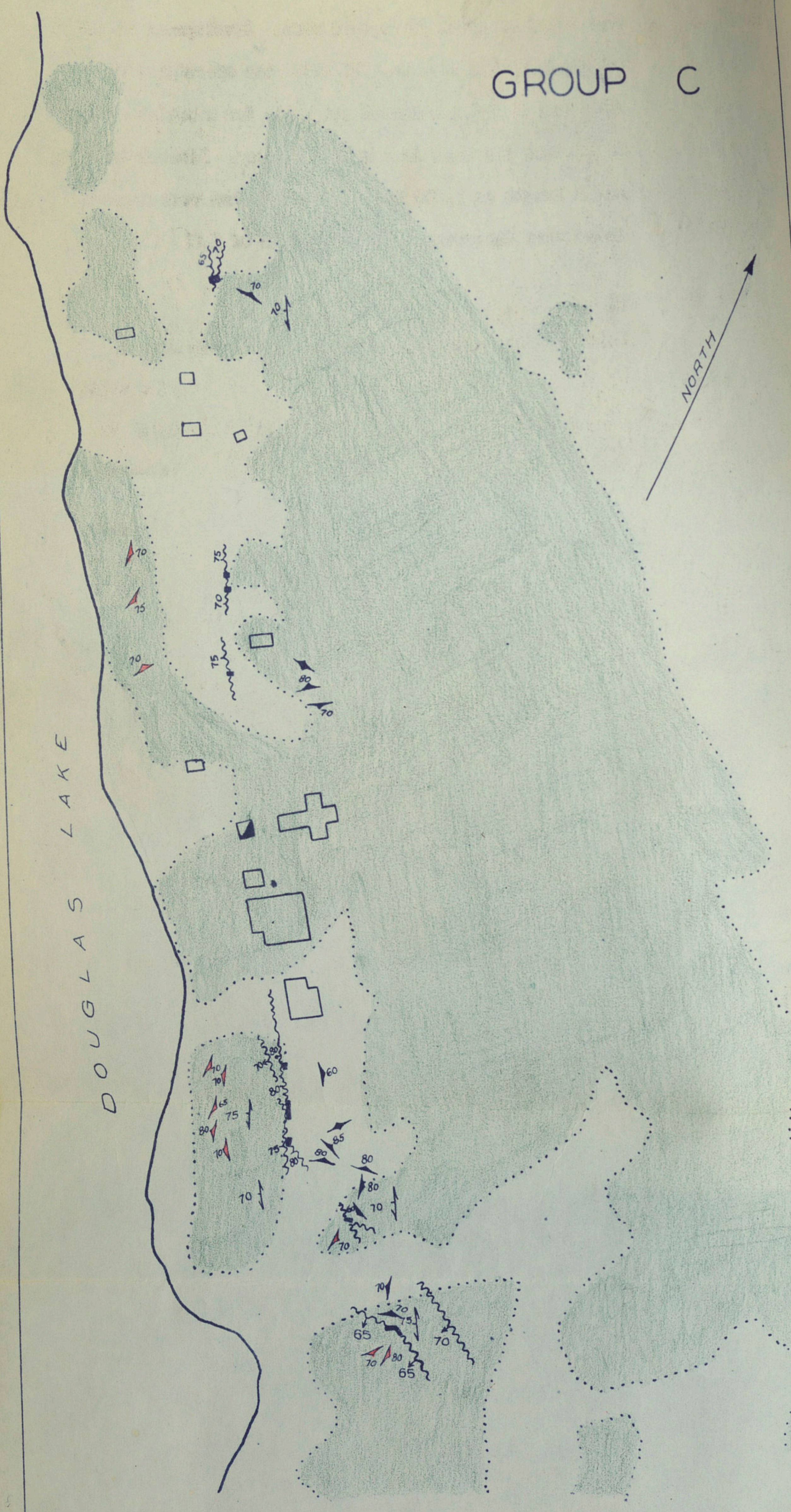
GROUP C

Newcor Mine

Location and Development

The Newcor Gold Mine is about 3½ miles southwest of Flin Flon and lies several hundred feet east of Douglas lake as shown on Map I.

GROUP C



NEWCOR MINE

SCALE: I INCH TO 200 FEET

The operation consisted of mining a quartz-arsenopyrite vein which has a general trend of north 32 degrees west. Development of the mine extended to a depth of 410 feet in 1947 when the operations were forced to close down due to the low demand and price for arsenic. Considerable exploration work has been done by the company. Diamond drilling was conducted along a length of 1,000 feet. Nine trenches were mapped by the writer; these were distributed along a length of 2,000 feet.

Geological Setting

A fault zone striking north 32 degrees west and dipping 65 to 85 degrees southwest intersects basic flow breccia and andesite which is locally amygdaloidal. The strike of the volcanic rocks is north 35 degrees west and they dip about 70 degrees southwest. The fault cannot be traced for any distance either to the north or south of the mine. To the south it branches to the west and east. The west branch fault strikes north 42 degrees west and dips 70 degrees southwest. The branch to the east trends south 60 degrees east and dips 65 to 70 degrees southwest. Further to the southeast another fault parallel to and 80 feet to the northeast is present. Branch faults at north 85 degrees east occur along these faults.

Three sets of joints are apparent. One set strikes east-west and dips steeply to the north or is vertical. A west of north trending joint set dips vertically or steeply in either direction. The third set strikes east of north and also possesses a varying dip in either direction or is vertical.

A lenticular vein up to 30 inches wide, consisting of quartz interbanded with sulphides and altered wall rock inclusions, occurs in and parallels the fault zone. Quartz stringers are also present and occur in three directions. Two of the directions correspond to the east of north and west of north trending joint sets, while the third set of quartz stringers strikes north and dips steeply to the east.

Mineralization

The following Table shows the approximate percentages of the minerals present in the altered andesite and in the vein.

TABLE 5

<table>
<tr><th rowspan="2">MINERALS</th><th colspan="2">ALTERED ANDESITE</th><th colspan="2">VEIN</th></tr>
<tr><th>#35(b)[1]</th><th>#36(b)</th><th>#36</th><th>#35(a)</th></tr>
<tr><td>Chlorite</td><td>30</td><td>30</td><td>8</td><td>tr</td></tr>
<tr><td>Quartz</td><td>20</td><td>44</td><td>75</td><td>84</td></tr>
<tr><td>Carbonate</td><td>7</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Plagioclase</td><td>10 (unalt.)</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Saussurite</td><td>32 (80% of total feld)</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Sericite</td><td>med.</td><td>20</td><td>12</td><td>3</td></tr>
<tr><td>Sulfides</td><td rowspan="2">tr</td><td rowspan="2">6</td><td>tr</td><td>tr</td></tr>
<tr><td>Arsenopyrite</td><td>4</td><td>12</td></tr>
</table>

(1) Specimen number.

In the southern-most trench (Map Group C), a vein of vuggy quartz up to 18 inches wide occurs in the fault zone. Massive sulphides are not present, but pyrite is disseminated along the shear planes of the wall rock. In the trenches to the north, stringers of massive sulphides up to several inches wide are associated with the quartz vein. Disseminated sulphides are also found in the vein quartz.

The wall rock is silicified and cut by quartz stringers apart from the main quartz-sulphide vein. Ankerite and calcite are associated with some of the quartz stringers and are confined to them. The main alteration consists of chloritization and sericitization, but with increasing silicification chlorite and sericite decrease in amount.

Masses of chlorite and sericite are prevalent replacing fractured quartz. Penninite comprises the majority of the chlorite. The chloritization and sericitization probably date back to the commencement of the period of replacement. There is always a certain degree of chloritization and sericitization in weakly metamorphosed rocks indicating that rocks are very susceptible to this type of alteration. Therefore, it is reasonable to assume that chloritization and sericitization date back to the outset of alteration caused by hydrothermal solutions. From textural relationships, chloritization ended before the sericitization as sericite replaces the chlorite.

Carbonates are not visible in the thin sections of highly mineralized quartz veins, but are present in hand specimens of this quartz. Their distribution must therefore be local, and since they are associated with quartz stringers and veins, they were probably deposited with the quartz. Minor amounts of carbonates are present in a thin section of altered wall rock, and replace chlorite and sericite. Since the main carbonatization was probably deposited with the quartz prior to the main chloritization and sericitization, a second period of carbonatization is suggested by the carbonate replacing chlorite and sericite.

Arsenopyrite is confined to the quartz vein and does not appear in the wall rock. The arsenopyrite forms automorphic grains which replace

PLATE 9

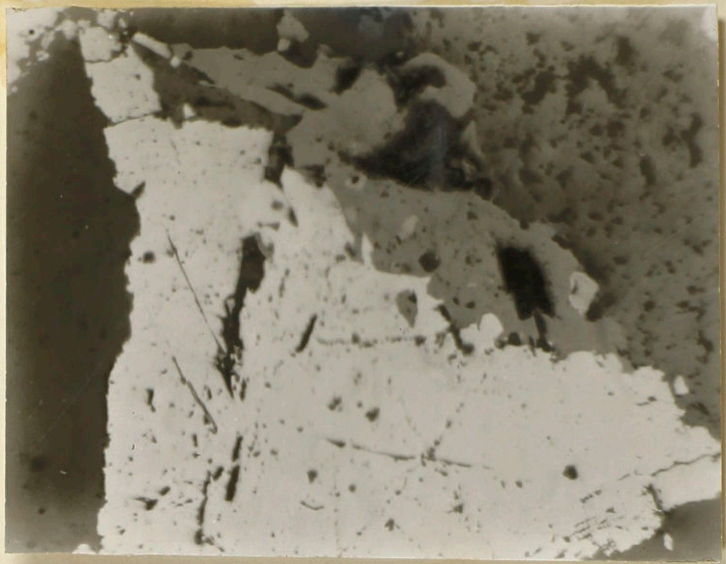


Fig. 1 Specimen No. 42. Sphalerite (medium grey) replacing arsenopyrite (light grey). Inclusions of chalcopyrite in sphalerite. (Dark grey to black is quartz). Plain reflected light. X132.

Fig. 2 Hand specimen of arsenical gold ore. Banding of arsenopyrite and quartz. The wide arsenopyrite band grades from fine-grained on left to coarser-grained on right. Plain light. 3/5 size.

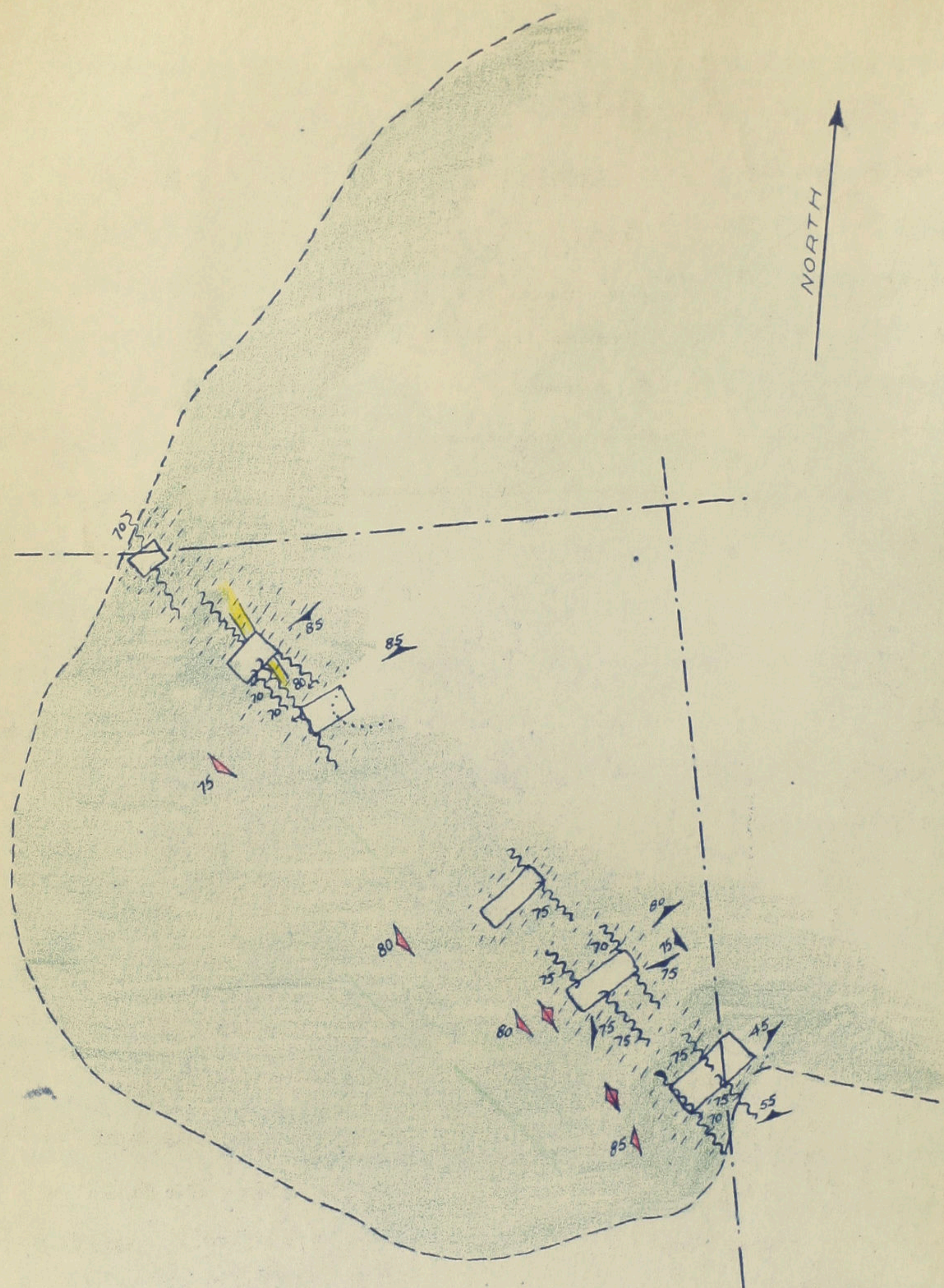
the quartz and contain unstrained quartz inclusions. Many of the arsenopyrite grains are fractured and quartz has recrystallized within the fractures and around the arsenopyrite grains. (Plate 8, Fig. 2). This indicates that the arsenopyrite was deposited with the quartz and replaced the quartz mostly before and during a period of recurrent movement. Since most of the arsenopyrite crystals are fractured, there was little or no arsenopyrite deposited after the stresses waned.

The arsenopyrite is replaced by minor amounts of other sulphides. Pyrite replaces arsenopyrite irregularly and its presence along fractures shows that it was deposited after the period of fracturing. Stringers of sphalerite cut across arsenopyrite, and sphalerite also replaces pyrite irregularly. The sphalerite shows later replacement by chalcopyrite (Plate 9, Fig. 1). Gold was not visible, but its presence has been proven by the mining operation and it is known to be associated with the arsenopyrite.

The arsenical gold ore shows a banded appearance under both megascopic and microscopic examination. An interbanding is seen between arsenopyrite and quartz. The arsenopyrite also shows gradation from fine-grained on one side of the band to coarse-grained on the other. (Plate 9, Fig. 2). Microscopically, bands of pyrite and sphalerite are also present. The sphalerite bands occur where the fine-grained arsenopyrite is in contact with the quartz band.

Paragenesis

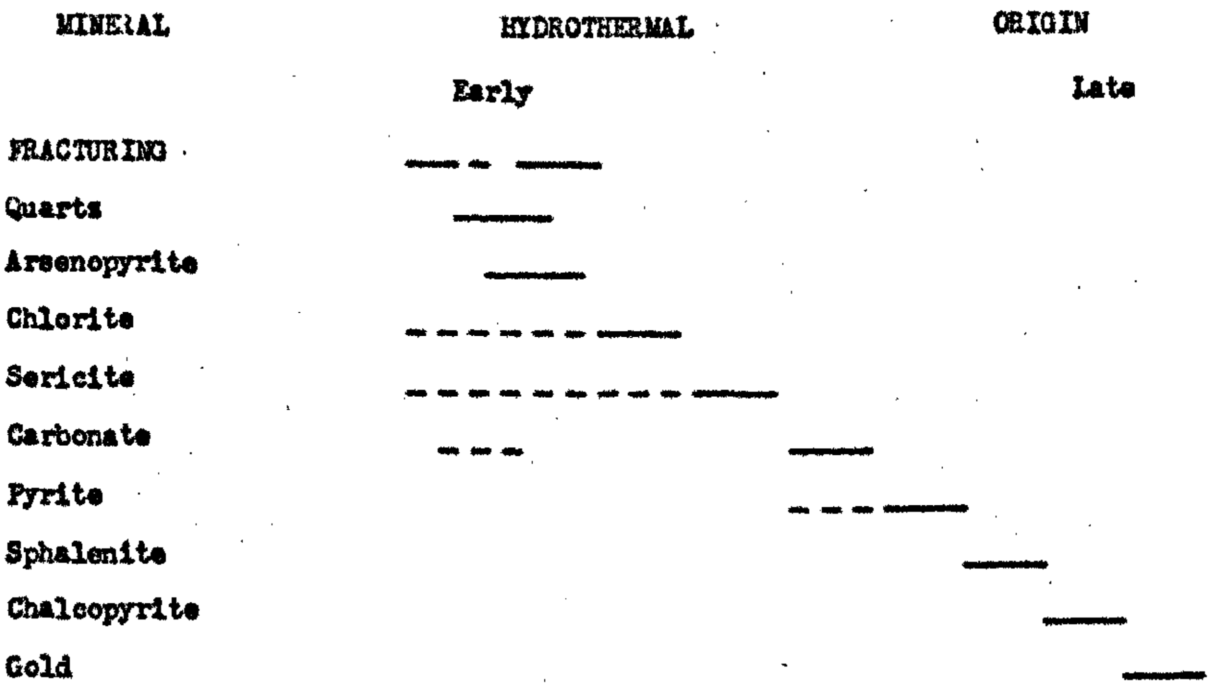
The following paragenetic diagram illustrates the sequence mineral deposition as determined by microscopic examination.



GROUP D

SCALE: 1 INCH TO 50 FEET

DIAGRAM 4



GROUP D

Location and Development

The Group D trenches are about 2,400 feet east of the Newcor Mine and between Douglas and Phantom lakes as shown on Map I.

A fault zone trending north 45 degrees west has been explored by six pits over a length of approximately 250 feet. The fault zone has not been traced to the northwest or the southeast as the outcrop is surrounded by a muskeg.

Geological Setting

The fault zone occurs in volcanic rocks which are part of a large belt of the Amisk group extending from approximately near the Second Meridian east to Phantom lake and north towards Flin Flon. The outcrop traversed by the fault zone consists mainly of amygdaloidal andesite and andesite breccia with interbanded rhyolite or dacite. The light colored rhyolitic or dacitic interbands are massive and may either be flows or intrusive equivalents. The width of the acidic bands could not be measured as they pass gradationally and irregularly into more basic and darker volcanics. At the southern and western part of the outcrop, rhyolitic or dacitic bands are more prevalent and occur in equal or greater abundance than the andesite with which they are interbanded. To the north, however, the more acidic bands progressively diminish in abundance and are absent at the north end of the outcrop. The fault zone occurs on the southwestern part of the outcrop and cuts across the volcanics where the acidic bands are present.

The fault zone consists of several parallel faults which strike north 45 degrees west and dip 70 to 80 degrees southwest. One fault at the south end of the zone dips 70 degrees northeast. The parallel faults together with variously altered and unaltered wall rock between them comprise a zone up to 20 feet wide. The width varies along the length of the zone depending on the number of parallel faults present. The location of the faults within the zone is marked by intensely altered schistose volcanics mineralized by sulphides and quartz.

Two sets of joints have been recognized. One set strike east of north, is perpendicular to the fault zone, and dips steeply both ways. Another set of joints strike west of north up to an angle parallel to the fault zone and dips 75 degrees in both directions.

Mineralisation

The percentage of minerals occurring in the altered volcanics and in the mineralised zones is given in the following table.

TABLE 6

MINERALS	Altered Wall Rock Specimen Nol 37(a)	Vein Specimen No. 37(b)	Sulphides Specimen No. 38
Chlorite	1	2	tr
Quartz	40	78	34
Carbonate	-	tr	tr
Saussurite	-	3	-
Sericite	54	14	tr
Epidote and Zoisite	3	tr	-
Opaque	2	2	64

Carbonatization is negligible, but silicification is quite intense in the wall rock as shown by Specimen No. 37(a) in the above table. The quartz in the wall rock is fine-grained and its presence can only be suspected by the increased brittleness and hardness of the rock. Quartz occurs in two ways: (1) As stringers in the altered wall rock adjacent to the intensely schistose rock marking the zone of movement, and (2) as veins within the zone of movement. Sericitization is intense in the wall rock and chlorite occurs only in minor amounts. Epidote and zoisite characterize the altered wall rocks and replace the quartz along the crushed bands. The chlorite of the variety penninite surrounds and replaces the epidote and zoisite. Carbonate occur-

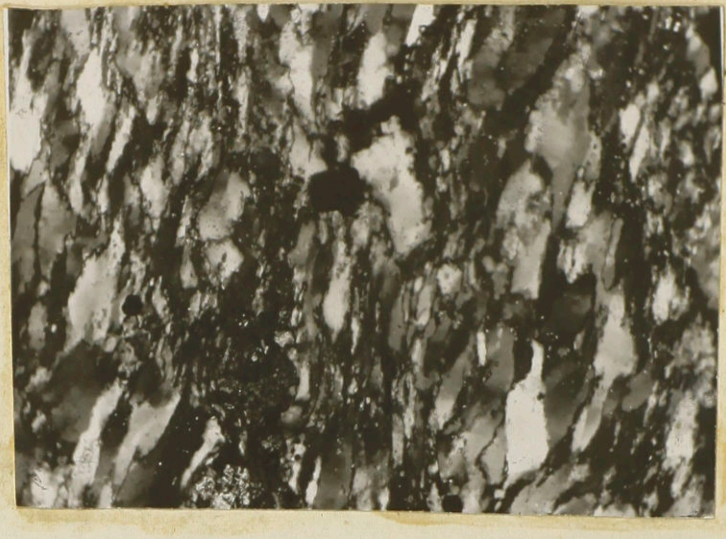


Fig. 1 Specimen No. 37(b). Quartz as lens shaped grains due to movement. Sericite (fine greyish-white specks) along planes of movement. Epidote, zoisite and carbonate (rounded, dark grey bodies in lower left third), and sulphides (black), also along planes of movement. X-nicols. X100.

Fig. 2 Specimen No. 38. Pyrite forming automorphic grains in quartz. Plain reflected light. X132.

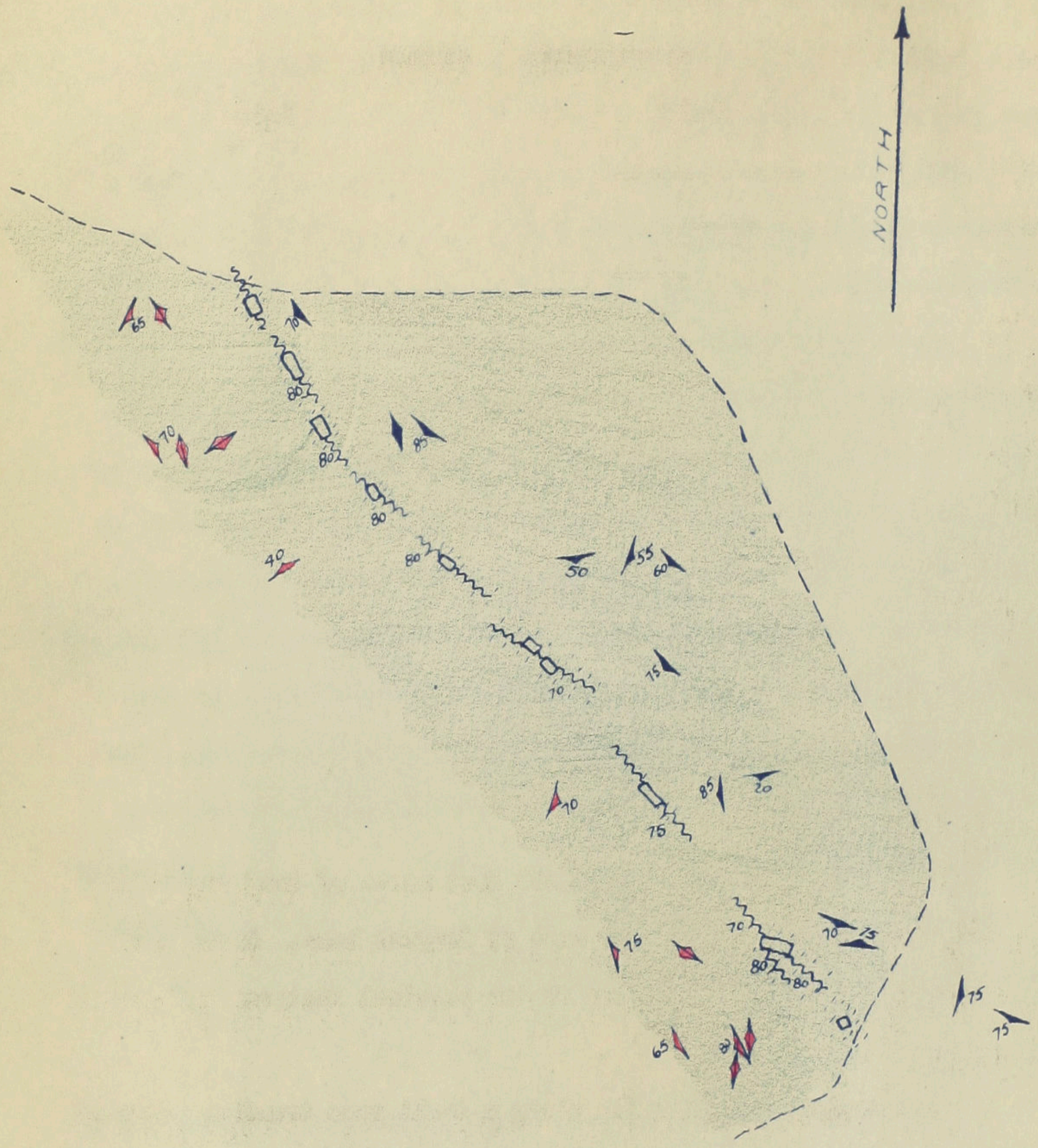
ring in traces also replaces the epidote and is replaced by the chlorite. Sericite laths definitely replace irregular bodies of chlorite and also replace quartz along fractures.

Sulphides occur disseminated through the altered wall rock and as stringers associated with vein quartz which parallels the shearing. Some massive sulphide stringers are up to 6 inches wide.

Microscopic observation of polished sections shows that the sulphides consist of pyrite, pyrrhotite, and chalcopyrite. (Plate 10, Fig. 2). Pyrite is most abundant and shows automorphic crystallization. Pressure shadows of recrystallized quartz surround the pyrite cubes and suggest that the rock was under stress after the pyrite was deposited. The pyrrhotite and chalcopyrite replace pyrite irregularly. Pyrrhotite occurs only in traces, and chalcopyrite though more abundant is also present in small amounts. Chalcopyrite replaces the pyrrhotite. The age of pyrite replacement by chalcopyrite and pyrrhotite relative to chloritization and sericitization, is not known, and it may be inferred from other mineral deposits that the pyrrhotite and chalcopyrite were deposited during and after the chloritization and sericitization.

Paragenesis

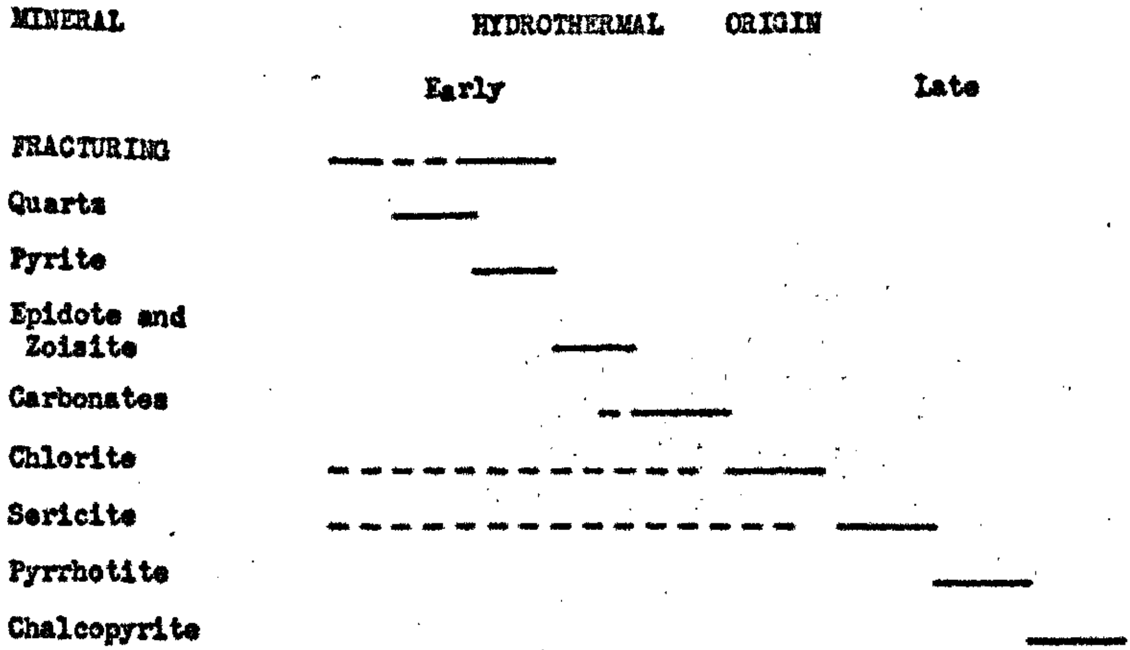
The following paragenetic diagram illustrates the sequence of mineral deposition.



GROUP E

SCALE I INCH TO 50 FEET

DIAGRAM 5



GROUP E

Location and Development

The Group E trenches are 1,600 feet north of the Newcor Mine shaft and approximately 1,400 feet east of Douglas lake. Group E on Map I shows their location relative to the physical features and geology of the area.

Ten exploration pits lie along a fault zone trending north 42 degrees west over a length of 300 feet. The zone was not traced either northwest or southeast due to the lack of immediately adjacent outcrop and the presence of muskeg.

Geological Setting

The country rock cut by the fault consists of andesite, a unit of the Amisk group of volcanic rocks. A northerly trending belt of these volcanic rocks lies between Douglas and Phantom lakes.

Mineralization is controlled by the fault which strikes north 42 degrees west and dips 70 to 80 degrees southwest. The planes of major movement are marked by zones of highly altered and schistose andesite up to 2½ feet wide, but the adjacent wall rock appears to be unaltered. A single or two parallel planes of movement approximately 5 feet apart make up the main fault zone, the width of which depends on the number of planes of movement.

Jointing occurs in approximately three directions. One set parallels the fault, a second set strikes at a large angle east of north and dips gently to the south, and the third set approximates a northerly strike and varies in dip in both directions. Two directions are common to both the joint sets and quartz stringers; the direction parallel to the fault and the other striking approximately north. Quartz stringers also occupy a third direction which trends perpendicularly to the fault zone and dips vertically or at 40 degrees northwest.

Mineralization

The following table gives the approximate percentage of minerals in the altered wall rock and in the quartz vein traversing andesite, as determined by microscopic examination of thin sections.

TABLE 7

MINERALS	Altered Wall Rock Specimen No. 40(b)	Quartz Vein Specimen No. 39	Quartz Vein Specimen No. 40(a)
Quartz	10	85	86
Chlorite	15	-	tr
Carbonate	10	-	5
Plagioclase	20 (altered) (An30)	-	-
Hornblende	40	-	-
Epidote and Zoisite	5	-	-
Saussurite	(extreme)	-	-
Opaque	-	15	8

Mineralization is confined to the zone of intense alteration associated with the planes of movement. Locally a quartz vein is found in the highly altered rock. This quartz vein is lenticular and may possess a maximum width of 14 inches or may decrease in size to a stringer.

Sulphide mineralization occurs as disseminated replacement of the highly altered wall rock, or as massive stringers in the quartz. Where quartz is absent, pyrite stringers parallel to the fault zone still occur.

With the advent of stresses fractures were produced in the andesite along which hydrothermal solutions migrated and altered the rock by altering the original minerals and introducing new minerals. Oligoclase is extremely saussuritized and amphibole is altered to chlorite, biotite, carbonate and quartz. Quartz was introduced and a minor amount of carbonate is associated with this silicification. Later minor carbonati-

PLATE 11

Fig. 1 Specimen No. 40(a). Tourmaline (fuzzy and medium grey, near center) replacing quartz. The tourmaline and quartz are fractured, and sulphides (black) found along fractures in the tourmaline and between quartz grains. X-nicols. X100.

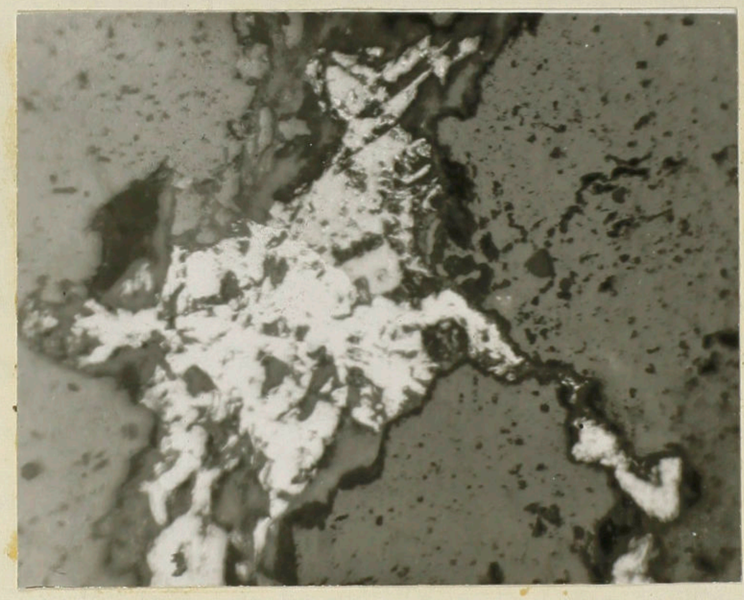


Fig. 2 Specimen No. 41. Chalcopyrite (greyish-white) and sphalerite (medium grey) simultaneously deposited. Chalcopyrite specks in sphalerite due to exsolution (quartz is dark grey). Plain reflected light. X132.

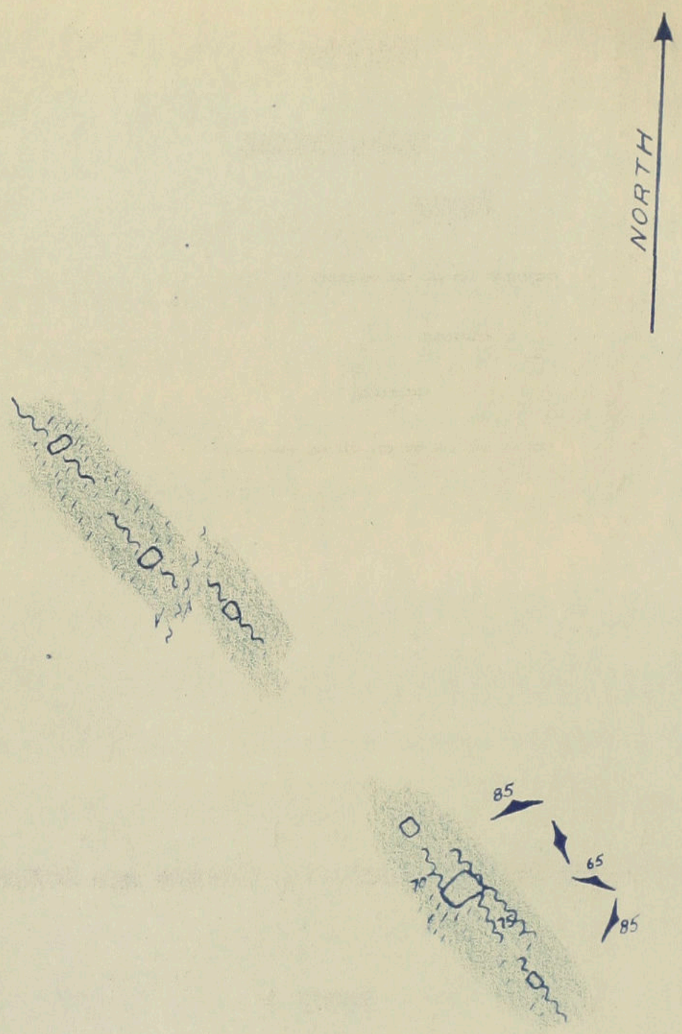
sation is shown by stringers of carbonate which formed after a period of fracturing. Chlorite, of the variety penninite, has also been introduced along stringers. Irregular masses of chlorite are replaced by rounded masses of epidote and zoisite, which occur along crushed bands. The later carbonate stringers cut stringers of chlorite.

Tourmaline was noted in one thin section. It replaces the vein quartz and in turn is replaced by sulphides. The tourmaline is fractured and strained, and therefore was probably deposited during the silicification before recurrent movement along the fault. (Plate 11, Fig. 1).

Arsenopyrite, pyrite and chalcopyrite are the only sulphides present. Microscopic examination shows that pyrite is most abundant and occurs as irregular masses replacing crushed quartz and as stringers along fractures in the quartz. Chalcopyrite is second in relative abundance and occurs in the same habit as the pyrite. There is a slight tendency for confinement of the chalcopyrite to fractures. It also replaces the pyrite in irregular masses. Arsenopyrite was not observed in the polished section, but is present in the hand specimen, and by comparison with other deposits where arsenopyrite occurs, it is probably the oldest sulphide.

Paragenesis

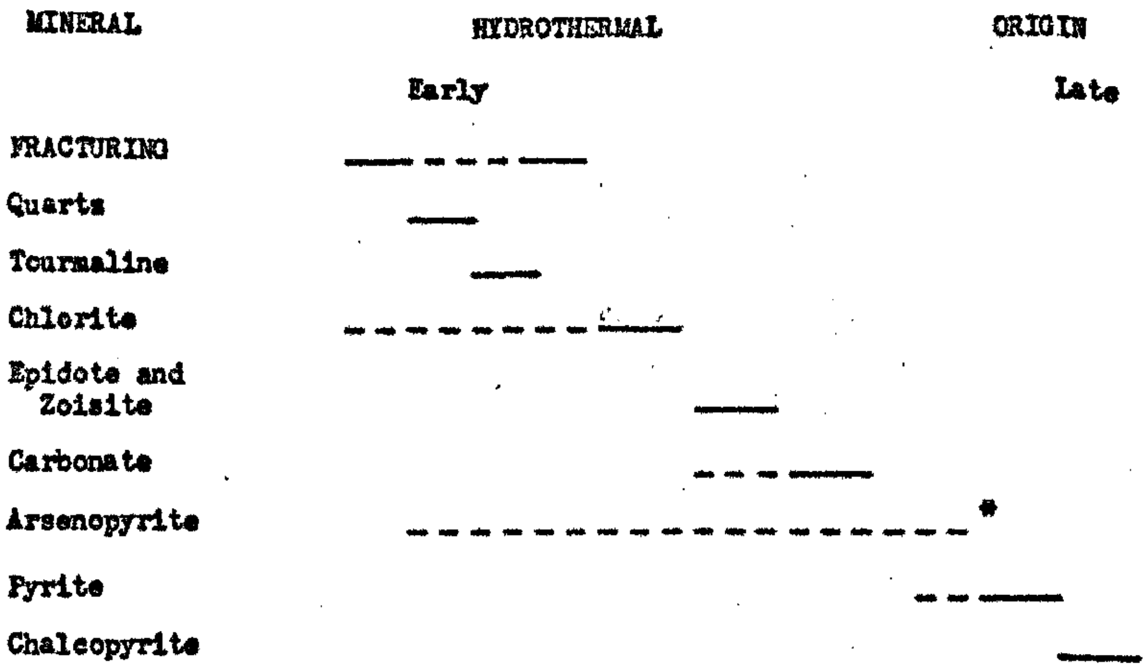
The following diagram illustrates the sequence of mineral deposition.



GROUP F

SCALE : 1 INCH TO 50 FEET

DIAGRAM 6



* In hand specimen only, therefore relative age inferred from other deposits.

GROUP F

Location and Development

The Group F pits are 175 feet southwest of the south shore of Bomber lake. Bomber lake is half a mile southwest of the village of Creighton and north of the Beaver Lake highway as shown on Map I.

Group F consists of six small pits which lie along a fault zone trending north 40 degrees west. The fault zone extends over a length of 225 feet and then the fracturing decreases in intensity and gradually fades out along strike. Exploration work was conducted along the highly sheared zone.

Geological Setting

Mineralization occurs in andesite of the Amisk group of volcanic rocks. The andesite is part of a belt of volcanics lying west of Flin Flon.

The mineralization is structurally controlled by the fault trending north 40 degrees west and dipping vertically to 70 degrees southwest. This zone appears to be offset to the left at about 60 feet from the north end by a possible fault. Another explanation for this left-hand offset is that there are two en echelon zones present.

Mineralization

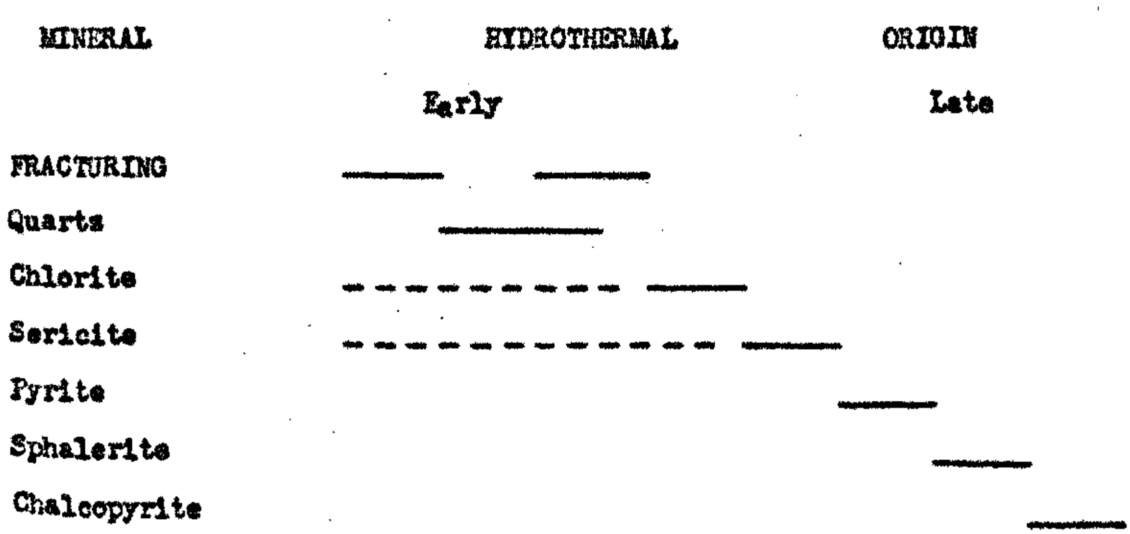
Quartz and sulphides occur in highly altered and schistose andesite which marks the zone of fault movement. The quartz occurs as a lenticular vein ranging up to 30 inches wide. Two varieties of quartz are present. One is coarse-grained and white, the other is fine-grained and cherty-looking. The two types grade into one another. The coarse-grained variety is mineralized by pyrite cubes up to 3/16 of an inch. The cubic pyrite may occur as disseminated crystals or as massive bodies in the fractured quartz. Stringers of massive pyrite are also found parallel to the fault surface. In the fine-grained quartz the pyrite is also fine-grained and does not show crystal form to the same degree as in the coarse-grained quartz. Molybdenite also occurs in the dense quartz but is not present in the coarse variety.

Microscopic examination of a thin section and a polished section of the mineralized quartz shows 95 per cent quartz, 4 per cent sericite, 1 per cent chlorite and a trace of metallic minerals. The quartz grains are fractured and possess sutured boundaries. The larger grains of quartz show recrystallisation along their boundaries. Chlorite occurs along the crushed quartz boundaries and is replaced by sericite and sulphides. Sericitization is patchy and appears to have proceeded during the fracturing period and also after the crushing. The sulphides consist of pyrite, chalcopyrite and sphalerite. Pyrite occurs in a few large masses, usually along fractures as has been described megascopically. Chalcopyrite is most abundant, and it occurs as irregular masses and along fractures in the quartz and as irregular replacements of pyrite. Sphalerite is associated with and was probably deposited at the same time as the chalcopyrite. The chalcopyrite, however, was deposited over a greater time range as it is seen to replace the sphalerite by fine irregular haphazardly located bodies. (Plate 11, Fig. 2).

Paragenesis

The following diagram illustrates the sequence of mineral deposition.

DIAGRAM 7



DION LAKE COPPER

Location

The Dion Lake shaft is approximately 800 feet west of the north end of Dion lake as shown on Map I.

Geological Setting

A shaft seven feet square and of unknown depth has been sunk in granodiorite. The granodiorite is part of a mass of Stockwell's (1946) younger intrusions lying west of Phantom lake and east of Bootleg lake. This granodiorite is cut by a dike of Kaminis porphyry south of the shaft.

The east side of the shaft is bounded by closely spaced slips striking north 50 degrees west and dipping vertically. Striae indicate a horizontal movement. Two sets of joints along which there has been movement are present on the south side of the shaft. One set strikes north and dips vertically, the other strikes north 50 to 65 degrees east and dips 70 to 85 degrees northwest. Fifty feet west of the shaft the Kaminis dike has been displaced 3 feet to the right along a plane striking north 15 degrees east and dipping 60 degrees west.

Mineralization

Mineralization is confined to a fracture zone in the granodiorite. The Kaminis porphyry dike intruding the granodiorite south of the mineralization is not as highly fractured nor is it altered or mineralized. The following table shows the approximate percentage of minerals present as the alteration of the granodiorite progresses.

TABLE 8

	Unaltered Granodiorite #391	Altered Granodiorite #392	Ore #393
Quartz	25	35	30
Chlorite	5	tr	tr
Sericite	10	39	69
Plagioclase	34 An30 (unalt.)	-	-
K-Feldspar	20(unalt)	15	-
Biotite	5	10	-
Calcite	tr	tr	tr
Epidote and Zoisite	tr	tr	-

Alteration has changed the light pinkish-grey weathering granodiorite to a darker greenish-grey rock. The granodiorite has also decreased in grain size. Sericitization is the main type of alteration. There has been no apparent silicification other than that due to the feldspar alteration. Plagioclase feldspars have been completely converted to sericite, whereas potash feldspars remain relatively unaltered. A similar condition is described by Schwartz (1939, p 192). There is no chloritization associated with the hydrothermal alteration. Chlorite is present in the unaltered rock, but as alteration increases the proportion of lath-like biotite increases and it has been concluded that the biotite has been reconverted from the chlorite. The chlorite is probably due to deuteric alteration of original amphibole or biotite. A minor amount of carbonate is present, part of which was derived from

PLATE 12

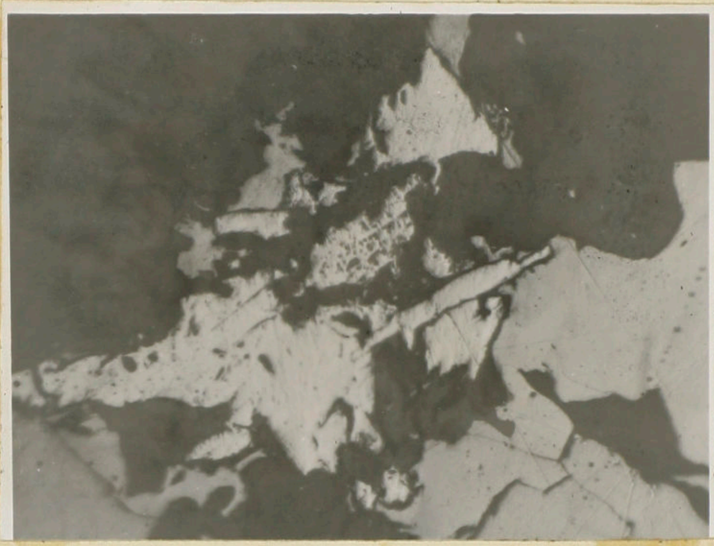


Fig. 1 Specimen No. 393. Chalcopyrite (medium grey) replacing pyrrhotite and pyrite. (Pyrrhotite and pyrite both light grey). Pyrite (as shown) appears to have aligned triangular depressions. Plain reflected light. X132.

deuteric alteration and the remainder was introduced. Epidote and zoisite associated with chlorite occur in minor quantities in the unaltered and altered rock. A deuteric alteration of feldspar and ferromagnesian minerals appears to be the explanation for their deposition.

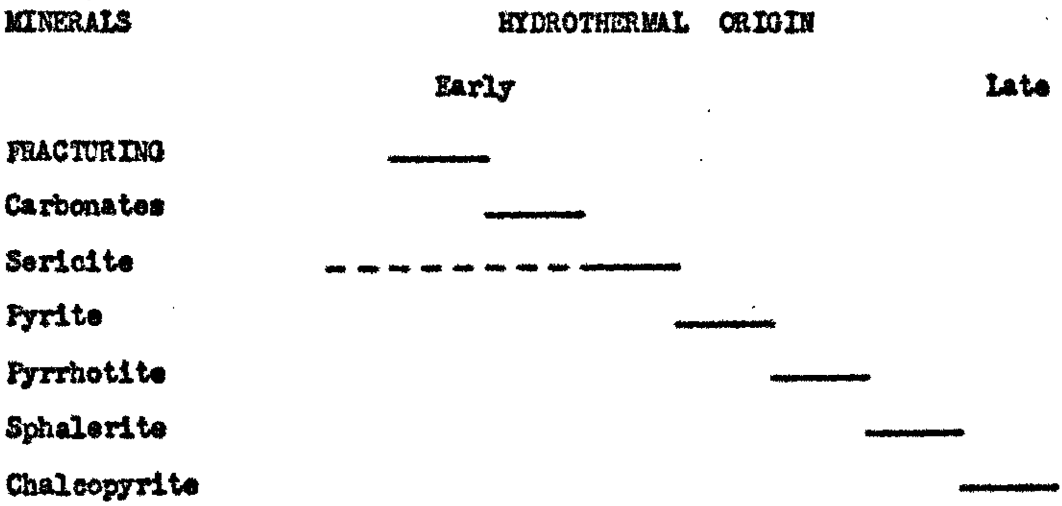
Sulphide mineralisation consists of pyrite, pyrrhotite, sphalerite and chalcopyrite. Megascopically sulphides appear to be finely disseminated throughout the rock, with greater concentrations along weak foliation planes. Microscopic study shows that chalcopyrite is the most abundant sulphide. It occurs as irregular masses and is found along fractures between and within the gangue minerals. Pyrite, pyrrhotite and sphalerite are less abundant, with pyrrhotite being relatively scarce. (Plate 12, Fig. 1).

Pyrite is the oldest and is replaced by pyrrhotite sphalerite and chalcopyrite in that order. Small masses of unreplaced pyrrhotite are found within the chalcopyrite and therefore pyrrhotite is definitely older. Two explanations for the relative ages of sphalerite and chalcopyrite are possible. Fine "specks" of chalcopyrite occur within large masses of sphalerite. One explanation for this is that the two minerals formed simultaneously, then with later change in conditions chalcopyrite separated out by exsolution. The alternative explanation is that the chalcopyrite is younger and is replacing the sphalerite. The writer prefers the latter explanation as the chalcopyrite inclusions are too irregular and are too irregularly spaced to be explained by the exsolution phenomenon.

Paragenesis

The following diagram illustrates the sequence of mineral deposition as determined by microscopic examination.

DIAGRAM 8



DISCUSSION AND SUMMARY

Types of Deposits

Classification of the different mineral deposits into types is based on the concentration of some minerals and the absence of others. The following table illustrates the degree of abundance of these minerals in the various types of deposits.

TABLE 9

	TYPE OF DEPOSITS		Gold-Quartz-Sulphide Veins			
	Characteristic Minerals	(1) Gold-Quartz Veins	(2) Quartz-Sulphide-Carbonate Veins	(3) Quartz-Sulphide Veins	(4) Quartz-Arsenopyrite Veins	(5) Sulphide Replacement Deposit
Vein	Quartz	X	X	X	X	*
	Ankerite	-	x	-	*	-
	Calcite	-	-	*	*	*
	Chlorite	*	-	*	*	*
	Sericite	*	x	x	x	X
	Metallic Minerals	*	x	x	X	x
	Pyrite	(x)	(X)	(X)	(x)	(x)
	Arsenopyrite	(*)	-	(*)	(X)	-
	Pyrrhotite	(*)	-	(*)	-	(*)
	Galena	-	(*)	-	-	-
	Molybdenite	(*)	-	-	-	-
	Sphalerite	-	(*)	-	(x)	(x)
	Chalcopyrite	(X)	(*)	(x)	(x)	(X)
	Gold	(*)	(*)	(*)	(*)	-
Wall Rock	Tourmaline	-	-	*	-	-
	Quartz	X	x	X	x	*
	Ankerite	-	X	-	*	-
	Calcite	x	?	*	*	*
	Chlorite	x	-	*	x	*
	Epidote & Zoisite	*	-	*	-	*
	Sericite	X	x		x	X
	Saussurite	*	-	-	*	*
	Metallic Minerals	*	*		*	*

X - Mineral occurring abundantly.
x - Average abundance
* - Minor abundance
(X) - Most abundant metallic mineral
(x) - Average to minor abundant metallic mineral
(*) - Metallic mineral not occurring in all deposits and present in minor amounts, or if found in all deposits of that particular type, then occurs in very minor amounts.

(1) Henning-Maloney Gold Mine and Group F mineralization belong to this type.
(2) North trenches of Group A mineralization and Group B Mineralization
(3) Group D and Group E.
(4) Group C, the Newcor Mine.
(5) Dion Lake copper mineralization.

There are certain limitations in the preceding table which must be realised before conclusions regarding the classification of the deposits may be made. Detail has been sacrificed in order that more important facts may be emphasised. A certain amount of exaggeration in estimating relative proportions of the characteristic minerals has been made in order that differences in the deposits may be magnified. Minerals characterizing a particular type of deposit, though not comprising the greater percentage of the minerals are listed as abundant, while others though relatively abundant are listed as occurring in minor abundance. An example of this is found in the sulphide replacement deposit making up the Dion lake copper mineralization. An approximately corresponding content of about 30 per cent quartz is present in the unaltered granodiorite and in the ore. As no marked addition of quartz is recognized, the silicification is listed as present in minor abundance.

Wall Rock Alteration

Wall rock alteration, regardless of the rock type, takes place according to a definite sequence. A few minor deviations from this general set scheme have been noted, and with the exception of carbonatization, a general rule is followed. Alteration by deuteric solutions is masked by alteration related to the later fracturing and hydrothermal solutions.

In general, deuteric alterations are caused by the action of gases and solutions present within and related to the solidified magma. As physico-chemical conditions change, the primary minerals are changed over into minerals more stable under the prevailing conditions. Ferromagnesian minerals are first reconverted into mainly chlorite, and feldspars change over into mainly sericite and calcite.

Alterations by hydrothermal solutions are due to the addition and subtraction of ions or elements, and chemical reactions resulting from the presence of residual solutions which emanate from the magmatic reservoir after intrusion of the magma. Regularities in the metasomatism noted consist of chloritisation always succeeding silicification and carbonatisation, and sericitization succeeding chloritisation. Metallic mineral deposition is usually the youngest. A sequence in agreement with the one noted has been described by Lindgren (1928). In the various deposits he studied, ferromagnesian minerals were propylitized, and with increasing intensity of alteration, chlorite is replaced by sericite. Quartz though a stable mineral may be sericitized and chloritized. G. M. Schwartz (1939) made a study of hydrothermal alteration of igneous rocks and he also reviewed other literature on the subject, and noted a similar sequence.

This is only a general pattern and is not strictly adhered to in every deposit studied, but a certain degree of agreement is present in all the deposits. This sequence of final deposition does not mean that the introduction of the alteration minerals mentioned was all post-silicification. It both pre-dates and post-dates silicification, but silicification has been superimposed on the prior alteration and only the final period of deposition is observed. A fact worthy of note is the short period of silicification relative to the other periods of alteration.

So far the discussion has been only descriptive, not explanatory. Literature published on wall rock alterations is also mostly descriptive. To explain why a particular alteration sequence is present in particular types of rock is a research problem in itself and will not be discussed.

The explanation must ultimately depend upon thermodynamic considerations, the energy changes involved in assembling ions of differing size and change in particular crystal lattices, and the effect of their concentration in the mineralising solutions and in the solid minerals.

Origin of the Mineral Deposits

In the formation of metallic mineral deposits two factors are of major importance; (a) the origin of the mineralising solutions, and (b) the formation of fissures along which solutions travelled and where they deposited the minerals. Upon these two factors also depends the age of the mineralisation.

There is a general agreement among geologists who have worked in the Flin Flon area, and among geologists who have worked in other areas where similar deposits occur, that the mineralization is related to igneous intrusion. Bruce (1918) based his conclusion on the fact that there is muscovite (sericite) and tourmaline in the deposits. These minerals could not have been derived from basic volcanic rocks that surround some of the mineral deposits, as these rocks lack the necessary radicals or elements for the formation of these minerals. Tourmaline and muscovite are usually associated with intrusions, therefore the presence of these minerals in metallic mineral deposits indicates the deposits are related to igneous intrusions. He also states as evidence that the mineralization occurs a short surface distance away from intrusive bodies, and that the vertical distance to the intrusion is probably less.

There are two possible igneous sources for the mineralizing solutions. The solutions may have originated as emanations from the intrusive mass shortly after its intrusion or during its intrusion. Another possible source is the emanation of solutions directly from the parent magma reservoir. If the solutions originated from the intrusive mass then the mineralization would be related to the age of the intrusion it is associated with. However, if the solutions originated from the parent magma reservoir, then the age of mineralization cannot be ascribed to any one intrusion of the area, and may have been emplaced anytime after the first phase of the intrusions ended.

The original magmatic reservoir could easily have been the source of residual mineralizing solutions. Mineralizing solutions would be in a gaseous state within the magmatic chamber where the temperature is above the critical temperature of the residual solutions. These therefore would rapidly diffuse through the rock aided by pressure at depth till a temperature below the critical temperature is reached. The gaseous state would then change to a liquid state and would migrate until a favourable condition for deposition of minerals would be encountered.

The alternative origin for the mineralizing solutions is that they were related to the end products of the various intrusive masses in the area. Their transportation as a gas or liquid would depend on whether the critical temperature was reached. The age of mineralization would correspond to the age of a particular intrusion.

Regardless of whether the mineralizing solutions originated from the original magmatic chamber or as emanations from a cooling intrusive mass, the deposits are related to igneous activity and have been deposited during a definite age. The variability of mineralization would primarily be controlled by the physico-chemical conditions prevailing.

Fissures are important in the control of mineral deposition. Mineralisation in fissures has been noted in the Amisk group of volcanic rocks and in fissures cutting the post-Missi intrusions. Fissures mineralisation can only be dated relative to the post-Missi intrusions, as recurrent movement along old faults related to the Amisk group folding may also take place due to stresses set up during and after the period of intrusion.

Two general trends of faults are apparent with probably different ages of mineralisation associated with them. Fissures trending west of north tend to be pre-Kaminis granite. Stockwell (1946) noted that a Kaminis granite dike cut the arsenopyrite vein at the Newcor mine. The writer however, saw a Kaminis dike on the east side of the vein, but was unable to trace it across the vein due to a thick cover of overburden and mine waste rock. At Dion lake, granodiorite is replaced by sulphides, while nearby Kaminis granite is unaltered and less fractured. Fissures trending east of north tend to displace Kaminis granite dikes. Kaminis dikes are displaced by fissuring in the north trenches of the Group A map area and by the faulting of the Group B mineralisation. At the Henning-Maloney mine fissures trend east of north across the dioritic facies of the granodiorite, but their age relative to the Kaminis granite is not known.

The age of mineralization may be related to the granodiorite or to the Kaminis granite. Mineralization along pre-Kaminis northwest fissures is related to the emanations from the pre-Kaminis intrusions. Northeast trending fissure mineralisation is related to either pre-Kaminis or post-Kaminis intrusions.

CONCLUSIONS

1. Two main types of mineralisation occur in the area: (A) Sulphide replacement deposits, and (B) Gold-quartz-sulphide veins. The gold-quartz-sulphide veins have been further subdivided on the basis of certain characteristic minerals into: (1) gold-quartz veins, (2) quartz-sulphide-carbonate veins, (3) quartz-sulphide veins, and (4) quartz-arsenopyrite veins.

2. Wall rock alteration and deposition of metallic minerals has taken place at intermediate to high temperatures, and has been caused by hydrothermal solutions migrating along fissures.

3. The mineralization is related to the granodiorite or to the Kaminis granite.

4. A definite sequence of deposition is present. With the exception of carbonatisation, which may be deposited at any time during the sequence, chloritization always succeeds silicification and usually carbonatisation, and sericitization succeeds chloritization. In the deposition of metallic minerals, the sulphides with the exception of pyrite and arsenopyrite, which may be deposited during the beginning of the mineralization, are the youngest. A general sequence is pyrrhotite, galena, molybdenite, sphalerite, chalcopyrite, and native gold which is the last to be deposited.

5. Table 9, summarizing the differences in the types of mineralization, shows that with the exception of silicification, carbonatization, chloritization and sericitization occur in varying amounts, either

alone or together. Since the deposits occur in rocks of approximately the same chemical composition, the type of wall rock alteration depends on the nature of the hydrothermal solutions, and onphysical conditions, such as temperature and pressure, prevailing during deposition.

LEGEND AND SYMBOLS

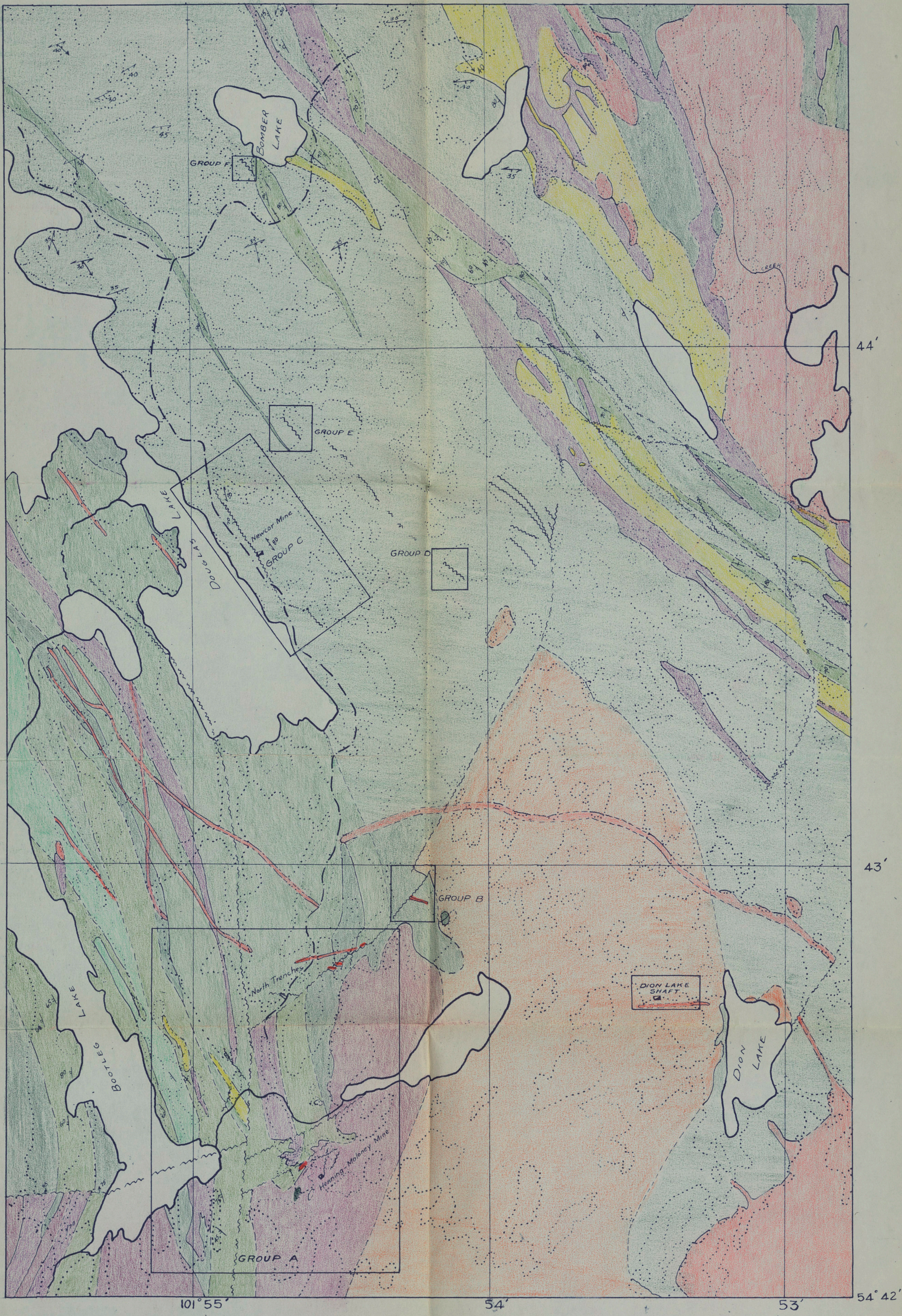
(For All Maps)

LEGEND

- Quartz veins, stringers
- Kaminis granite, porphyritic granite.
- Boundary Intrusions
- Granodiorite, quartz diorite, granite
- Diorite, gabbro (border facies of granodiorite)
- Meta-diorite, meta-gabbro, amphibolite.
- Rhyolite, quartz porphyry, quartz porphyry breccia.
- Rhyolite
- Tuff, agglomerate
- Porphyritic andesite breccia, andesite breccia. porphyritic andesite
- Andesite, basalt, dacite, and flow breccia

SYMBOLS

- Lineation
- 30 Foliation (dip known, vertical)
- Bedding (direction of dip known, upper side of bed unknown)
- Bedding (vertical)
- 30 Bedding (inclined, top known)
- Bedding (upper side known, dip unknown)
- Fault
- Shear zone
- Trench
- Shaft
- Building
- 30 Quartz stringers (inclined)
- Quartz stringers (vertical)
- 30 Jointing (inclined)
- Jointing (vertical)
- Outcrop pattern

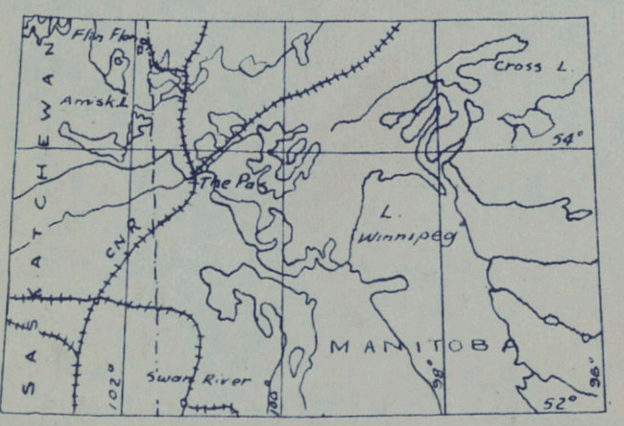


MAP I

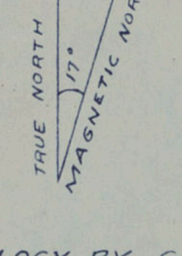
FLIN FLON AREA

SHOWING GENERAL GEOLOGY AND LOCATION OF MINERALIZATION STUDIED

SCALE: 1 INCH TO 800 FEET

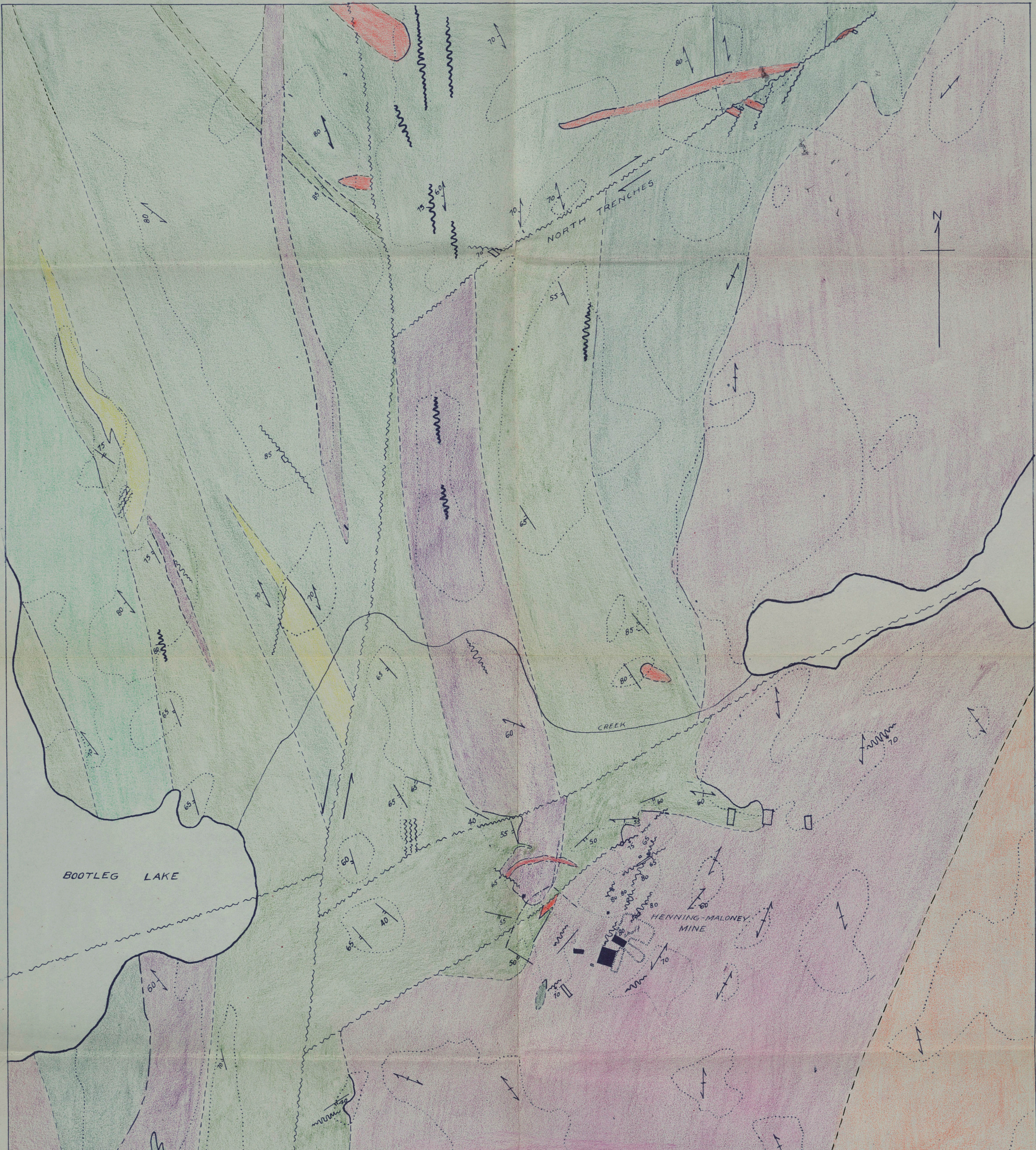


SCALE 1 INCH TO 100 MILES



GEOLOGY BY C.H. STOCKWELL,
1943, 1944, 1945.
W. P. BOYKO, 1952.

LEGEND AND SYMBOLS ACCOMPANY MAPS SEPARATELY



GROUP A
HENNING-MALONEY MINE
AND
NORTH TRENCHES
SCALE: 1 INCH TO 200 FEET