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CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

GEOLOGICAL SURVEY OF CANADA
MEMOIR 250

GEOLOGY AND MINERAL DEPOSITS OF FILE-TRAMPING LAKES AREA, MANITOBA

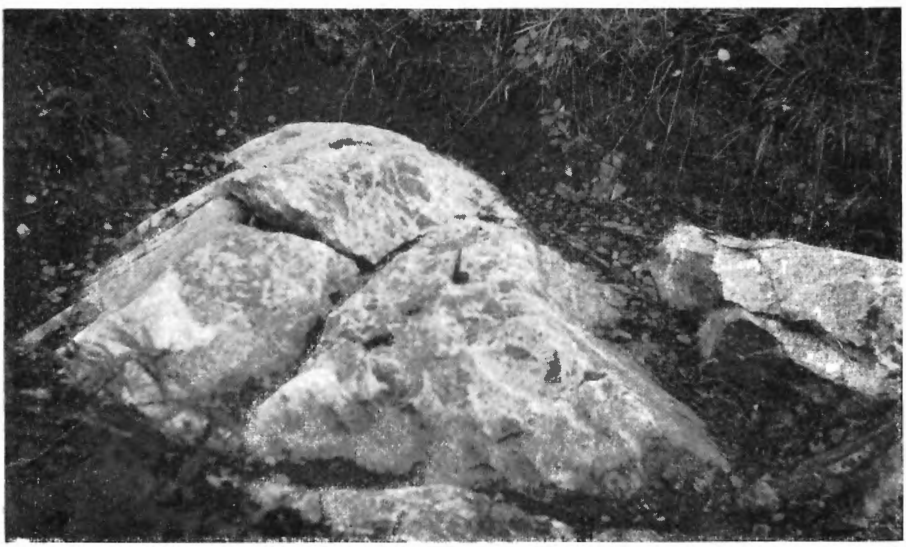
BY

J. M. Harrison

OTTAWA
EDMOND CLOUTIER, C.M.G., B.A., L.Ph.,
KING'S PRINTER AND CONTROLLER OF STATIONERY
1949

Price, 25 cents No. 2487

95880
A. Nor-Acme mine camp in September, 1944. View looking north from small island in Snow Lake. (Page 68.)



95885
B. Breccia cemented by quartz, Nor-Acme ore. Dark fragments are thought to be remnants of basic pyroclastic rocks. (Page 71.)

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PREFACE

The File-Tramping Lakes area forms part of the important Flin Flon-Sherridon-Herb Lake mineral belt in west-central Manitoba and east-central Saskatchewan, which is currently being mapped geologically on a scale of 1 inch to 1 mile. The Flin Flon and Sherritt Gordon copper-zinc mines are at present the only producing properties, but underground development of the Cuprus copper-zinc property at Schist Lake and the Nor-Acme mine at Snow Lake is expected to result in two more producers by the end of 1948. In addition, several promising prospects are being explored. As a result of these activities most of the interest in the belt is concerned with its economic aspect, but there are also many other problems of petrological, structural, and stratigraphic significance. The belt as a whole provides an opportunity to study the features of metamorphism, granitization, and regional folding, many of which are related to the genesis and location of the ore deposits.

In the present report Dr. Harrison is concerned chiefly with the Precambrian succession of events in the more easterly part of the mineral belt, and with the mineral deposits contained in it. Detailed studies have disclosed a pattern in the arrangement of these deposits; new data are presented on effects of regional metamorphism and granitization; and some new information is afforded on the stratigraphic succession. Field studies on which the author's conclusions are based were made by him in the File Lake map-area during the seasons of 1944, 1945, and 1946, and by Mr. M. S. Stanton in the Tramping Lake map-area in 1945. Three geological maps accompany this report: those of the File Lake and Tramping Lake map-areas, on a scale of 1 inch to 1 mile; and that of the Nor-Acme mine area on a scale of 1 inch to 1,000 feet.

GEORGE HANSON,
Chief Geologist, Geological Survey of Canada

OTTAWA, March 20, 1948

FILE-TRAMPING LAKES AREA, MANITOBA

CHAPTER I

INTRODUCTION

The File-Tramping Lakes area of west-central Manitoba extends from 54° 30′ to 55° 00′ north latitude, and from 100° 00′ to 100° 30′ west longitude. The centre of the area is about 65 miles east of Flin Flon, and 42 miles southeast of Sherridon. Geological mapping was done as for publication on a scale of 1 inch to 1 mile, except for a limited area about Snow Lake where information was assembled in more detail (*See* maps in pocket). The geology of Tramping Lake area was mapped by M. S. Stanton in 1945, that of File map-area and Nor-Acme mine area by the writer in 1944-46.

The only means of travel to, and within, the areas mapped were by canoe from Wekusko (Herb) Lake or Cranberry Portage, and by air from Flin Flon or Sherridon. Early in 1946 construction of a road was begun from Mile 81 (Wekusko Station) on the Hudson Bay Railway to Snow Lake where the Nor-Acme mine is being developed.

Unfailing courtesy and assistance were given by officers of various mining and exploration companies active in the area. Particular thanks are given to Dr. N. S. Beaton, who supplied much detailed information on geology of ground held jointly by Northern Canada Mines, Limited, and Pioneer Gold Mines, Limited. Mr. Frank Ebbutt and Mr. G. C. Lipsey of the Howe Sound Exploration Company made possible the compilation of much data on the Nor-Acme property. The kind co-operation and material assistance of many others are acknowledged in detail throughout the report. Student assistants in the File Lake area were Messrs. H. G. Kristjanson, J. F. Donoghue, W. J. Musick, and D. B. Mackinnon in 1944; Messrs. W. J. Kozak, C. W. Bildstein, and T. B. Gentles in 1945; and Messrs. J. B. Currie, C. E. Purcell, and J. F. Donoghue in 1946. In the Tramping Lake map-area assistants in 1945 were B. B. Brown, W. F. Fahrig, and J. Bryant. The first named in all years were senior assistants who at times undertook independent mapping.

PREVIOUS WORK

The first geological reconnaissance in the area was that of J. B. Tyrrell in 1896. He noted (39, pp. 41-43) [1] variations in the granitic rocks along Grass River, and the conglomerate on the east shore of Tramping Lake. Bruce (10) made a geological reconnaissance from Cranberry Portage to Wekusko Lake in 1916 and his work was expanded by Alcock in 1917 and 1918 (1, 2). The present area forms part of Alcock's Reed-Wekusko area (3). J. F. Wright (43) examined many prospects in the area in 1930,

[1] **Numbers in parentheses are those of bibliography at the end of this chapter.**

and a few years later Stockwell (30) reported on some in the western part. Armstrong (5) mapped the Wekusko area in 1939, which joins the File-Tramping area on the east, on a scale of 1 mile to 1 inch. Shepherd (27) touched on some highlights of geology in the immediate vicinity of Snow Lake in 1943, and in the following year Ebbutt (16) described briefly some features of the Nor-Acme property at Snow Lake.

PHYSICAL FEATURES

Most of the File-Tramping Lakes area displays the typical hummocky surface of low relief so characteristic of this part of the Canadian Shield. Tops of hills are generally 100 feet or less above the levels of nearby lakes, but in a few places relief may be nearly 200 feet. South of Reed and Tramping Lakes, flat, swampy land characterizes the areas underlain by Palæozoic limestone, and local relief seldom exceeds 25 to 50 feet. The southern and northeastern parts of the area drain eastward through Grass River, and the northwestern part through Burntwood River to the north. File and Grass Rivers are fairly good water routes, and Woosey and Squall Creeks are navigable by canoe, but other streams are only locally suitable for canoe travel. Large swampy areas prevail between Woosey and Tramping Lakes, east of Reed Lake, north of File River, and a few miles south of Snow Lake. Gravelly clay and sand covers much of the bedrock around Reed Lake, north to Morton Lake, and west and north from Snow and Squall Lakes. Some of the country has been burned clean of vegetation, and outcrops are well exposed for study. However, in unburned areas rock exposures are unsatisfactory, due either to growth of lichen or to a coating of black, opaque products of organic weathering that successfully obscures structural features and lithology.

Some good stands of spruce and jack pine occur here and there in the area. Spruce trees measuring 24 inches at the butt were noted near Snow Lake at the extreme east edge of the File Lake map-area. Large spruce and jack pine occur west of the central part of Squall Lake and along and near Berry Creek.

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CHAPTER II

GENERAL GEOLOGY

GENERAL STATEMENT

All consolidated rocks in File-Tramping Lakes area, except for the Ordovician limestone, are of Precambrian age and probably Archæan (Early Precambrian). In 1920 Alcock (3) classified all the old sedimentary and volcanic rocks as the Wekusko group, but stated that later, more detailed work would probably disclose the presence of two series separated by an unconformity. Two successions have been distinguished in these rocks, but positive evidence of an unconformity is lacking. The older group consists mainly of basic volcanic rocks, and is considered to be equivalent to Amisk rocks, named by Bruce (11, p. 9) in the Flin Flon district. The younger group is predominantly sedimentary in origin and in some respects is similar to the Missi series, also named by Bruce (11, p. 9), which overlies the Amisk with marked unconformity (11, p. 9; 33). However, the Missi series is composed almost entirely of clastic sediments, and contains many beds of conglomerate and beds that are pebble bearing. The sedimentary group in File Lake map-area, on the other hand, includes a large proportion of argillaceous material, lacks conglomerate, has sparse pebble beds, and contains interbedded basic volcanic rocks. Also, this group is cut by many dykes of diorite and gabbro, whereas the Missi strata lie unconformably above rocks cut by similar intrusions. In view of these distinctions it has seemed appropriate to designate this younger group by a local name, and it has, accordingly, been termed the "Snow" group from its typical occurrence about Snow Lake.

A few small, scattered areas within the File-Tramping Lakes area are underlain by sedimentary rocks, which appear to resemble the Missi series in part, but, except that some are known to lie above the volcanic rocks of the Amisk group, their age is unknown. They are not classified as to age. Thus the rocks termed "Wekusko" by Alcock are divided into the Amisk volcanic assemblage, the Snow group, and an unclassified group of sedimentary rocks.

The rocks of the File-Tramping Lakes area are continuous through Wekusko map-area, where Armstrong (5) classified them in relation to the Laguna series on the east side of Herb Lake. Using that classification, all Precambrian sedimentary and volcanic rocks in the File-Tramping Lakes area would be pre-Laguna, and presumably Amisk, in age.

In the northern part of File Lake map-area rocks of the Snow group have been converted to typical Kisseynew gneisses. Bruce, who named these gneisses north of Flin Flon (11), showed them to be older than Missi strata in his stratigraphic column (p. 9), but stated (p. 27) that both Missi and Amisk rocks are probably included in the gneisses, and (p. 29) that the sedimentary part of them "is believed to be younger than the Amisk volcanics". Wright (43, p. 14) thought that the Kisseynew gneisses lay conformably above the Amisk volcanic rocks and that they represented metamorphosed equivalents of the sedimentary strata about Wekusko Lake. Bateman (8) related the Kisseynew gneisses to the Missi series on the basis of an unconformable contact against the Amisk in the northern part of the Mikanagan Lake map-area, and further pointed out their lithological identity with the metamorphosed Missi of the type area near Flin Flon. Conclusions based on the present study are in general agreement with Bruce's hypothesis. Kisseynew gneisses in File Lake map-area are, in part at least, clearly derived from rocks of the Snow group that are younger than Amisk rocks, and are equivalent to some of the sedimentary rocks at Wekusko Lake. Amisk rocks, too, have been transformed to gneisses west of Squall Lake, so that it appears that the Kisseynew gneisses are metamorphosed equivalents of all stratified rock types in this region of Manitoba and Saskatchewan, but were mainly derived from sedimentary rocks.

Relations of the 'quartz-eye' granite are obscure. It cuts Amisk rocks and some of the unclassified sedimentary rocks, but nowhere was it found in contact with Snow rocks. It, in turn, is cut by dykes of basic rock and by the biotite granite. Stockwell (30, p. 4) found that some basic rocks just west of the present map-area pass "without intrusive relations into typical 'quartz-eye' granite". No such relations were found in the File-Tramping Lakes area, but in a few places a dark diorite with large 'eyes' of opalescent quartz passes gradationally into gabbro. The writer noted a similar relation in the southern part of the Mikanagan Lake map-area (8). 'Quartz-eye' granite at Flin Flon, called the Cliff Lake granite porphyry by Bruce (11) and considered by him to be pre-Missi, has been shown by Stockwell (33) to be unconformably overlain by Missi strata. Wright (44) showed that the 'quartz-eye' granite at Gods Lake may be older than Oxford sediments, and that a similar granite on Lookout Island in Amisk Lake may be older than Missi rocks (45).

The rhyolitic rocks near Morton Lake and elsewhere in the area cannot be properly classified as to age. They may, in part, be equivalent to the porphyries and rhyolites near Flin Flon (34), but Stockwell (30, p. 7) relates them to the 'quartz-eye' granite. Similar rocks are common, but not abundant, elsewhere in the region.

Various members of the complex of basic rocks are widespread in the File-Tramping Lakes area. Some cut 'quartz-eye' granite and some are cut by the younger granite. Some varieties may be older than others, but no evidence was found to indicate any appreciable distinction. Most of the various rock types of the basic complex are common to all areas mapped in this part of Canada. However, the serpentinized peridotite west of Cook Lake and the gabbroic anorthosite south of Loonhead Lake are, so far as known, unique for their kind.

Intrusion of the younger granitic rocks of the File-Tramping Lakes area was marked by widespread granitization, a feature common to all areas of Precambrian rocks in this region. They, and their pegmatitic derivatives, are the youngest of the Precambrian assemblage. No late diabase dykes, so characteristic of certain areas in Quebec and Ontario, are present in the File-Tramping Lakes area, nor are they known to be present in the general region. Armstrong (5) classified some dykes as late diabase in the Wekusko map-area, but detailed examination of some of these by the writer failed to disclose any significant distinction between them and other basic intrusions nearby. Wright (44) reports the presence of diabase dykes that cut late granite in the Oxford House area, but, in general, such rocks are rare in explored parts of Manitoba.

The Ordovician limestone in Tramping Lake map-area is the northern part of the belt that extends north from Lake Winnipeg. No basal sandstone was found.

TABLE OF FORMATIONS

Age	Formation	Description
Quaternary		Sands, gravels, clays
	Great unconformity	
Ordovician		Dolomite, dolomitic limestone
	Unconformity	
Archæan or Proterozoic		Pegmatite Gneissic and massive biotite granite, granodiorite, quartz diorite; quartz-feldspar porphyry; contact breccia
	Intrusive contact	
		Peridotite; pyroxenite; hornblendite, gabbroic anorthosite, gabbro; hornblende diorite; biotite diorite; quartz diorite, garnetiferous gabbro and diorite
	Intrusive contact	
		Quartz porphyry, quartz-feldspar porphyry, rhyolite[1] 'Quartz-eye' granite; related porphyry[1]
	Intrusive contact	
	Snow group	Granitized rocks Arkose; derived gneisses and schists Basic flows; minor tuff; undifferentiated and contemporaneous diorite; gradation to hornblende gneiss Coarse, hornblende-rich agglomerate, breccia, tuff, and undifferentiated basic intrusions; hornblendite, gabbro, diorite, feldspar porphyry Acidic volcanic rocks and feldspathic sedimentary rocks; minor acidic intrusions and rhyolite Staurolite and staurolite-sillimanite schist and gneiss; interbeds of garnet gneiss; coarsely crystalline garnet schist and gneiss; minor argillite and greywacke Garnet gneiss and schist derived from greywacke; minor argillaceous members

[1] Relations to Snow group not certain, but are later than Amisk.

Possibly granitic intrusions; possibly folding

Archæan	Amisk group	Granitized rocks Hornblende-feldspar gneiss and amphibolite; diorite; in part probably intrusive Basic volcanic breccia, agglomerate, and tuff; minor flows; undifferentiated diorite and gabbro; minor argillite Basic flows with many interbeds of argillite Massive and pillowed basic lavas; flow breccia; minor pyroclastic rocks; undifferentiated basic intrusions; derived hornblende-plagioclase gneisses

Relations not known

Archæan or Proterozoic	Unclassified[1]	Granitized rocks Interbedded argillite and greywacke; minor slate, arkose, quartzite, pebble beds, garnet gneiss, staurolite schist Conglomerate

AMISK GROUP

DISTRIBUTION AND THICKNESS

Rocks of the Amisk group underlie most of the area not invaded by intrusive rocks south from Snow, File, and Loonhead Lakes to Reed Lake, and between Squall and File Lakes.

About 30,000 feet of basic volcanic rocks are exposed along the axis of Threehouse syncline south from Snow Lake. The base of the section is not exposed and the top is in faulted contact with rocks of the Snow group. Between Morton and Woosey Lakes are 30,000 to 35,000 feet of basic lavas, all facing towards the east, and an additional 15,000 to 20,000 feet whose attitude is not known. Elsewhere in the File-Tramping Lakes area the exposed thickness is much less.

LITHOLOGY

The Amisk rocks have been separated into two divisions on the basis of relative age and differences in lithology. However, the age distinction is not absolute. The basic pyroclastic rocks of the upper division are everywhere underlain by basic flows of the lower division, but most of pyroclastic rocks are in turn overlain by flows.

The lower division consists almost entirely of basic lavas, including pillowed and massive flows and flow breccias. Intrusions of dark, fine- to medium-grained diorite are locally plentiful, and probably represent intrusive equivalents of the lavas. Between Morton and Woosey Lakes almost all of the flows are pillowed, although narrow interbeds of flow breccia are common near Woosey Lake (Plate II A). Most of the lavas

[1] These are probably younger than Amisk, in part at least, but relations to Snow group not known.

west of Morton Lake are massive. South of Loonhead Lake they contain a large proportion of greywacke and tuff as narrow interbeds. South of Snow Lake to the main sill of 'quartz-eye' granite most flows are pillowed, but flow breccias are common. South of the sill and west of Tramping Lake pillowed flows and flow breccias are rare, but amygdaloidal structures are common. The lavas about Reed Lake are, for the most part, massive. Some dark green pillowed flows east of Cook Lake contain small orange garnets.

The upper division of the Amisk consists predominantly of basic pyroclastic rocks. South of Snow Lake they attain their maximum thickness of about 5,500 feet as exposed along the axis of the Threehouse syncline. West of this axis these rocks interfinger rather bluntly with basic flows of the lower division, and immediately south of Snow Lake Narrows contacts between pyroclastic and flow rocks are intricately faulted. The fragmental rocks are mainly agglomerates and breccias, but contain many thin interbeds of fine breccia and tuff. Some of the narrower bands of pyroclastic rocks contain alternating thin beds of fine breccia and agglomerate; other bands are coarse breccias, and still others are predominantly tuffs.

North from the west end of Snow Lake the basic volcanic rocks of both divisions of the Amisk group become more altered and finally indistinguishable. They have been metamorphosed to feldspathic hornblende gneisses in which light and dark constituents are segregated into alternate bands. This banding is characteristic of nearly all high-grade metamorphic rocks in the area and the feature has been termed 'foliation' by Harker (19, p. 203).

In thin section both the pyroclastic and the flow rocks of Amisk type are seen to be largely altered to fine-grained aggregates of secondary minerals. Epidote, albite, chlorite, actinolitic amphibole, and quartz are most common, and occur in widely different proportions. In many places, particularly west and north of Snow Lake and south of Loonhead Lake, the rocks have been thoroughly recrystallized to actinolitic, blue-green amphibole and secondary andesine with addition of considerable quartz. In spite of these complete mineralogical transformations original structures are still plain in most areas where weathered surfaces are clearly exposed.

SNOW GROUP

DISTRIBUTION AND THICKNESS

The Snow group of rocks is predominantly sedimentary in origin and is exposed only in the northern half of File Lake map-area. All rock units of the group are represented in the vicinity of Snow Lake, but only the staurolite schist and its equivalents cross the entire map-area. The schist was first mapped by Armstrong in the Wekusko map-area (5), who found that it extended east from Snow Lake for about 4 miles before passing into garnetiferous gneisses and schists. It has now been traced through a general westerly, but exceedingly sinuous, course to at least 2 miles north of Corley Lake, and probably to the northeast corner of the map-area. However, north of Loonhead Lake the distribution of this unit is based on structural trends observed on air photographs and on very few outcrops.

North of File and Squall Lakes it passes out of the area for short distances. The total length of the unit, as mapped, is more than 35 miles and probably exceeds 40 miles.

So far as can be judged from few outcrops and sparse top determinations, the stratigraphic sequence of principal components is as follows: garnet gneisses and schists derived from greywacke, staurolite-sillimanite gneisses and schists derived from interbedded argillite and greywacke, feldspathic sedimentary and acidic volcanic rocks, basic pyroclastic rocks, basic lavas, and gneisses derived from arkose. All are shown separately on the map.

Garnet gneisses and schists derived from greywacke form discontinuous units, but where they do occur they underlie staurolite schist. They are thickest about Squall and File Lakes. Staurolite, or staurolite-sillimanite schists and gneisses are most abundant at File and Snow Lakes. North of these lakes they become much thinner, passing largely into garnet gneisses and schists derived from more arenaceous rocks. A wedge-shaped body of sillimanite-garnet schist lies just east of File River, but its stratigraphic relation to the main map-unit is not known. Two narrow bands of feldspathic sedimentary rocks, which are in part pebble bearing, are interbedded with acidic flows and breccias containing minor related intrusions. They lie above staurolite schist at Snow Lake, and the bands are separated by a layer of basic volcanic rocks. Basic volcanic rocks, and probably also some basic sills, occur at various stratigraphic horizons within the sedimentary rocks, but form two distinct lithologic units just north and east of Snow Lake. The lower one, consisting of three bands, is composed entirely of pyroclastic members and related intrusions, whereas the other is predominantly a succession of flows. Arkoses, and gneisses derived from them, are best displayed about Herblet Lake in McLeod Lake syncline, north of Squall Lake, and west of File River.

Total maximum thickness of the rocks in the Snow group in File Lake map-area is probably in the order of 14,500 feet near Snow Lake, although it is much less at other localities. Thicknesses, in feet, may be apportioned, from top to bottom as follows:

	Min. thickness	Max. thickness
Arkose derived gneisses	0	1,800
Basic flows	0	1,500
Basic pryoclastic rocks	1,000	2,200
Feldspathic sediments and acidic volcanic rocks	1,000	2,500
Staurolite schist and gneiss	200	5,000
Garnet gneiss and schist	0	1,500
Total	2,200	14,500

LITHOLOGY

Most of the rocks of the Snow Lake group have been altered to rocks representing medium- to high-grade metamorphism, namely garnet, staurolite, sillimanite, and hornblende schists and gneisses. In places granitization has been extensive, resulting in rocks mapped as granitized gneisses. Metamorphism in the northern 3 to 6 miles of the area has produced gneisses of the type called Kisseynew by Bruce (11, p. 9).

Garnet gneisses, and minor greywacke from which they are derived, are typically medium-grained rocks. They have a brownish grey, weathered surface speckled with small, reddish or violet garnets and small flakes of biotite or crystals of hornblende. In a few places, notably north of Squall Lake, they have a knobby-weathered surface that results from resistance to weathering of quartz-sillimanite intergrowths. In thin section these gneisses appear as recrystallized granular to gneissic aggregates consisting principally of quartz and fresh plagioclase (An_{28-35}), with subsidiary hornblende or biotite, or both, and lesser amounts of ragged, sieve-textured to euhedral garnet. Accessory minerals include magnetite, apatite, zircon, epidote, and pyrite. Fine needles of brownish sillimanite occur as clusters and rosettes in quartz grains of specimens from some localities. In rare places garnets are sparse or absent.

The staurolite-sillimanite schist and gneiss vary greatly in appearance from place to place. Actually only about half or two-thirds of the beds in this map-unit were argillaceous, the rest having been derived from greywacke. In a few places, as at the south sides of File and Snow Lakes, the rock is a fine-grained, biotitized, black argillite, which passes northward to a coarser, garnet-bearing variety. As staurolite schist it is best displayed at Snow Lake, where some crystals of staurolite, as much as 6 inches long, occur in a medium-grained, brownish grey, garnet-biotite-quartz-plagioclase matrix. Staurolite-sillimanite schist and gneiss are best exposed between File and Corley Lakes (Plate II B). About half a mile south of Corley Lake sillimanite-quartz knots constitute about 50 per cent of some beds. Between File and Squall Lakes, and north from Corley Lake, the rock is a medium-grained, brownish grey gneiss or schist dotted with large, euhedral, brownish pink garnets. Some of these garnets are half an inch or more in diameter. They weather high, and give a striking appearance to the rock. In the field it was called the 'pudding-stone' from its resemblance to a pudding containing extra large raisins. Locally, it contains quartz-sillimanite intergrowths. North of Loonhead Lake the formation is not so distinct, for outcrops are widely separated and granitization has obscured the more typical lithology.

It is impossible to indicate a typical mineral composition for this map-unit, as it is so variable. Staurolite crystals are mainly euhedral but poikilitic, and sillimanite occurs as rosettes and felted masses intergrown with, or surrounding, grains of quartz. The matrix is fine to medium grained, and consists of biotite, quartz, and plagioclase, with minor to subsidiary amounts of garnet and hornblende. Plagioclase varies in composition from albite to andesine, the more calcic varieties occurring in more highly metamorphosed types. Accessory minerals are magnetite, zircon, apatite, and, locally, tourmaline and white mica.

Interbedded feldspathic sedimentary and acidic volcanic rocks, which occur in two main layers at Snow Lake, commonly weather light grey to pinkish grey or brown. They are mainly fine-grained, gneissic, and garnetiferous. Near the east edge of the map-area many beds contain elongated pebbles and cobbles in a rather coarse, granular matrix of quartz and feldspar. In some places, particularly near the Nor-Acme mine, the rock is thinly laminated and siliceous, and is marked by what appear to be flow lines. In other places it is fragmental, and autoclastic breccia is developed near the mine. A few small dykes of rock of similar composition were noted as intrusions in basic volcanic rocks. A few bands of siliceous rock, thought to be rhyolite flows, are intercalated between some basic flows north of Snow Lake, and have been included in this map-unit.

All these feldspathic sedimentary and acidic volcanic rocks are recrystallized, rich in feldspar, and locally carry much quartz. Biotite is the chief accessory mineral, and forms 20 per cent of the rock in some localities. Amphibole is locally present in amounts up to 15 per cent. Pink to red anhedral garnets are common, but not abundant. Crushed and granulated grains of quartz characterize the more easterly members.

Three belts of basic pyroclastic rocks and related basic intrusions lie north of the main body of Snow Lake. The most southerly of these forms the hanging-wall of the Nor-Acme mine, and the best exposures of these rocks are about 1,000 feet west of the main surface showing of the mine. There the rocks are well-bedded agglomerate, breccias, and tuffs. Beds vary in thickness from an inch or less to several feet. In one bed an angular fragment measured 24 by 14 inches in exposed dimensions (Plate III A), but most fragments do not exceed 6 inches in maximum dimension. Fragments of many types of rock are present—fine-grained felsite, bedded felsite, feldspar porphyry, quartz-feldspar porphyry, andesite porphyry, andesite, carbonated andesite, hornblende porphyry, and hornblende-feldspar porphyry. Fragments of light-coloured rocks are most abundant, but all represent types occurring within this formation or those below it. The matrix for these large fragments is a finer breccia characterized by small fragments of plagioclase and more abundant blocky hornblende (Plate III B). Beds of finer, dark, tuffaceous rock contain as much as 80 per cent hornblende and the upper part of the middle belt is a fine-grained, thinly laminated, andesite tuff.

Plagioclase in these pyroclastic rocks is commonly calcic andesine, but oligoclase occurs in the vicinity of ore. Hornblende is the typical blocky, blue-green, poikilitic, metamorphic type. Epidote, sphene, and apatite are present locally, and tourmaline is common in some beds near mineralized zones. Where the rocks are sheared, carbonate is abundant. The northernmost belt of these rocks is transected by faults, which results in a streakily carbonatized matrix containing attenuated fragments. All minerals in the rocks are recrystallized, but except where sheared the original features such as bedding are clear on weathered surfaces, and the rock appears remarkably fresh.

Various types of basic intrusions are mingled irregularly with the pyroclastic rocks. They include hornblendite, hornblende porphyry, gabbro, diorite, and basic feldspar porphyry, and were recognized only where the pyroclastic rocks are present. Fragments of all intrusive varieties have been found in agglomerate members. A contact between hornblendite and breccia is well exposed about 150 feet north of the main Nor-Acme showing. Small stringers of hornblendite extend into breccia for a few inches, and the breccia is impregnated with crystals of hornblende for a foot or more from the contact. In other places zones of alteration and impregnation of breccia by basic intrusions are more than 50 feet wide, but where feldspathic sedimentary beds or basic flows are cut by these rocks the contacts are sharp. Thus, the mode of intrusion and restricted occurrence suggest a common source for both pyroclastic and intrusive material. However, in thin section the basic intrusions are much less altered than the pyroclastic members. The hornblende present is not the metamorphic type, although in places it is partly altered to a blue-green, actinolitic variety. Plagioclase, it is true, is mostly converted to epidote and clinozoisite, especially in more feldspathic types, and chlorite is locally common, but these minerals are more typical of a lower grade of metamorphism than characterizes the pyroclastic rocks. Although the intrusions have been sheared there is no definite evidence that they have been folded. It may be that the intrusions, especially hornblendite, are more resistant to alteration and deformative processes for they do not appear to be appreciably younger than the pyroclastic rocks.

Basic lavas within the Snow group attain their greatest thickness north of Snow Lake, where characteristics of volcanic origin are still evident. Northwards they become typical hornblende gneisses, and elsewhere in the area the gneisses occur as discontinuous, rather thin layers at various horizons within the group. Between Snow and Cleaver Lakes it is possible, here and there, to distinguish pillow structures, breccia bands, tuffs, and intrusive relations, but for the most part the origin of these rocks at other places is obscure. Much of the more highly metamorphosed rock displays a well-defined banding (foliation) that simulates bedding (Plate IVA).

These basic rocks are well recrystallized, and consist predominantly of oriented blades of hornblende with lesser amounts of andesine (An_{30}-An_{50}). Hornblende is the bluish green metamorphic type, commonly poikilitic (sieve-textured), and varies from subhedral to euhedral in outline. In some specimens it is partly altered to dark brown biotite. Magnetite, apatite, epidote, and sphene are common accessory minerals, and quartz is present locally.

Gneissic arkose, and gneisses derived mainly from arkose, are most common in the McLeod Lake syncline, around the west end of Herblet Lake, and north of Squall and File Lakes. They are fine- to medium-grained, pink or grey rocks that weather to pink and blue shades of grey. Except that bedding is commonly well preserved they appear much like granite. Some beds of greywacke help mark the bedding, and are especially abundant nearest the underlying basic flows west of Herblet Lake. The rocks are sparsely garnetiferous and, in a few localities, weather with the knobby surface characteristic of quartz-sillimanite intergrowths.

In thin section these rocks appear as fine- to medium-grained, recrystallized aggregates. Quartz and plagioclase predominate in widely varying proportions. Plagioclase varies from An_{10} to An_{40}. Biotite locally comprises 40 per cent of the rock, but for the most part constitutes only 5 to 10 per cent. Other minerals present in some sections include muscovite, microcline, garnet, sillimanite, hornblende, and carbonate. Andalusite was noted in one section from a rock outcrop north of Squall Lake. Minor accessory minerals are magnetite, apatite, sphene, and occasional tourmaline and zircon.

RELATIONS TO AMISK ROCKS

The relations of the Amisk rocks to those of the Snow group are not clear. Shepherd (27) stated that an unconformity appeared to separate staurolite schist of the Snow group and the volcanic rocks that outcrop along the south shore of Snow Lake. Ebbutt (16) likewise felt there was some evidence for an unconformity between the two rock groups, but during conversations with the writer in 1944 he suggested the possibility of faulting through Snow Lake Narrows. In fact, shearing marks the contact of the Snow and Amisk rocks along the shores of Snow Lake, and at least as far north as Squall Lake. A few knobs of garnetiferous argillite, an equivalent of staurolite schist, occur in contact with basic flows on the west shore of Snow Lake, but both rocks are so altered by shearing and carbonatization that contact relations are obscured. Diamond drill records and magnetometer surveys indicate that the lower contact of staurolite schist and argillite follows closely the south and west shores of Snow Lake, but nowhere is there any evidence of basal conglomerate. Northwest from Squall Lake to the north edge of the map-area outcrops are scarce, and dips and plunges are so low that the position of the contact between Amisk and Snow rocks is indefinite. Again, the contact between Snow and Amisk rocks is faulted through File Lake and north to Loonhead Lake. The only locality in the west half of the map-area where contacts between the two groups are not marked by strong shearing is that just north of the portage from Woosey Lake to File Lake. There the sedimentary members overlie a small anticline in Amisk rocks, but no evidence for unconformity was recognized. Another point against an unconformity is the lack of a basal conglomerate in the Snow group; in fact, the lowest member of the group is, in most places, argillite or its altered equivalents. On the other hand, it should be noted that 'quartz-eye' granite and its metasomatic derivatives are common in rocks of the Amisk group, but were not seen anywhere in rocks of the Snow group, though their occurrence would be expected if the two groups are conformable. However, this can only be regarded as negative evidence in support of unconformable relations, which otherwise can be accepted only with extreme reservation.

UNCLASSIFIED SEDIMENTARY ROCKS

DISTRIBUTION AND THICKNESS

Sedimentary rocks, whose relations to one another and to other sedimentary and volcanic groups are unknown, occur throughout the File-Tramping Lakes area, but chiefly along and near the shores of lakes. The principal occurrence is that west from the north end of Tramping Lake; others are elsewhere on that lake, and about Reed, Woosey, Morton, Morgan, and Tent Lakes.

Assuming a monoclinal structure for the unclassified sedimentary rocks west from Tramping Lake, their maximum thickness is 7,500 to 8,000 feet. However, structural data are scant, and in most places their thicknesses, as exposed, vary from about 200 feet to as much as 2,000 feet.

LITHOLOGY

These unclassified rocks vary a great deal in appearance and alteration from place to place. Conglomerate is well exposed on the east shore of Tramping Lake. Nothing is known of its age relations except that it is cut by dykes of granite. No contacts are exposed. The rock appears very fresh, and contains pebbles of quartz, basic volcanic rocks, pink and grey granite, pegmatite, felsite, quartz-feldspar porphyry, diorite, epidotized material, and possibly some tuff and argillite.

Sedimentary rocks west from the north end of Tramping Lake appear very fresh. Near the Berry Creek fault they are mainly coarse greywacke with sparse pebble beds. They become irregularly but progressively finer grained to the east, and on the shore of Tramping Lake are very fine-grained, black, earthy-weathering argillites. Quartz is the predominant recognizable primary mineral, all others having been largely transformed to chlorite, carbonate, sericite, iron ore, and clayey minerals. Remnants of albite-oligoclase are apparent locally, and streaks of carbonaceous material characterize thin sections.

Sedimentary rocks about Reed Lake consist principally of impure quartzite or greywackes with interbedded, thin, slaty members. A few pebble beds of restricted occurrence consist of ovoid pebbles of greywacke in a matrix of similar material. Sedimentary rocks about Woosey, Morgan, and Morton Lakes are much the same, except that they contain more abundant argillite. Garnets are common in the rocks of the northern parts of these lakes. Poorly formed porphyroblasts of staurolite occur in rocks forming some of the islands in the north-central bay of Woosey Lake. Staurolite schist outcrops along the southeast shore of Tent Lake, where garnet schists and gneisses also have a restricted occurrence.

AGE RELATIONS

The stratigraphic position of the unclassified sedimentary rocks is unknown. Their general fresh appearance about Tramping Lake, and the variety of rock types contained as pebbles in the conglomerate, suggest an age equivalent to Missi rocks at Flin Flon, but such an age can only be inferred. Similarly, the sedimentary rocks at Reed Lake may be Missi. Those around Woosey and Morton Lakes are more highly altered and, especially in their more northern exposures, approach rocks of the Snow group in appearance. Relations with Amisk rocks are obscured by drift, faults, or lack of structural data. A small syncline in sedimentary beds on the west shore of Morton Lake suggests that they overlie basic volcanic rocks, but the fold is small and may represent dragging along a fault. The rocks on Tent Lake are highly metamorphosed, and except that they contain much chlorite are no different from similarly metamorphosed rocks of the Snow group. North from Tent Lake they become transformed by the same agency that affected the basic volcanic rocks, and which is believed to be 'quartz-eye' granite. No similar alteration was found in rocks of the Snow group. It is possible, then, that some of these sedimentary members may be Missi in age, some may equal the Snow group, and some probably represent local areas of sedimentation in the Amisk volcanic rocks.

'QUARTZ-EYE' GRANITE

'Quartz-eye' granite is fairly widespread in northern Manitoba. Stockwell noted intrusions of it between Morton and Elbow Lakes (30, p. 5), east of Wekusko Lake (31, p. 9), and at Flin Flon (33). It is also present in Mikanagan Lake map-area (8).

The main occurrences in File-Tramping Lakes area are south of Snow Lake, where one large and two small sill-like masses form part of the Threehouse syncline. A small boss lies south of Morgan Lake, and other, smaller intrusions occur here and there in the east half of the area.

The rock is characterized by 'eyes' of opalescent or white quartz that vary in diameter from one-twentieth to one-third inch, and are made up of small, interlocking grains of strained quartz. The matrix is fine to medium grained, and is commonly chloritic, but in the central parts of the larger intrusions much of the rock is pink or grey, and massive. Phenocrysts of plagioclase are locally abundant, especially in interiors of larger masses of the rock. Poorly formed, reddish garnets occur mainly near the margins. No potash feldspar was noted. The bulk of the matrix consists of plagioclase, which varies in composition from albite to sodic andesine, and which occurs in granitic to granular intergrowths with quartz. Accessory minerals include either or both biotite and hornblende, and minor apatite, magnetite, and garnet. The rock contains varying amounts of alteration products such as sericite (paragonite?), chlorite, epidote, and the clay minerals. In the margins of intrusions nearly all the rock is schistose or strongly gneissic.

Intrusion of 'quartz-eye' granite has resulted in widespread metasomatism of Amisk rocks, and in many places contacts between intrusions and invaded lavas are placed arbitrarily. This is especially true where the 'U'-shaped body, which lies south of Snow Lake, terminates at Anderson Lake on the east and near Cook Lake on the west. In a few places 'quartz-eye' granite outcrops near poorly stratified greywacke, and at Morgan and Woosey Lakes it was practically impossible to distinguish intrusive from sedimentary rock.

Age relations of the 'quartz-eye' granite are not completely clear. It certainly intrudes Amisk rocks and some unclassified sedimentary types; it is cut by dykes and sills of basic intrusions, which in turn are cut by biotite granite. However, no dykes of 'quartz-eye' granite were found in rocks of the Snow group, nor were any of the rocks in that group marked by the alteration characteristic of this granite. Positive evidence, therefore, indicates that the 'quartz-eye' granite is younger than Amisk lavas and some associated sedimentary types, and is older than the basic intrusions and potash granite. Negative evidence suggests it is older than rocks of the Snow group, which in turn suggests that the Snow group and Missi series of Flin Flon are of the same age. However, it must be emphasized that no positive evidence has been found for this relation.

QUARTZ PORPHYRY, QUARTZ-FELDSPAR PORPHYRY, RHYOLITE

Quartz porphyry, quartz-feldspar porphyry, and rhyolite are sparsely distributed in the area, the largest body being that west of Morton Lake. The big island in Morton Lake is composed of rhyolite, and a little rhyolite was seen on a small lake about 2,000 feet south of Loonhead Lake. Quartz porphyry occurs near Tramping Lake.

These rocks typically weather a chalky white to distinct green, depending on the amount of contained chlorite. The more chloritized parts resemble andesite, except that tiny phenocrysts of quartz can be seen. The less altered types consist of fine-grained, dense aggregates of albite-oligoclase and quartz, with minor biotite, sericite, and local amphibole. Small rounded phenocrysts of quartz, and, locally, oligoclase, comprise 5 to 10 per cent of the rock. The large mass west of Morton Lake contains as much as 50 per cent chlorite and carbonate in some places. In the northwest part of this mass the rock is coarser grained; needles of hornblende locally constitute 15 to 20 per cent of it, and it is virtually a hornblende granite. The rhyolite on the islands in Morton Lake is light grey to brown, dense, and quite cherty on fresh surfaces. Weathered outcrops are white to pale grey. The rock lacks phenocrysts and, in the southern part of the largest island, has the appearance of a flow, or flow breccia. However, this feature may be a result of fracturing and shearing. Quartz porphyry near the Berry Creek fault appears to be thinly bedded, but this feature could also be due to shearing.

Stockwell (30, p. 10) considered that these acidic rocks were probably related to dykes of hornblende granite and garnetiferous granite that cut gold-bearing quartz veins west of Morton Lake. In his map-legend these porphyries are indicated as the youngest rocks in the area. Those exposed in File Lake map-area are definitely intruded by basic rocks, and are locally chloritized or amphibolitized by them. They must, therefore, be older than basic intrusions and biotite granite. General composition and the appearance of coarser grained phases suggest affinities with the 'quartz-eye' granite, but positive evidence is lacking.

BASIC INTRUSIONS

Almost all types of basic intrusive rocks are displayed in the area. They occur as plugs, stocks, dykes, and sills that vary in composition through peridotite, pyroxenite, hornblendite, anorthosite, gabbro, and diorite to quartz diorite and granodiorite. Mineral composition is constant in some intrusions, varies regularly in others, and is irregular in the rest. Some of those indicated on the accompanying maps probably represent intrusive equivalents of the basic volcanic rocks, but where field evidence indicated such a relation the intrusions are not differentiated from the flows on the map. Other than the above relation no evidence was obtained to indicate an appreciable difference in age among the basic intrusions. Armstrong (5) indicated some dykes of diabase on Herblet Lake as the youngest rocks in the Wekusko area. These dykes extend into File Lake map-area and, in spite of careful search, no evidence was found to indicate they were other than a phase of the common basic intrusions. Dykes of diorite and gabbro cut 'quartz-eye' granite and its alteration products, but are cut by intrusions of biotite granite.

Basic intrusive rocks in the File-Tramping Lakes area fall into two main groups—those with compositions between peridotite and gabbro, and those varying from gabbro to granodiorite, but more detailed distinctions are shown on the the File Lake map.

The largest body of the more basic types is that at Jackfish Lake, where the rock varies from pyroxenite to gabbro and quartz gabbro. It is typically coarse grained, but is cut by fine-grained varieties, which, in turn, are cut by coarser phases. Quartz-gabbro is the most common type, and contains opalescent 'eyes' of quartz as much as one-eighth inch in diameter. Deposits of sulphides are numerous in this intrusive complex. At Chisel Lake a rounded mass of gabbro and diorite is partly sheathed in fine- to medium-grained, serpentinized peridotite. Most of the peridotite weathers with a rusty brown, coarsely pitted surface, but just west of a small lake, about 2,000 feet northwest of Chisel Lake, the rock is characterized by randomly oriented, abundant slip planes marked by asbestiform serpentine. The central body of gabbro appears to cut the peridotite, and both are cut by dykes and plugs of coarse hornblendite. West of Morton Lake, an oval plug of fine-grained, serpentine-rich rock cuts and chloritizes quartz porphyry.

A well-defined mass of coarsely diabasic gabbroic anorthosite[1] lies south of Loonhead Lake. Plates of andesine, many of them 2 inches or more in length, constitute 80 to 85 per cent of this rock. Subsidiary hornblende, minor apatite, iron ore, and sphene complete the assemblage. This rock is not significantly different from gabbroic anorthosites in southeastern Ontario (20). Gabbro is chilled against it, and it is cut by the granite at Norriss Lakes.

By far the greater proportion of basic intrusions in the area are dark, fine- to medium-grained, speckled-weathering gabbro and diorite. A few approach hornblendite in composition; others are quartz diorite or granodiorite. Textures vary from granitic to gabbroic and diabasic. Amphibole is the main mineral, and in some of the rocks two kinds are present; the more common of these is a rather pale bluish green variety that is locally pseudomorphic after pyroxene; the other is nearly colourless, prismatic tremolite. Andesine or labradorite is the other main constituent. Accessory minerals are mainly apatite and iron ore, but biotite is locally present. Both biotite and epidote occur as secondary minerals in some places. Garnetiferous gabbros and diorite are common about Snow and Chisel Lakes.

Some parts of the basic intrusion west of Morton Lake are rich in hornblende and carry large opalescent 'eyes' of quartz. Creamy coloured, quartz-rich granodiorite or monzonite occurs on the southwest shore of File Lake, on the north part of the east shore of Morton Lake, and north through Dummy Bay between the two faults. A peculiar garnet-quartz gabbro outcrops on the north shore of Snow Lake Narrows, near the west end of the lake. In outcrop the rock appears orbicular, a structure due

[1] Rocks defined by Buddington (13, p. 19) as consisting of calcic plagioclase with 10 to 22½ per cent of mafic minerals.

to large, rounded crystals of garnet. The fine-grained matrix is composed of crushed labradorite, pyroxene, amphibole, biotite, quartz, and magnetite, to which carbonate and more quartz has been added.

Where basic rocks intrude Kisseynew gneisses they are gneissic, locally carry much biotite, and in general exhibit the type of metamorphism characteristic of the gneisses.

An extensive, though apparently shallow, roof pendant of fine- to medium-grained quartz gabbro and diorite occurs in granite east of Highway Lake in the Tramping Lake map-area. Between the basic rock and the granite a belt of contact breccia varies in width from a few hundred feet to almost 1½ miles, and was mapped separately. It consists of closely spaced blocks of more basic material in a matrix of granite. Xenoliths form more than 50 per cent of the exposed rock.

GRANITE AND ALLIED ROCKS[1]

Granitic intrusions are the most plentiful rocks in the File-Tramping Lakes area. They occur as batholiths, stocks, bosses, dykes, and sills, and vary widely in appearance and composition. All the larger bodies contain a large amount of partly assimilated material, but the smaller masses appear less contaminated. All are typically medium to coarse grained, and weather in shades of pink and grey. Where foliation or gneissosity is present it is concordant with the intrusive contacts.

DISTRIBUTION

The largest intrusions of granitic rocks are the Reed granite, lying between Reed and Woosey Lakes; the Ham granite, lying between Woosey Lake and the north edge of the area; the File granite north of File Lake; the Norriss granite about Norriss Lakes; and an intrusion east of Tramping Lake. The interior of the Squall Lake dome is also occupied by granite, and a small plug of granite is exposed in the centre of the Loonhead Lake dome. An ovoid stock of porphyritic granite lies on the west side of Tramping Lake, and smaller intrusions are scattered here and there throughout the entire area. Pegmatite dykes are plentiful about Loonhead Lake, but are exceedingly rare elsewhere.

LITHOLOGY

The Reed, Ham, and Squall Lake granites of File Lake map-area are mainly grey to pink, medium-grained, gneissoid or foliated rocks. Trend lines are marked by lineation of biotite or amphibole or both, but, except locally, the rocks themselves are not markedly gneissic. They vary in composition from biotite granite to hornblende diorite depending, to some extent at least, on degree of contamination by the characteristically abundant inclusions. Parts of both Reed and Ham granites consist of coarse, pink, granite porphyry that is quite distinct from the main rock. The porphyritic phase is massive, and weathers pink or white, features that make it readily apparent on air photographs, although in some places contacts with the gneissoid granite are gradational. Where large enough, intrusions of the porphyry have been distinguished on the map.

[1] For the sake of brevity all these rocks are referred to as 'granite' in the text, although they vary in composition from diorite to granite and syenite.

The mineral composition of these granites varies as widely as their appearance. The porphyritic type consists mainly of potash feldspar and quartz, with subordinate biotite, local hornblende, and accessory zircon, apatite, and iron ore. In the main bodies of granite potash feldspar varies in amount from 5 to 50 per cent, oligoclase or andesine up to 50 per cent, and quartz up to 50 per cent. Biotite commonly comprises 5 to 15 per cent, but locally constitutes nearly one-quarter of the rock. Amphibole and muscovite are local constituents. Accessory minerals are apatite, sphene, iron ore, and zircon. Parts of the Ham granite, particularly north of Vickers Lake, contain poorly formed garnets. Alteration products such as epidote, chlorite, carbonate, and sericite vary greatly in amount, but are generally sparse.

Granites west and east of Tramping Lake, on the east side of Woosey Lake, and the Norriss granite are massive, non-porphyritic, pink to grey rocks. They vary in composition from granite to diorite, the more basic facies occurring at the margins. The Norriss granite is quite fresh and has a uniform composition of quartz-diorite or granodiorite.

The File granite, and other intrusions exposed north of File Lake, are strongly gneissic, rather fine-grained, pink to red rocks, and are commonly deficient in dark minerals. Some parts of the File granite have sharp contacts with the enclosing gneisses, but the contacts of this, and other similar bodies of granite, are more commonly gradational with the enclosing rocks, and are placed arbitrarily on the map. These bodies are essentially granodiorite in composition, but in many places contain a high percentage of potash feldspar, a principal distinction between these rocks and those classed as granitoid gneisses.

Pegmatite dykes are most abundant around Loonhead Lake, and a few are exposed about Squall Lake. Elsewhere they are extremely rare except as local facies within granitic intrusions. All weather pink to white and consist mainly of coarse quartz and feldspar. Biotite is the chief accessory mineral, but amphibole was noted in a few dykes. No other minerals of importance were noted, and the dykes tested showed no reaction to a Geiger-Mueller counter.

GRANITIZED ROCKS

The term "granitized", as here applied, includes all rocks in the File-Tramping Lakes area that have had such materials of igneous origin added to them that they have become more like a granite in composition and appearance than they were originally. Rocks were not mapped as "granitized" unless the change had altered the original appearance rather thoroughly and unless the rocks so affected covered a fairly large area.

Rocks of the Snow group have been mapped as granitized gneisses where original structures and lithology are still discernible, and as granitoid gneisses where alteration has produced a rock similar to granite except for foliation, or banding of mineral constituents.

Amisk basic volcanic rocks have been granitized both by 'quartz-eye' granite and by the younger, biotite granite. Alteration by the 'quartz-eye' granite typically produces a fine-grained, siliceous or feldspathic rock that weathers chalky white to ashy grey or pinkish grey speckled with dark mafic minerals and, commonly, red to pink garnets. All gradations can be seen in the field from typical basic lavas and pyroclastic rocks through the typical alteration zones to 'quartz-eye' granite. Alteration by the younger granites typically produces a medium-grained rock with a granitic texture and a composition varying between diorite and granodiorite. These two types of granitized rocks were mapped separately in the File Lake map-area, but in the southern part the granitization effects of the younger granite are superimposed on those of the 'quartz-eye' granite and the two can be distinguished only with increasing difficulty. In Tramping Lake map-area the two could not be separated and, consequently, were mapped together. However, north of Reed Lake in Tramping Lake map-area the younger biotite granite has produced a third distinctive alteration product, which is indicated on the map. This product, derived from basic flows, is a coarse, granitized and epidotized amphibolite containing magnetite.

Granitized equivalents of the unclassified sedimentary rocks are sparse. They were noted chiefly north of Tent Lake and on Woosey Lake in File Lake map-area, where they are similar in appearance to the altered greenstones except that they are, perhaps, more siliceous and contain more garnets.

A type of granitized rock different from those described above is exposed west of Tramping Lake. Rather large areas of contact breccia have been formed there, and have been mapped separately. They consist of angular blocks of gabbro and diorite in a matrix of biotite granite. In one direction, these breccia zones pass into gabbro and diorite by decrease in the amount of intruded granite, and in the other direction they pass into batholithic granite by decrease in number of inclusions.

A more detailed discussion of all these grantized rocks is presented in the chapter on regional alteration.

ORDOVICIAN

Flat-lying beds of Ordovician dolomite and dolomitic limestone are believed to underlie the south part of Tramping Lake map-area. Time did not permit an investigation to the south border of the area, but air photographs show the flat, swampy topography characteristic of those parts known to be underlain by Ordovician strata.

The strata are best exposed at the south end of Tramping Lake, where they form an escarpment 15 to 20 feet high. They are massive, fine-grained, buff-coloured rocks, and though the beds near the base of the escarpment are quite reddish, no basal sandstone was observed.

A few fossils, collected by M. S. Stanton near Tramping Lake, were identified by R. A. C. Brown of the Geological Survey as follows:

Receptaculites sp.
Columnaria cf. *Alveolata*
Streptelasma ? sp.
Cephalopod indet.

These indicate that the rocks are part of the Red River formation of southern Manitoba, and as such are probably of Richmond (Upper Ordovician) age.

UNCONSOLIDATED DEPOSITS

Large parts of the File-Tramping Lakes area are covered by a mantle of unconsolidated sand, gravel, clay, and boulder till. Most of the larger deposits consist of a mixture of sand and clay, and probably represent raised beaches and lake deposits. Tops of outcrops have been striated and locally polished by glaciers that moved in a direction about 20 degrees west of south. As a result, the south slopes of hills are commonly covered with glacial debris whereas the north slopes are relatively bare.

A mixture of sand and clay covers much of the area underlain by staurolite schist north of Snow Lake Narrows. Another broad expanse of such material runs north from the west end of Snow Lake for about 6 miles to the north edge of the map-area, and south for a mile or two where it is dissipated in more abundant outcrops. Similar material covers most of that part of File Lake map-area underlain by garnet and staurolite schist and gneisses. It probably represents old glacial-lake bottoms and, in places, outwash material from glaciers.

A broad, flat sand plain straddles the junction of File and Tramping Lakes map-areas east of Morgan Lake. It is probably a raised beach, or spit, for it is almost entirely surrounded by deep, wet muskeg. Three raised beaches were recognized by Alcock[1] on a sand plain followed by the portage between Reed and Morton Lakes. Gravel beds on which test pits were sunk to a depth of 10 feet lie just north of Snow Lake at, and beyond, the eastern extremity of File Lake map-area. A small terminal moraine containing large boulders rises rather abruptly just north of Tern Lake and apparently extends south from the high outcrops at the south side of Snow Lake.

A few erratics of Ordovician limestone were noted. The most northerly one lies at the north end of the small lake immediately south of Photo Lake. Others were seen south of Edwards Lake and about 3 miles west of Woosey Lake. These probably are remnants of Ordovician strata that formerly covered the Precambrian rocks in this region, indicating that glacial erosion was shallow. This is further borne out by remnants of preglacial weathering preserved here and there in the map-area.

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[1] Reported by Johnston (23, p. 1).

CHAPTER III

REGIONAL ALTERATION

GENERAL STATEMENT

This chapter deals with alterations of rocks that have taken place on a regional scale. Alteration related to the deposition of ore minerals is described in the chapter on mineral deposits.

The regional alteration of rocks involves mainly metamorphism and metasomatism. These are two distinct processes, though it is commonly difficult to distinguish their separate effects. Metamorphism infers a change in form only, and metasomatism a change in substance, or composition. In this discussion, therefore, metamorphism refers only to alteration involving no apparent change in chemical composition, and metasomatism to alteration that has produced chemical reconstitution. Where metasomatic processes have produced a rock more like granite in appearance and composition than the original rock, the process is termed 'granitization'. Granitized rocks are widespread in the File-Tramping Lakes area, and are by far the most abundant rocks resulting from metasomatic effects. Hence, the two main types of rocks described here are those resulting from metamorphism and granitization.

METAMORPHISM

All types, and nearly all grades, of metamorphism are exemplified in the File-Tramping Lakes area. Except for some of the younger intrusions, most of the rocks of the area are noticeably altered. Dynamic metamorphism was confined solely to faulted and sheared rocks, and resulted in the formation of chlorite and sericite schists. Quartz and carbonate are common added constituents. Effects of thermal metamorphism are locally distinct near the margins of granitic intrusions. There the older rocks have been recrystallized, and commonly show an increase in grain size. Garnets have formed in some places, and west of Cook Lake small, orange-red garnets have formed in basic pillow lavas. Dynamothermal or, as it is more usually termed, regional metamorphism of all grades has been recognized, and is best displayed in rocks of the Snow group where it has been studied in considerable detail.

REGIONAL METAMORPHISM

In general, the intensity of regional metamorphism increases from south to north in File Lake map-area. The least altered sedimentary rocks are those about Tramping Lake, and the most completely transformed are those north of File and Loonhead Lakes. Areas underlain by Amisk rocks commonly contain many granitic intrusions, so that the regional metamorphic effects are obscured by thermal and metasomatic processes.

However, within the Snow group some bands of basic igneous rocks present an opportunity to compare regional metamorphic effects on them with those on sedimentary rocks, and the effects on these two groups of rocks will be discussed separately.

Regional Metamorphism of Sedimentary Rocks. Increasing intensity of regional metamorphism is marked by changes in mineral composition of the rock, and certain of the minerals so formed lend their names to the particular grades, or zones, of metamorphism. Thus the grades, or zones, of regional metamorphism for argillaceous rocks, from lowest to highest, are those in which chlorite, biotite, garnet (almandine), staurolite, kyanite, and sillimanite are the distinguishing minerals. Each succeeding zone begins with the first appearance of one of the diagnostic minerals, usually referred to as the isograd of that zone, and continues to a point where the next diagnostic mineral first appears. Minerals characteristic of lower grades commonly persist into rocks distinctive of higher grades, but never the reverse. Thus, biotite is usually present in rocks of all grades except those of the chlorite zone, but no almandine, staurolite, kyanite, or sillimanite could appear in the biotite zone because the temperatures and pressures needed to form them had not been reached. Some of the zones are believed to represent large increases in temperature; others probably represent small increases. Thus, the temperature is thought to increase considerably from the point where almandine garnet first appears (garnet isograd) to the point where staurolite first appears (staurolite isograd), after which relatively small increases are necessary to produce kyanite. Almandine garnet is, therefore, considered to be diagnostic over a broad zone of regional metamorphism, whereas staurolite is considered to represent a narrow zone. It is, of course, necessary that the rocks have a bulk composition such that these minerals can form, which means that aluminous material must be fairly abundant. The stress factor, too, must be at, or near, its limiting value throughout the time of metamorphism, otherwise certain of the diagnostic minerals cannot form.

The locality that best displays degrees of regional metamorphism in File Lake map-area is the long point separating Dummy Bay from the main body of File Lake. Rocks at the south end of the point and on the islands immediately south are recrystallized argillite and greywacke. Small flakes of rather pale biotite have been formed, and a few small, ragged garnets occur in some of the greywacke. About half a mile north, garnets are larger and quite common, biotite occurs in larger flakes, and sparse, small crystals of staurolite are peppered through argillite beds. Within the next mile north, garnets become larger and abundant in nearly all beds, and argillite contains staurolite in crystals an inch or more in length. Near the north shore of the lake staurolite crystals reach their largest size, and rounded knobs of quartz-sillimanite intergrowths appear on weathered surfaces. From this point north to Corley Lake, quartz-sillimanite intergrowths become more abundant, and staurolite less so (*See* Plate II B). About half a mile south of Corley Lake sillimanite-quartz knots comprise 50 per cent of some beds, whereas north from Corley Lake the staurolite-sillimanite schist is represented by a rock containing large garnets, but intergrowths of sillimanite and quartz are rather sparse, due probably to deficiency of argillaceous material.

North from Snow Lake, in the west half of the area, the change from biotitized argillite to sillimanite schist is not so marked. However, on the north shore of Snow Lake Narrows fine-grained argillite grades northwards to staurolite schist. The largest crystals of staurolite in the area were noted at the north end of the main body of Snow Lake and for a mile or two northwards. Some individuals are 6 inches or more in length. From south to north along the east shore of Squall Lake staurolite crystals become fewer, and near the north end of the lake a few sillimanite-quartz knots were seen. Exposures are rare north of the north end of the lake, but those seen indicate that the rock becomes characterized by large euhedral garnets, such as mark the continuation of the formation across the north side of the map-area and north of Corley Lake.

Progressive regional metamorphism is not so distinct in gneisses derived from greywacke and arkose. Biotite and garnet zones are readily discernible, but minerals diagnostic of the higher grades are not so common. Sillimanite-quartz intergrowths were seen in a number of places, but staurolite was seen only in argillaceous interbeds in greywacke. In other places the higher grades of metamorphism are represented by coarsening of grain and partial, or total, obliteration of bedding.

Kyanite has been reported from schists just east of the map-area (3, p. 15), but none was seen in the File-Tramping Lakes area. According to the grades of regional metamorphism outlined in a preceding paragraph, which were first suggested by Barrow (6) in 1893, and defined by Tilley (35) in 1925, a zone of kyanite should appear between the staurolite and sillimanite zones. In spite of careful search along the point between Dummy Bay and File Lake, and along the east shore of Squall Lake, no kyanite was found. In fact, some specimens from the point show clearly that staurolite crystals have been wholly replaced by fibres of sillimanite with the original outlines of staurolite still sharp and distinct. It seems clear, therefore, that either the sillimanite or staurolite zone, or both, overlap the typical kyanite zone, so far as these rocks are concerned.

Three samples, representing different grades of metamorphism in the argillaceous rocks, were collected for analysis from the exposures between File and Corley Lakes, in order to determine whether or not any peculiarities of chemical composition in them would prevent kyanite from forming. Sample No. I, near the south end of the point separating Dummy Bay from File Lake, was a fine-grained, dark, well-bedded argillite containing abundant fine flakes of biotite and very sparse, minute garnet crystals. Sample No. II, taken a short distance north of No. I, was a fine- to medium-grained, slightly schistose rock, peppered with crystals of staurolite as much as half an inch long and one-tenth inch wide. Sample No. III, from the southwest end of Corley Lake, was a very schistose, rather coarse-grained rock that contained poorly formed crystals of staurolite slightly larger than those in No. II, and intergrowths of sillimanite and quartz about one-quarter inch in diameter. These analyses are shown in Table I, compared with an analysis of biotite-kyanite gneiss, another of sillimanite-garnet gneiss, and a composite analysis of fifty-one shales.

TABLE I

Analyses of Argillaceous Rocks

	I	II	III	IV	V	VI
SiO_2	58·55	64·63	58·90	55·82	60·33	60·15
Al_2O_3	18·95	19·00	21·70	18·91	17·17	16·45
Fe_2O_3	0·51	1·56	1·20	1·80	3·93	4·04
FeO	5·16	3·63	5·10	8·43	6·55	2·90
CaO	2·70	3·48	1·54	2·23	0·90	1·41
MgO	2·70	2·49	2·63	5·38	3·35	2·32
K_2O	4·07	1·60	2·41	2·48	4·57	3·60
Na_2O	1·85	1·54	1·39	1·22	0·73	1·01
H_2O+	1·37	0·92	1·32	1·66	1·00	3·82
H_2O-	0·23	0·20	0·46	0·19	–	0·89
CO_2	0·60	tr.	0·00	–	–	1·46
TiO_2	0·53	0·42	0·63	1·10	1·52	0·76
P_2O_5	0·17	0·21	0·50	0·09	0·04	0·15
C	2·58	0·64	1·56	–	–	0·88
MnO	–	–	–	0·21	0·09	Trace
SO_3	–	–	–	–	–	0·58
Total	99·97	100·32	99·34	99·52	100·18	100·42

I. Garnetiferous argillite, File Lake, Manitoba. Analyst, R. J. C. Fabry.
II. Staurolite schist, File Lake, Manitoba. Analyst, R. J. C. Fabry.
III. Sillimanite-staurolite schist, File Lake, Manitoba. Analyst, R. J. C. Fabry.
IV. Biotite-kyanite gneiss, Lewisian, Scotland. Analyst, E. G. Ridley (18, p. 114, anal. 440).
V. Sillimanite-garnet gneiss, Papineau county, Quebec. Analyst, M.F. Connor (41, p. 393).
VI. Average of 51 Palæozoic shales. Analyst, H. N. Stokes (14, p. 552).

It is readily seen from these analyses that the chemical composition of the rocks should not inhibit the formation of kyanite. Modal compositions estimated from thin sections, and normative compositions calculated from analyses, are shown for the same three samples from the File Lake map-area in Table II.

It should be noted that for sample No. II no kaolin or similar mineral was noted in the rock, but recasting the analysis leaves an excess of alumina, shown as kaolin, and is further evidence supporting the need for some explanation other than chemical composition to account for the lack of kyanite.

Another feature of regional metamorphism of sedimentary rocks in the Snow group is the delay in appearance of sillimanite in arenaceous beds as compared with its appearance in argillaceous members, a characteristic that is probably related to the lack of kyanite. Metamorphic grade increases from south to north in this area. Garnets appear at about the same geographic latitude in both the arenaceous and argillaceous types, but increase in size and abundance at a much greater rate in the argillites. Staurolite appears in argillite within a short distance north of the first appearance of garnet, but occurs very sparsely, if at all, in the more arenaceous rocks. The staurolite zone in argillite is relatively broad, contrary to its usual occurrence, and sillimanite does not appear at File Lake until the northwest corner of the lake is reached. It is present in argillites

TABLE II

Modes and Norms of Metamorphosed Argillites

—	Modes (volume per cent)			Norms (weight per cent)		
	I	II	III	I	II	III
Quartz	35	50	25	26·9	41·5	34·4
Plagioclase[1]		5	10–15	13·4	4·8	8·4
White mica	25–30	5	5	18·7	12·7	10·0
Dark mica	25–30	20	20	23·9	13·8	20·4
Chlorite	minor	minor	–	0·9	–	–
Staurolite	–	10	5–10	–	12·1	7·2
Sillimanite	–	–	15–20	–	–	13·5
Garnet	minor	5	–	5·6	7·5	–
Kaolin	–	–	–	3·9	4·8	–
Calcite	–	–	–	1·4	–	–
Iron ore	minor	minor	minor	1·7	1·1	1·6
Apatite	–	–	minor	0.4	0·6	1·3
Sphene	–	minor	minor	–	1·0	0·4
Rutile	–	–	–	–	–	0·2
Graphite	5–10	5	5–10	2·6	0·6	1·6
Totals	100	100	100	99·4	100·5	99·0

[1]Compositions of plagioclase as determined in thin sections are: No. I, An_{10}, No. II, An_{33}, No. III, An_{34}.

farther east, and again in a very thin selvage of argillite near the south end of the west shore of the bay leading to the outlet of the lake. Apparently the sillimanite isograd is nearly due east from the northwest corner of File Lake, but no sillimanite was observed in greywackes and arkoses for some distance north of this line. Staurolite and sillimanite occur in some fine beds in greywacke about ½ to ¾ mile north, and are sporadically present as far north as Corley Lake. No staurolite was seen anywhere in the arkose, and sillimanite was first observed in it about ½ mile north of the File-Corley Lakes portage. Knots of typical sillimanite-quartz intergrowths appear abruptly and attain large dimensions within a few hundred feet. Their first noted occurrence in arkose thus lies more than 2 miles north of the sillimanite isograd of argillites. Similarly, at Squall Lake, sillimanite was noted in argillite on the east shore about a mile south of the north end. But sillimanite does not occur in arkose until a point about 1½ miles east of the north end of Squall Lake granite, or nearly 3 miles north of its first occurrence in argillite. It was, however, observed in greywacke within a mile of its appearance in argillite.

A striking feature of the sillimanite-quartz knots in arenaceous rocks is their size. Where developed in argillaceous types they rarely exceed ¼ inch in maximum dimension, but are quite abundant (*See* Plate II B). The largest knots observed occur about 1 mile east of the north end of Corley Lake in arkosic gneisses. There, one lens-shaped knot, which had been planed on one surface by glaciation, measured 1·3 by 1·1 by 0·6 inches, and other knots were nearly as large. Under the microscope it was seen to consist of about 50 per cent quartz, 40 per cent sillimanite, less than 10 per cent muscovite, and minor magnetite, apatite, and sericite. All knots contain these minerals but in different proportions, some containing as much as 90 per cent sillimanite. All have a flaser or augen structure, in which grains of quartz are enclosed by oriented fibres of sillimanite that "flow" around them. Sillimanite partly replaces muscovite, and also occurs as acicular individuals oriented at random in grains of quartz.

Some of the factors that might cause the lag in appearance of diagnostic minerals in regionally metamorphosed rocks have been considered in the literature. Harker (19, p. 184) argued convincingly that shearing stress is constantly maintained at its maximum value with changing temperature, and, as stress is an inverse function of temperature, it falls off as temperatures rise. He further noted (p. 187) that maximum stress at a given temperature may be much greater in one rock than another. Thus (p. 245), owing to their superior rigidity, arenaceous rocks resist stress, thereby postponing the appearance of biotite in them. However, it appears that this superior rigidity is lost as the temperature rises, because the higher index minerals, such as almandine, appear at about the same place in arenaceous as in argillaceous rocks. Turner (37), in a detailed account of regional metamorphism in Otago, New Zealand, stated that the chlorite zone as determined for greywackes probably includes rocks of rather higher grade than those of the chlorite zone as defined for pelites in Scotland.

According to the above observations such a lag in appearance of diagnostic minerals should occur only in zones of lower grade metamorphism, perhaps to the lower limit of the garnet zone, whereas it extends to the highest grade of regional metamorphism in this area. It is possible that the lower limit of sillimanite was missed in the arenaceous rocks, but most improbable that it was missed for 2 or 3 miles. It could also be argued that the compositions of the greywackes and arkoses were not elsewhere appropriate for sillimanite to form. However, it would be a remarkable coincidence if beds of appropriate composition first appeared only at the sillimanite isograd in two different formations, in two localities 10 miles apart, and in the same relative positions. Further, once the sillimanite isograd is passed, the mineral is quite common in the arenaceous rocks.

The stress factor in the sillimanite zone is less important than the heat (Harker, 19, p. 209), so the selective appearance of sillimanite might theoretically be dependent on heat available at a given point. However, in this area intrusive granite is much nearer to greywacke at Squall Lake, and to arkose at File Lake, than it is to argillite. Further, if the stress factor were deficient, minerals such as cordierite and andalusite should be formed. Only one grain of andalusite was seen in examining many thin sections, and neither andalusite nor cordierite was seen in the field.

It appears, therefore, that under certain conditions the appearance of certain diagnostic minerals can be considerably delayed in arenaceous as compared with argillaceous sediments. Neither heat, pressure, nor composition appears to be a controlling factor in this case. The only other variable is the length of time available for mineral reconstitution. Formation of metamorphic minerals is generally considered to result from diffusion of rock materials to centres of crystallization. Minerals forming at the centres are those in equilibrium with temperature-pressure conditions existing at that time. Fine-grained rocks, which withstand less shearing stress than coarser types, should react more quickly. Diffusion should be more rapid, as the materials are more finely divided and numerous centres should be available for mineral formation. Materials in a coarser grained rock are more widely separated, and the aureole of diffusion for any centre must be greater to obtain all the constituents necessary for a particular mineral. Consequently, in a greywacke or arkose the clayey constituents necessary to form kyanite, staurolite, and sillimanite would, in all probability, be interstitial to detrital grains. If at minimum temperatures and stress for the formation of, say, sillimanite, the time available was not sufficient for the necessary constituents to migrate, or diffuse, through these relatively long distances to crystallization centres, sillimanite could not form. But if the temperature passed well beyond the minimum, the rate and range of diffusion would be greater, and sillimanite could form rather quickly at the sparse crystallization centres. The crystals so formed would be fewer, but larger, than those in argillites. It is perhaps possible, too, that a rapid increase in temperature could prevent formation of kyanite from staurolite in the pelitic rocks, and hence staurolite would pass directly to sillimanite. Thus, it would appear that high temperatures operated for a relatively short time when these rocks were metamorphosed. In other words, temperatures were probably not maintained long enough for the mineral assemblages of the rocks to attain equilibrium with the existing conditions, at least in the higher grades of metamorphism.

Three other characteristics of the metamorphic rocks in the Snow group also suggest that equilibrium was not reached in the higher grades. These are: (1) local distribution of sillimanite-quartz knots in individual beds of argillite; (2) preservation of original structural features such as grain gradation, even in rocks in the lower part of the sillimanite zone; and (3) relatively fresh character of the Snow rocks near contacts of basic volcanic rocks, even though the main bulk of the sedimentary members is well within the higher zones of regional metamorphism.

Several examples of the first of these features are well illustrated north of File Lake. Layers derived from argillite, separated by beds of greywacke, are as much as a foot thick. No bedding is discernible in these layers, but they probably represent several thin beds. Intergrowths of sillimanite and quartz are concentrated in patches, belts, and clusters in the layers and show no relation to the contacts of the layers (bedding), or to any imaginable stratification within the layers of argillite to which they are confined (Figure 1).

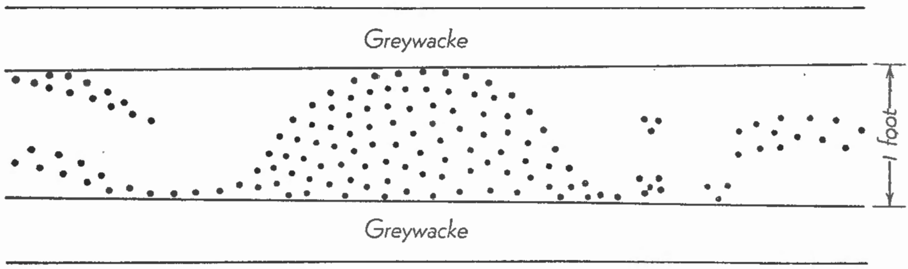


Figure 1. Illustrating concentrations of intergrowths of quartz and sillimanite (stippled areas) in argillite.

At several localities near the north shore of File Lake, which is within the lower part of the sillimanite zone, grain gradation is well preserved in the argillaceous beds, in spite of the fact that they have been subjected to sufficient heat and pressure to contain sillimanite. Sillimanite is mainly present in the finer grained parts of the beds, as would be expected, so that on superficial examination there appears to be a reversal of grain gradation. However, this was not noted in the higher parts of the zone.

Finally, it appears that large masses of rock that are resistant to shearing stress exert an influence on the grade of metamorphism in the argillaceous rocks near their contacts. In nearly all places where exposures of Snow rocks have been found near large bodies of basic lavas, the Snow rocks appear remarkably fresh. Thus, near the right-angled bend of the Cleaver Lake fault north of Snow Lake, well-bedded, fine-grained argillites lie east of the fault, but 300 or 400 feet west they contain staurolite crystals as much as 4 inches long. Similar conditions were noted at a number of localities farther south. Where diamond-drill holes cross the fault on the Nor-Acme property the sedimentary rocks are argillites, which grade into staurolite schist in a few feet. Similarly, diamond-drill logs of holes in Snow Lake Narrows show that the rock does not contain staurolite crystals. Further, the rocks along the Dummy Bay fault pass from argillite to sillimanite schist in a few scores of feet east of the fault. Analogous conditions have been noted in other areas mapped by the writer, even where there are no known faults. It appears that the basic rocks are more resistant to stress than the argillaceous rocks, and act as an anchor for them. As the degree of regional metamorphism depends on stress, as well as on temperature, the diagnostic minerals are unable to form. Probably, too, at least part of the shearing that characterizes these contacts is caused by the fact that the argillaceous rocks deform readily, but, near contacts with more resistant rocks, the weaker rock fails by shearing.

An interesting sidelight on reverse grain-gradation was noted on the east side of the point separating Dummy Bay from File Lake. Many beds of greywacke are contained in the argillaceous rocks, and primary grain-gradation can be distinguished in them along the length of the point. At the south part of the point garnets are common in the finer grained parts of beds, the garnets being larger than the primary grains in the coarser grained parts. A similar condition was noted near the east end of Snow Lake, about 40 feet west of the No. 2 post of the Rostov claim, but in this instance staurolite crystals lend to the rocks the reverse grain-gradation. Thus, this feature is produced in File Lake map-area by garnet, staurolite, and sillimanite. However, on the east side of the point in File Lake it was found that, where the argillaceous beds contained abundant staurolite, the garnets in the interbedded greywacke were coarser at the bottom of the beds than in the top. That is, in the lower part of the garnet zone for greywacke, reverse grain-gradation was the rule, but in the higher part the metamorphic and primary grain-gradations were coincident.

Read (26) noted reverse grain-gradation in the Dalradian of Scotland where andalusite formed in the fine-grained, upper parts of beds where clayey materials are most abundant, and where metamorphic diffusion could take place most easily due to the fineness of grain. There can be little doubt that the same conditions caused similar concentrations of staurolite and sillimanite in argillaceous beds of the Snow group. However, it appears that another condition was effective in the garnetiferous beds of greywacke, and is probably dependent on grain size and aureole of diffusion, as has been postulated for the delay in appearance of sillimanite in the arenaceous rocks. In the lower parts of the garnet zone the upper parts of the beds were fine enough to permit diffusion of the materials necessary to form garnets, although a few did form in the coarser parts of the beds. But, as the degree of metamorphism increased, so did the aureole of diffusion, and the garnets added material drawn from a relatively large radius. Thus, in the higher grades of metamorphism, abundant, comparatively small garnets occur in the upper parts of beds, whereas fewer, but relatively large, garnets characterize the lower parts.

Regional Metamorphism of Basic Igneous Rocks. Basic volcanic rocks are most abundant in the Amisk group, and some are present in the Snow group. They, too, have been regionally metamorphosed, but in most places metasomatic effects have been superimposed on the metamorphic.

Grades of regional metamorphism in basic volcanic rocks, which are equivalent to those established for pelitic sedimentary rocks, are difficult to determine. First, the chemical composition of basic volcanic rocks is radically different from the sedimentary rocks, so that, with few exceptions, the same minerals cannot form, and secondly, the composition of the basic rocks is such that diverse minerals diagnostic of different degrees of metamorphism do not form to the same extent as they do in the pelites. Among the minerals formed in basic rocks, and which may be used to determine grades of regional metamorphism, are chlorite, amphiboles, plagioclase, garnet, pyroxene, epidote, and biotite.

Wiseman (42) found that progressive metamorphism of basic igneous rocks in the Highlands of Scotland produced albite and pale hornblende in the chlorite and biotite zones of pelitic schists, but in the garnet zone plagioclase becomes more calcic and the hornblende is typically blue-green, and andesine is characteristic of the kyanite and sillimanite zones. Turner (36, p. 540) noted that "oligoclase normally appears as a product of dynamothermal metamorphism at relatively high grades such as prevail in the zones of almandine and perhaps kyanite". Ambrose (4, p. 268) found, in examining greywackes of the Missi series near Flin Flon, that, concurrently with the appearance of garnet, the anorthite content of the associated plagioclase rose abruptly from An_{6-8} to An_{28-32}. Greenstones exposed in the garnet zone are composed mainly of greenish blue amphibole, and plagioclase is more calcic than albite (p. 277). Harker (19, p. 283) noted that chlorite soon disappears in the garnet zone, epidote diminishes, greenish hornblende becomes the dominant mineral, feldspar passes through oligoclase to andesine, and, in the highest zones, pyroxene should appear. Bateman (7, p. 796) noted that, in general, the greater the intensity of metamorphism, the deeper the colour of the amphiboles. From these observations it appears that blue-green hornblende, plus plagioclase at least as calcic as An_{20-30}, can be considered to indicate a grade of metamorphism for basic igneous rocks equivalent to the garnet zone of fine-grained sediments.

Hornblende gneisses and schists of the Snow group vary greatly in appearance. Some are distinctly volcanic in origin, others intrusive, but for most of them the origin is obscure. Thin sections of them reveal that from south to north the plagioclase becomes more calcic, the hornblende more strongly coloured and darker, and the grain size somewhat coarser.

The basic flows west of Birch Lake and north of Snow Lake are fine grained, the plagioclase is a sodic andesine, and the hornblende is actinolitic. These probably represent rocks near the lower limit of the garnet zone, and, in fact, are associated with garnetiferous greywacke and arkose. Farther north these rocks become distinctly coarser, and are characterized by deeply coloured hornblende and calcic andesine. However, the mineral facies cannot be followed with certainty, for these rocks in this part of the area are extensively faulted and sheared, and locally contain abundant quartz and carbonate.

The hornblende gneisses in the west half of the area are not exposed south of the recognizable sillimanite isograd of the argillites, but as they occur interstratified with sedimentary rocks some comparisons are possible. Some volcanic types are represented by the hornblende gneiss that is bounded by coarse sillimanite schists and gneisses just north of File Lake. At a point about 200 feet from a contact with sillimanite schist remarkably fresh-looking, thinly bedded, basic tuff is well exposed. Thin section examination shows the rock to be recrystallized, slightly gneissic and granulated, and compositionally banded. Minerals are 50 per cent andesine (An_{40}), about 30 per cent pale, bluish green, prismatic hornblende, and about 10 to 15 per cent iron ore. Minor sphene and stringers of vein quartz comprise the rest of the rock. The assemblage is characteristic of high-grade regional metamorphism, but not as high as that of the sedimentary rocks on either side. On Loonhead Lake regional metamorphism is more apparent, for the basic igneous rocks show a distinct foliation, or banding, and locally contain garnets. A garnet-bearing member from the west shore of the lake consists of 40 to 50 per cent labradorite (An_{55}), 35 per cent dark green hornblende, subordinate quartz and reddish garnet, and minor magnetite. Quartz appears to be introduced. Light and dark minerals are concentrated in alternating streaks. Another member, from the largest island, consists of 50 per cent very dark green hornblende, 40 per cent sphene, and minor magnetite. These, again, indicate high-grade types of regional metamorphism, and, judged by the dark colour and blocky character of the hornblende, as well as by the more calcic plagioclase and more abundant sphene, these rocks at Loonhead Lake probably indicate a somewhat higher grade than those at File Lake.

Currie (15) studied these basic rocks in considerable detail and noted that clinopyroxene commonly occurs in the higher metamorphic grades, although it is seldom abundant. He distinguished two main facies in these rocks: (1) green hornblende-andesine (An_{30}-$_{36}$) and (2) blue-green hornblende-andesine (An_{36}-$_{42}$)-garnet, the first being characteristic of the basic rocks on the north side of File Lake, and the second of those at Loonhead Lake. Clinopyroxene is present in places at both localities. The first-mentioned facies is thought to be equivalent to the garnet zone, and the second to the sillimanite zone of sedimentary rocks. However, both these must include some parts of the intervening staurolite zone of sedimentary rocks, which in turn has been shown to include some at least of the typical kyanite zone. At any rate, it is apparent that zones of regional metamorphism are much less clearly defined for basic igneous than for pelitic rocks.

Distinct compositional banding, or foliation, is a feature of some regionally metamorphosed basic flows in File Lake map-area, and is considered to represent results of metamorphic differentiation. The idea of such a process is not new. Stillwell (29) proposed diffusion of materials in the solid state to account for some phenomena in metamorphic rocks of Antarctica. Eskola (17) and McCallien (25) suggested a similar origin for pseudo-stratification in rocks of Finland. Harker (19, p. 203) considered development of foliation (banding) in a similar light, but felt that it was more probably an accentuation of original structures. Turner (38) found that foliation had been developed in rocks that were not originally marked by distinct compositional differences. It appears that, during regional metamorphism, the crystallization centres of the minerals being formed are likely to become concentrated in particular layers. As a result, any one layer is characterized by an abundance of a mineral that occurs only in subordinate amounts in adjacent layers, and, in some places, a pronounced banding, or foliation, is thereby induced.

Where this phenomenon was first encountered in greenstones northwest of Squall Lake, it was thought that the rocks were metamorphosed tuffs. However, it was noted that these bands, which so resembled bedding, did not persist more than 10 to 20 feet along the strike, but were actually very elongated and flattened lenses, and the rocks exhibiting this feature were subsequently traced southwards into massive, basic flows. Again, in the region about Loonhead Lake, this foliation is distinct, but the individual bands do not persist more than a few feet along strike. They are due to concentration of light and dark minerals into separate, very elongated, flat lenses. Contacts between bands in hand specimen are sharp, but when viewed with the microscope they are abruptly gradational. Dark layers consist mainly of the typical blue-green metamorphic amphibole, and the light bands of recrystallized andesine, with or without quartz. Thus, the predominant minerals of one layer become the subordinate minerals of adjacent layers. If this be due to bedding it presupposes a remarkably consistent alternation of material to form the beds. Also, as no layer noted was more than 10 or 12 feet long, an origin other than bedding seems indicated.

Finally, unmistakable foliation induced in massive flows by metamorphism is demonstrated in outcrops of Amisk lavas about $1\frac{3}{4}$ miles west of the south end of the curving arm of Woosey Lake, and $\frac{1}{8}$ mile north of the Reed granite. There the rocks have been burned clean and are well exposed for study. They consist of massive, basic flows with a few intercalated flow breccias, and pillow lavas. At one place a contact between breccia and originally massive lava is exposed. Fragments of breccia are extremely attenuated. The lava that was originally massive is now thinly banded, due to alternating grey and whitish streaks, and to less numerous, but thicker, lenses or layers rich in mafic minerals (*See* Plate IV A). A short distance away lenses of contrasting composition in a lava flow are even more strikingly displayed, the bands varying from $\frac{1}{40}$ to $\frac{3}{4}$ inch thick and from 1 foot to 12 feet long. Some are rich in hornblende, others in pyroxene and hornblende, some in epidote, and others in feldspar. All contain subordinate to minor amounts of other minerals. In thin section the hornblende is deep bluish green, fine grained, blocky, and in some layers intergrown with colourless, highly birefringent pyroxene. Plagioclase is granular, partly untwinned, and has the composition of andesine (An_{34}). Epidote, or clinozoisite, is fine grained and confined largely to layers rich in andesine. Minor quartz, magnetite, and ilmenite complete the assemblage. It is probable that the quartz was introduced, for small veins cut the outcrop. The assemblage suggests the effects of thermal metamorphism superimposed on dynamothermal processes, a characteristic to be expected, for the contact of Reed granite is less than 400 yards distant.

It seems clear that processes of differentiation can take place when originally massive, rather fine-grained rocks are subjected to metamorphism. No evidence, either in outcrop or under the microscope, indicates that this pseudo-stratification is in any way due to *lit-par-lit* injection, metasomatism, or differential fusion. That foliation has been produced in massive basic lavas of the File Lake map-area by a process of metamorphic diffusion appears to be an inescapable conclusion.

GRANITIZATION

Granitization has locally affected all volcanic and sedimentary formations in the area, but only those rocks have been mapped as 'granitized' that have been altered rather thoroughly. Amisk rocks and the unclassified sedimentary rocks have been granitized, in part, by two different periods of igneous intrusions, the first of these being 'quartz-eye' granite, the other the biotite granite. These were mapped separately, so far as possible, in File Lake map-area, but could not be separated in Tramping Lake map-area. North of Reed Lake, however, in Tramping Lake map-area, coarse, granitized and epidotized amphibolites derived by emanations from the biotite granite have been distinguished on the map from the more usual granitized rocks of that area. Where rocks of the Snow group have been granitized they have been mapped as granitized or granitoid gneisses, depending on the degree of alteration.

GRANITIZED AMISK ROCKS

Amisk rocks that have been granitized grade into 'quartz-eye' granite through highly siliceous and feldspathic rocks that are commonly gneissic and, in places, resemble rhyolite or sedimentary rocks, and into biotite granite through rocks that are more granitic in texture and have compositions approaching diorite or granodiorite. In most parts of File Lake map-area the two varieties can be distinguished with reasonable certainty, but near the south edge of the map-area the two are intermingled and the distinctions are not clear. Where the older alteration, associated with the 'quartz-eye' granite, has had superimposed on it the effects of the younger biotite granite, the rocks were mapped as related to the younger intrusions. In Tramping Lake map-area the two varieties are inseparable, and are classed as granitized rocks without implying a particular magmatic agent, the only exceptions being the plagioclase amphibolites north of Reed Lake, which are related to the younger granite.

Unclassified sedimentary rocks are so subordinate that their alterations are considered with those of the Amisk group.

Granitized Rocks Related to 'Quartz-eye' Granite. Granitized products believed to result from metasomatic effects of 'quartz-eye' granite on Amisk rocks are widespread south of Snow Lake and west of the creek draining Squall Lake, but none was recognized in rocks of the Snow group. Some of these hybrid rocks may have resulted from the intrusion of younger granites, but in many places the distinction is reasonably clear, for they grade into 'quartz-eye' granite.

The more completely altered product bears no resemblance to the basic volcanic rocks from which it was derived. It is typically a rock of fine to medium grain that weathers pinkish to ashy grey to chalky white. Dark minerals are subordinate or lacking, and garnets are common. Foliation is marked, and in many places the rock appears to be sedimentary, a feature that leads to confusion in mapping where sedimentary rocks are exposed nearby, as at Morgan Lake. At places there it was found nearly impossible to distinguish between poorly bedded, pinkish weathering greywacke and arkose, and altered rocks that could, locally, be traced into basic volcanic rocks.

In general, these hybrid rocks have lost all their original structures, but in a few places breccia fragments or outlines of pillows are still recognizable. At many localities the altered rock can be traced through a broad zone of increasing basicity to recrystallized basic flows or breccias; in a few others the contact is sharp.

Relict pillow structures are clearly exposed on an outcrop that is crossed by the portage between Threehouse and Moore Lakes. The interiors of these pillows are ashy grey on the weathered surface, speckled with sparse amphibole, biotite, and garnet, whereas the selvages are dark grey, consisting mainly of hornblende, biotite, garnet, and subsidiary feldspar. South of Snow Lake Narrows a small zone of hybrid rock shows fragment outlines, and about a mile southwest from the west end of Snow Lake a less altered breccia has well-preserved fragments. About a mile northeast of Chisel Lake, basic breccia and hybrid rock are in sharp contact, which is irregular in detail and is at an angle of about 30 degrees with the bedding. Similarly, contacts of hybrid rocks east of Ghost Lake cut across regional structural trends. Other examples of this alteration are widespread in the area.

The gradation from hybrid rock to 'quartz-eye' granite is likewise apparent, and can be seen at several localities around Cook Lake, a mile or two east of Woosey and Morton Lakes, southeast of Moore Lake, east of Anderson Lake, and south of Tern Lake. At these places the hybrid rock becomes increasingly more like granite and contains increasingly large numbers of 'quartz-eyes', so that it is seldom possible to indicate a definite contact.

The mineral composition of these hybrid types varies widely, depending on the degree of metasomatism. Plagioclase, varying from sodic oligoclase to calcic andesine, and quartz are the predominant minerals, and in some places constitute 90 per cent or more of the rock. Biotite (0-25 per cent), amphibole (0-35 per cent), and chlorite (0-15 per cent) are the chief subordinate constituents. Garnet, sericite, epodite, and carbonate are each locally present in amounts up to 15 per cent of the rock. Apatite and iron ore are common accessory minerals, and pyrite, sphene, pyroxene, zircon, and serpentine are less common.

Granitized Rocks Related to Biotite Granite. Rocks with granitic textures that have been formed by granitization of volcanic and sedimentary rocks are common near the margins of certain batholiths and stocks of the younger granitic rocks, and form mappable units south and southeast of Morgan and Woosey Lakes. Most of the granitized rocks in Tramping Lake map-area are probably related to these intrusions.

In many places the effects of the biotite granite have apparently been superimposed on those of the 'quartz-eye' granite, producing a rock rich in feldspar and quartz, and with a granitic texture. Such rocks are fairly common along the east side of the Ham granite. In File Lake map-area it is probable that some rocks, mapped as derivatives of 'quartz-eye' granite, are actually derived from the younger biotite granite.

Granitization by the younger, biotite granite produces gneissic and granular rocks varying from fine to coarse grained, and from diorite to granodiorite in composition. Such rocks grade on one hand into basic Amisk flows, and on the other pass into granite. Microscopic examination reveals that the rocks have been recrystallized, potash feldspar and quartz have been introduced, hornblende has been altered to biotite, and a general transition towards a rock with the composition of a granite is characteristic.

A contact zone of a type different from those usually associated with the biotite granite lies east of the north bay in Reed Lake, in Tramping Lake map-area. The rocks there are composed of coarse, epidotized amphibolite, which commonly contains considerable magnetite. This variety is thought to be derived from basic flows, and is shown separately from the other hybrid rocks on the Tramping Lake map.

GRANITIZED SNOW ROCKS

Rocks of the Snow group become more metamorphosed from south to north, and in the northern part of File Lake map-area they have been converted to Kisseynew gneisses. Some of these gneisses have been intensively granitized, and have been mapped as granitized or granitoid gneisses, depending on the degree of alteration.

The granitized gneisses include those derived from greywacke, arkose, argillite, and basic igneous rocks, to which so much granitic material has been added that the original lithology could not be determined. In part, the granite has been added in the form of abundant dykes, but, more commonly, the rocks have been 'soaked' by granitic fluids. In a few places structural trends are sufficiently clear, or granitization so local, that contacts may be projected through such rocks.

In outcrops the granitized gneisses are commonly pink or grey, fine to medium grained, and strongly gneissic. Bedding is preserved to a greater or lesser degree by layers differing slightly in composition. Compositional differences are seldom apparent on fresh surfaces, and the rocks vary in appearance from gneissic granite to diorite.

These rocks consist mainly of recrystallized oligoclase, quartz, and microcline in varying proportions, plus subordinate to minor amounts of biotite, amphibole, garnet, sphene, apatite, and iron ore. Strain extinction of the light constituents is common, and granulated borders are characteristic. Some quartz is in micrographic intergrowth with feldspar, and most of the microcline occurs in stringers and clots.

Rocks classed as granitoid gneisses have the composition of granite, granodiorite, or quartz diorite, and grade into intrusive granitic rocks as well as into the granitized gneisses described above. They differ from the latter in being generally coarser grained, more granitic in appearance, and lacking in bedding. They differ from gneissic granite in that dark constituents tend to be concentrated in narrow bands separated by bands of light minerals. This foliation is probably a characteristic inherited from rocks that were originally bedded. Boundaries between gneissic granite and granitoid gneisses are gradational.

The granitoid gneisses commonly are medium- to rather coarse-grained rocks that weather grey to pinkish grey streaked with dark minerals. Biotite is the main subordinate mineral, but hornblende is also common. The proportion of mafic minerals varies from about 10 to 35 per cent, and probably averages about 20 per cent of the rock. In thin section the granitoid gneisses are similar to granitized gneisses except that they are fresher, less granulated, more granitic in texture, and contain more microcline. Vermicular intergrowths of quartz and feldspar characterize granulated zones. These rocks appear to be a more completely granitized phase of the sedimentary gneisses, a conclusion reached in the study of similar rocks near Sherridon (9).

GENERAL CONSIDERATIONS OF GRANITIZATION

None of the rocks described in the preceding paragraphs can properly be termed granite. The granitoid gneisses are close to granite in appearance and composition and grade imperceptibly into rocks that are granite, a feature that is well displayed in the rocks of the File Lake anticline. The core of this structure is occupied by the File granite whose gneissic structure faithfully reflects the anticlinal form. Examination of thin sections shows the rock to be a granite in bulk composition, but the potash feldspar and some quartz occur as stringers and clots, and are unquestionably introduced. These rocks grade into granitoid gneisses, which contain less potash feldspar and more biotite, and these in turn grade into granitized gneisses and into sedimentary gneisses. At no place in this sequence is it possible to indicate a definite contact. The granite in the core of the anticline is not a batholith, as exposed, for it is only about 4½ by 1½ miles in area, but seems to demonstrate that granitization can produce masses of considerable extent.

A small granite mass at the southwest end of the Ham granite lies between the two north arms of Woosey Lake in File Lake map-area, and can be interpreted as representing a still more advanced stage in the process of granitization. This mass is nearly round, a little more than 2 miles in diameter, and air photographs of it show a marked concentric structure. Bedding in the enclosing sedimentary rocks conforms with the contact, and dips steeply away from the granite, which, therefore, appears as a pipe, or plug. Examination of the granite within the plug shows it to be quite massive, no sign of gneissic structure being seen more than a few feet from the contact. The granite is a rather coarse-grained, porphyritic, biotite-bearing variety that holds scattered, elongated inclusions of granitized sedimentary rocks that are oriented parallel with the trend of outcrops observed on air photographs. It appears that granitization at Woosey Lake has been sufficiently complete to destroy pre-existing gneissic trends, but not the major structural outline of the original rocks.

Neither of the granites described from File Lake map-area is a batholith in exposed dimensions, and some of the other small bodies of granite in the File-Tramping Lakes area have similar features. However, the Ham and Reed granites, the two largest batholiths in the area, do show some similarity to the smaller masses. The Ham granite north of Vickers Lake encloses an elongated domical structure composed of garnetiferous granite, and may represent sedimentary rocks converted to granite. Gneissic structure near the margins in all the large granite masses is parallel with the contacts, but such structures might represent flowage phenomena of a viscous magma.

From a consideration of all field and laboratory work it appears that a considerable proportion of the rocks mapped as granite have formed by granitization, and that large amounts of other rocks have been so altered that they are much more like granite than they were originally. However, there is much evidence that a granite magma did exist. The Ham granite batholith is full of inclusions in all stages of alteration from "ghost" remnants to sharply defined, angular blocks that have not visibly been altered. Both kinds of inclusions occur side by side, and it seems logical to assume that the fresh blocks were incorporated in the magma for a much shorter period than the "ghost" remnants. If so, the magma must have been reasonably fluid to permit the movement of inclusions through it. Further, the larger inclusions are cut by dykes of granite. Finally, the position of the Ham granite with respect to major structural features in File Lake map-area strongly suggests that it represents an intrusion accompanied by orogenic forces.[1]

Further evidence in support of magmatic granite is provided by the large zone of contact breccia lying west of Tramping Lake in Tramping Lake map-area. There the breccia consists of closely spaced, angular, xenolithic blocks of quartz gabbro in a matrix of granite. The blocks appear quite unaltered, and no evidence for granitization was noted, indicating that the granite must have been fluid, and have been injected into a brecciated rock (3, p. 39, Plate II A).

It appears, therefore, that granitization has taken place on a regional scale in the File-Tramping Lakes area, and has locally been intensive enough to produce granite, but abundant evidence indicates that magmatic granite also existed in large amounts.

[1] These structural features are described in the chapter on structural geology.

CHAPTER IV

STRUCTURE

GENERAL STATEMENT

Folds and faults are numerous in File Lake map-area and, in places, have been studied in considerable detail. A large part of Tramping Lake map-area is, on the other hand, underlain by granite and flat-lying Ordovician limestone or is covered by water and drift, so that distinguishable structures are few. The general trend of folded structures in the combined area is northerly. Folds plunge south in the west half of the area but, except near Squall and Morgan Lakes, plunge north in the east half. Shear zones are widespread. Many of them mark the loci of faults, but some are probably due to slippage between beds during folding. At least two periods of faulting and folding can be distinguished.

The direction and amount of plunge of linear elements and drag-folds are shown on the maps. The most common structure denoting plunge in the map-area is a ridging or fluting on bedding surfaces, which, presumably, formed by slippage between beds during folding. The direction and amount of plunge of these should be the same as that of the folds in which they occur. A somewhat similar lineation is in evidence on shear surfaces in fault zones (Plate IV B). Pencil structure is well displayed only between Herblet and Snow Lakes at the east edge of the area. The plunge of drag-folds is recorded in few places, for in areas where faults are common it is difficult to distinguish between drags due to faulting and those due to folding. The latter should give the plunge of the associated fold, but the former indicate only relative movement on a fault. Where outcrops are scarce and the folds are overturned, as in the northern part of the area, the direction of plunge is, in places, the only guide as to whether a structure is an anticline or syncline.

The northern 2 to 6 miles of File Lake map-area is underlain by Kisseynew gneisses. Primary structures, such as grain gradation, cross-bedding, and pillows, have been destroyed, and the formations are overturned to the west or southwest, a feature characteristic of the structures in the Sherridon map-area (9)[1]. The southern limit of such overturned strata is irregular, but is farther south in the west half than it is in the east half of the area.

In most places the trend of rock ridges is parallel with the direction of bedding and foliation, but south and west of the west end of Snow Lake the ridges trend parallel with regional schistosity whereas bedding and foliation are at a large angle to this trend.

Most faults are parallel to sub-parallel with bedding, dip steeply, and are marked by greater horizontal than vertical movements. However,

[1] Geological mapping of the Kississing map-area by the writer in 1947 revealed that this overturning is prevalent in Kisseynew gneisses as far west as Mari Lake on the Manitoba-Saskatchewan boundary.

Snow Lake fault is a normal fault, dips at a more moderate angle, and the vertical movement exceeded the horizontal. A few other, smaller shear zones have attitudes similar to that of the Snow Lake fault.

FOLDS

The main folds in the east half of File Lake map-area, from south to north, are Threehouse syncline, Herblet Lake syncline, McLeod Lake syncline, and Squall Lake dome. These are complicated to some extent by minor folds and crenulations. The main folds delineated in the western half are the File Lake anticline and Loonhead Lake dome. Foliation in granitoid gneiss outlines an anticline in the northern part of the area, and smaller folds are abundant, particularly between File and Corley Lakes.

The most prominent fold in the area is Threehouse syncline, so named because its axis extends southwest and south from Snow Lake through Threehouse Lake. Near Snow Lake it plunges about 40 degrees north, but south along the axis the plunge gradually steepens to 80-85 degrees north at the south end of Edwards Lake. Outlines of smaller folds on the west limb are masked by granitization of the basic volcanic rocks, but the axis of a small syncline extends through Ghost Lake, and a small anticline in hybrid rocks to the east can be inferred. Scant structural data indicate that the axis of a syncline may plunge steeply southeast across Morgan Lake.

Although the Herblet Lake syncline is a well-defined syncline east of File Lake map-area, where it was named by Armstrong (5), the nose broadens towards the west, and north of Snow Lake the fold is basin-shaped. Hence, no synclinal axis can be indicated in File Lake map-area. The structure is complicated by many faults and lesser folds. One of these lesser folds, on the southwest flank, is the overturned, easterly dipping, isoclinal Nor-Acme anticline on whose crest is located the Nor-Acme mine. A change in the plunge of linear elements takes place in the rocks southeast of the Cleaver Lake fault, and is especially distinct in the band of basic flows that lies along the fault. In the southwest part of the band linear elements plunge northeast at a low angle, but towards the northeast the angle of plunge gradually decreases to horizontal, and, still farther northeast, the rocks plunge southwest at a low angle. This feature indicates a shallow, synclinal cross-fold, which may have resulted from differential movement on the Cleaver Lake fault.

McLeod Lake syncline is separated from Herblet Lake syncline by the Cleaver Lake fault. Beds on the northwest limb of the syncline dip and face about 25 to 40 degrees southeast, and those on the opposite limb dip 40 to 60 degrees northwest. Thus, the axis of the fold is tilted to dip steeply southeast. Also, near the nose of the fold, the plunge, as determined from drag-folds, is 5 to 10 degrees northeast, but northeast along the axis the plunge steepens to about 30 degrees at the east edge of File Lake map-area.

Squall Lake dome is elongated somewhat in a north-south direction, and is marked by quaquaversal dips around a stock of granite. Prior to formation of the dome and intrusion of the granite the rocks plunged northward at a gentle angle. As a result of the doming the rocks near the south part of the granite dip and plunge south, resulting in erratic trends to low-dipping strata, and it is probable that the rocks near both sides of the

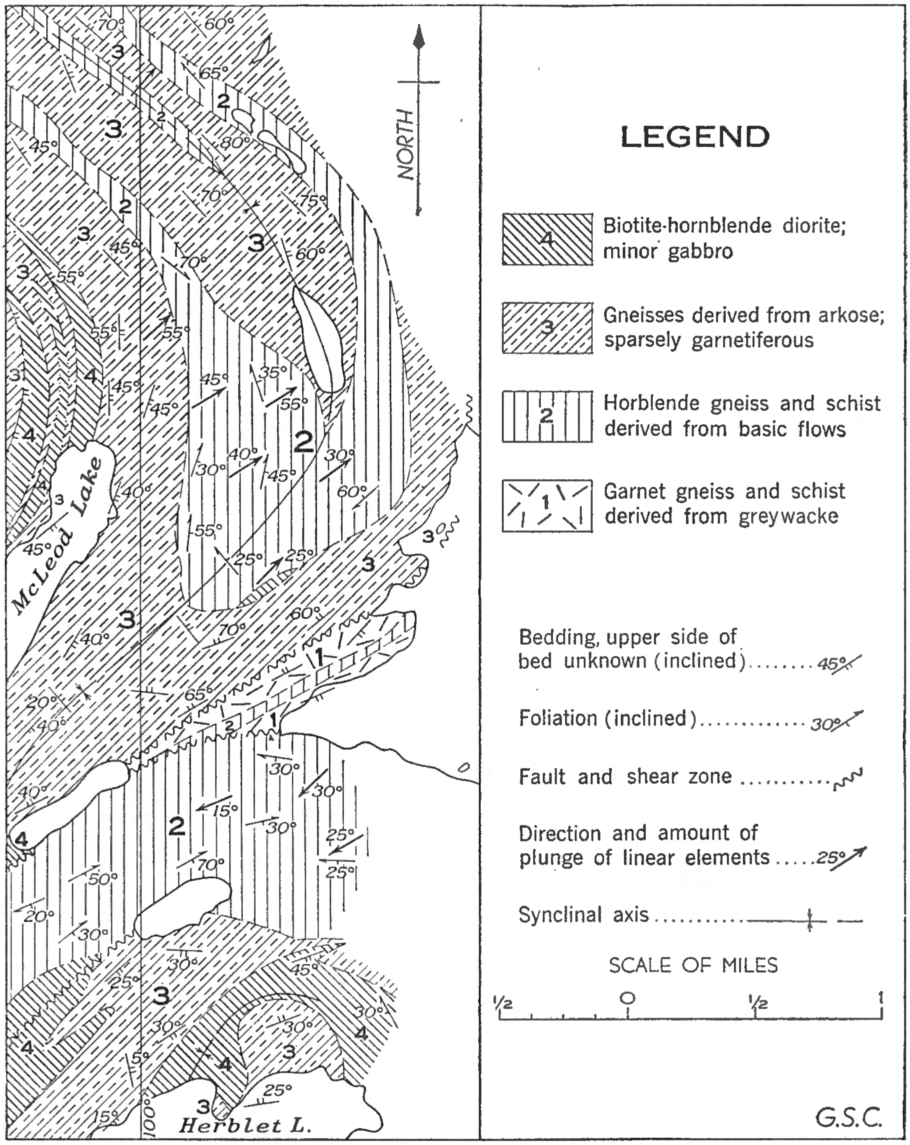


Figure 2. Warped syncline just east of the east border of File Lake map-area.

dome have been wrinkled into folds of small amplitude and very low southward plunge. About a mile east of the dome axis the characteristic northward plunge of the rock structures again prevails throughout. However, it is considerably steeper north of a line running east-west a short distance north of McLeod Lake. This line probably marks a hinge of warping due to doming. A small area east of the map-area was examined in order to discover what effect, if any, this doming had on the McLeod Lake syncline. The results of this examination, shown in Figure 2, are striking. The axial plane of the syncline is folded so that it swings from northeast to northwest; the beds become compressed; and where the axis crosses the northeast corner of File Lake map-area the fold is overturned and dips northeast.

Some small, northerly trending folds were distinguished northwest of Squall Lake. All plunge northerly, and those nearest the Ham granite are overturned to the west.

Rocks in the western half of the area are also intricately folded, but large amounts of granite, combined with lakes and sizable drift-covered areas, prevented a detailed study of structures in most parts. A marked distinction between structures in the two halves of the area is the southward plunge of those in the west contrasted with the northward plunge in the east.

The axis of File Lake anticline trends slightly west of south and plunges 20 to 30 degrees in that direction. The crest of the fold is occupied by gneissic granite, which is faulted on the west and has a comparatively narrow selvage of steeply dipping sedimentary gneisses on the east. If the fold axis continues southward beneath File Lake the plunge must steepen, for rocks on islands near the south shore, and in line with the projection of the axis dip about 60 degrees south.

Loonhead dome, of which only two-thirds lies in the map-area, is marked by a band of foliated hornblende gneiss with low quaquaversal dips. It is elongated in an east-west direction.

Between File and Corley Lakes sedimentary rocks are closely folded. Tops were determined at fairly regular intervals and, on the basis of these, three synclines and two anticlines were distinguished. Near File Lake the fold axes dip west, but northwards they steepen through vertical to dip east, an overturning characteristic of the Kisseynew gneisses. The folds appear to close just northeast of Corley Lake where they plunge east in contrast with their southward plunge at File Lake. This, in turn, suggests a cross-axial anticlinal fold trending northeasterly through Corley Lake, or else a warped, inverted, canoe-shaped fold. Near File Lake, where fold axes are more regular, sedimentary beds face away from basic volcanic rocks, whereas the sedimentary beds on the islands in the south part of File Lake appear to dip beneath the Amisk basic rocks. However, in both places the two rock types are separated by strongly sheared zones.

The axis of a small anticline is believed to lie along a blunt, burned point in File Lake, just north of the portage from Woosey Lake and south of the File Lake fault. Shapes of pillows in basic lavas on the point show that the flows strike 25 degrees west of north, and dip and face 55 degrees southwesterly. The plunge of pencil structure is parallel with the dip of the lavas, indicating that the lavas trend at right angles to the axial plane of the fold and must, therefore, be on the crest of an anticline that plunges 65 degrees west of south. Beds in sedimentary rocks of the

Snow group exposed on islands and points just northwest of the File-Woosey Lakes portage appear to be on the southerly flank of this anticline, and face away from the Amisk rocks. This is the only locality in File Lake map-area where sedimentary rocks of the Snow group and volcanic rocks of the Amisk group are not definitely separated by strong shears or large areas of drift, and here rocks of the Snow group lie stratigraphically above Amisk volcanic rocks.

A syncline in unclassified sedimentary rocks on the west shore of Morton Lake indicates that they are younger than Amisk. Similarly, at the southeast side of Morton Lake all tops in greywackes face away from basic Amisk rocks to the east, though this information is of dubious value as exposures are scant and no tops were obtained near the contact. However, it does suggest that these sedimentary rocks are younger than the Amisk group and, perhaps, equivalent to those of the Snow group.

Between the File Lake granite and File River a body of sillimanite schist and basic volcanic rocks is folded into a wedge-shaped mass. Exposures are poor, and the structural data obtained are insufficient for interpretation of the structure. Beds dip steeply to vertical and their trend is roughly parallel with the contacts. Locally they are strongly sheared, and a U-shaped fault may follow the southern exposures. In vertical section it may have the appearance of a pipe, or plug, that fans out at depth.

In the Tramping Lake map-area the axis of a westward-plunging anticline passes through some granitized rocks forming islands in the northeast part of Reed Lake. In a few places where volcanic rocks are intruded by gabbro or granite, steeply plunging folds are marked by schistosity in the older rocks around the ends of the intrusions.

FAULTS

Faults and shear zones are numerous, and one of their chief characteristics is their curving trends. Few of them follow a straight course for more than a mile or two.

The most prominent shear zone is the Berry Creek fault. It was mapped in the Wekusko area by Armstrong (5) for about 13 miles northeast from Berry Creek. The fault cuts across the southeast corner of File Lake map-area, curves gently to a more easterly course in Tramping Lake map-area, and appears to fan out in Reed Lake. Its total known length is, consequently, about 30 miles, in which distance it is marked by a rather broad zone of fissile schists that dip steeply east or west, or vertically. Sedimentary and volcanic rocks, granite, quartz porphyry, and diorite are all sheared. Subsidiary shears break away from the main fault, and the Tramping Lake fault is probably one of them. From it, a short east-west fault is believed to extend across the south part of Tramping Lake, and to effect a right-hand displacement of about 1,000 feet.

The Varnson Lake fault cuts basic intrusions, but where it passes close to the Ham granite the sheared rocks are granitized and recrystallized.

Probably the most important faults from an economic standpoint are those passing through or near Snow Lake. The Snow Lake fault follows the contact between sedimentary rocks of the Snow group and Amisk volcanic rocks through Snow Lake and north to Squall Lake. Another fault follows approximately the upper contact of staurolite schist through Snow Lake and northwest, perhaps to Squall Lake. However, about 2½ miles from Snow Lake the main shear zone breaks sharply northeast through Cleaver Lake along the southeast flank of McLeod Lake syncline to Herblet Lake, beyond the map-area, and thence north (*See* Figure 2). The trace of this fault suggests that it was bowed by doming that accompanied the intrusion of the Squall Lake granite. A more regularly accurate fault passes through Birch Lake. All these faults are marked by strong shearing, and all dip easterly at angles varying from 40 to 85 degrees. The areas between them are transected by a multitude of smaller faults.

Slickensides on sheared rocks in the Snow Lake fault indicate that movement was normal, with the north side downthrown to the northeast. The irregular fault trace through Snow Lake indicates only an irregular foot-wall. Diamond drilling across the fault discloses a broad zone in which shearing is confined largely to the lower contact of staurolite schist.[1] A host of smaller, easterly dipping faults extend south, but few continue north, probably because the staurolite schist absorbs the shears. Fault zones are distinct for a mile or two south from Snow Lake Narrows, but are more difficult to trace farther south. The fault that extends from Tern Lake south to Threehouse Lake is masked by recrystallized and granitized schists. Presumably then, some branches of the Snow Lake fault followed lines of weakness induced by faulting that was pre-'quartz-eye' granite. However, west of Tern Lake 'quartz-eye' granite is sheared and mineralized. The Varnson Lake fault cuts basic intrusions, but sheared rocks in the fault zone have been recrystallized and granitized by the Ham granite. Thus, in the east half of File Lake map-area faulting is both earlier and later than intrusions of 'quartz-eye' granite, basic rock, and younger granite.

In the west half of File Lake map-area the three most strongly sheared zones are those of the File Lake, Woosey Lake, and Morton Lake faults. The File Lake fault follows roughly the south shore of the lake. To the west, it curves north up Dummy Bay, and its position is lost in an area of sparse outcrops west of Corley Lake. File Lake and Snow Lake faults appear to be analogous to the extent that both separate rocks of the Snow group from those of the Amisk. However, the File Lake fault dips steeply south to vertically, whereas the Snow Lake fault dips north or east at angles varying from 50 to 70 degrees. The Woosey Lake fault follows the curving west arm of the lake, and thence north to File Lake where it appears to merge with the File Lake fault. The Morton Lake fault is well marked in the northern third of the east shore, but probably fans out to the south. North of the lake it passes through Dummy Bay and curves westward along the south shore of Loonhead Lake. Drag-folds due to this fault were noted in the rocks along Loonhead Lake and the large island in the lake. These folds are asymmetrical, strike parallel with the fault plate, and are virtually horizontal. Steep limbs of the synclines

[1] More detailed descriptions of some features of the Snow Lake and other nearby faults are included in the description of mineral properties located on, and near, them.

are on the south side of the folds, indicating that movement on the fault here was upthrusting from the south at a shallow angle. Strongly sheared rocks are also associated with the Dickstone mineralized zone, and with other showings west of Morton Lake (*See* Plate IV B).

GENERAL CONSIDERATIONS

The position of the Ham granite with respect to structural trends in File Lake map-area is a striking feature. It splits the map-area into two nearly equal parts in which the major structures are analogous. Thus, Woosey Lake and Varnson Lake faults, on opposite sides of the granite, are parallel, and both dip away from the intrusion. Snow Lake and File Lake faults are likewise similar to each other in outline, and both separate Snow from Amisk rocks. The granite itself appears to have accompanied, or been preceded by, forces that bulged the rocks to the north, for staurolite schist, which occurs with maximum thickness at about the same latitude at Snow and File Lakes, extends northward to form an inverted U around the north end of the granite. The general northward dip of the rocks off the north end of the Ham granite, and the trend of gneissosity within the granite, also suggest forceful emplacement from the south. The intrusion, then, must have been driven northeastwards and upwards. Varnson and Woosey Lake faults, and perhaps the File Lake fault, could represent tear faults along the flanks of the intruded mass. The multitude of smaller faults and folds on both sides of it may be, in part, drags, wrinkles, and slips attendant upon the major deformation. The Snow Lake normal fault may be due to the bowing of rocks to the northeast. If so, the rocks of the Amisk group must have been dragged forward and upwards to a greater extent than were the rocks of the Snow group, and the Snow Lake fault would then be an upthrust variety of a normal fault. The Squall Lake granite, which is identical in appearance with the Ham granite, occupies a dome and illustrates on a smaller, much simpler and less forceful scale, what may have occurred.

Even more difficult to explain is the opposition in plunge of folded structures on either side of the Ham granite. It may be that this granite was emplaced as a result of forces acting in a northeast-southwest couple, and that the File granite represents the southwest, downward component and the Ham granite is the result of the northeast, upward stress. If such be the case there should be more evidence of shearing along the northeast arm of File Lake and in the gneisses to the north. However, exposures are few and poor, and as the rocks are granitized to a considerable degree, evidence of shearing there may have been largely obliterated. File and Woosey Lake faults may represent this shearing, and their attitude is in agreement with the hypothesis.

CHAPTER V

MINERAL DEPOSITS

GENERAL STATEMENT

The only deposits in the File-Tramping Lakes area so far known to be of commercial grade and tonnage are those of the Nor-Acme gold mine at Snow Lake. Several other, but much smaller, deposits are known within 3 or 4 miles of the Nor-Acme. Encouraging assays in gold have been reported from showings close to Squall Lake, and low to moderate values have been reported from mineralized zones both east and west of the Squall Lake dome. A few gold-bearing veins have been found about Loonhead Lake, between Loonhead and File Lakes, and near Morton Lake, and gold mineralization is known at Fourmile Island in Reed Lake. Bodies of pyrrhotite, some of which are reported to carry nickel, are fairly common west and north of Morton Lake, and the Jackfish Lake basic intrusive complex carries nickeliferous pyrrhotite. Other pyrrhotite deposits occur near the north end of Tramping Lake and north of the Berry Creek fault near the east edge of the map-area. The Dickstone copper deposit at the west edge of the map-area is of good grade, but is too small to exploit economically under present conditions. Some copper showings lying east of Morgan Lake were discovered in 1946 and, though not seen by the writer, are reported to be small.

Most of the mineral deposits in the area are 2 miles or more from the Ham granite, and none is known between the Woosey Lake fault and the east shore of Morton Lake. Nearly all deposits hitherto found lie in, or near, shear zones, many of which probably mark faults, but some probably formed as a result of slippage between beds during folding. However, the Nor-Acme orebodies lie on the crests of anticlines that have been subjected to minor faulting, and the main Squall Lake mineralized zone lies on the flank of a syncline, dipping and plunging with the fold.

On broad mineralogical grounds it is possible to divide the deposits into four main groups: (a) those in which pyrrhotite is the most abundant sulphide; (b) those in which pyrite is the most abundant; (c) those that contain noticeable amounts of galena and sphalerite, usually in addition to pyrite; and (d) those in which arsenopyrite is the main sulphide. The last two groups are commonly gold-bearing.

Nearly all the pyrrhotite-rich deposits carry some chalcopyrite, and in many of them the pyrrhotite is reported to be nickeliferous. Most of these deposits are clustered west and north of Morton Lake at the west edge and southeast part of the File Lake map-area, and at Jackfish Lake in Tramping Lake map-area. Others are known here and there, but especially south and west of Snow Lake where most of them were discovered by prospectors in search of gold.

The pyritic deposits known are mainly concentrated southwest of Snow Lake to Morgan Lake, though a few are known west of File Lake, and on Fourmile Island in Reed Lake. These were prospected for gold, but little encouragement was obtained from them except for the Morgan Lake gold deposit. However, this deposit is not typical of the pyritic type, for it contains chalcopyrite, sphalerite, and galena in addition to pyrite. Some encouragement has been obtained from the gold deposits on Fourmile Island, but here again the mineralization is scarcely typical, for chalcopyrite and sphalerite are common minerals.

The pyritic deposits that carry noticeable amounts of galena are near Snow Lake and at Morgan Lake, the last named being the most important discovery of this type. These deposits are characterized by milky white quartz, which is partly vuggy, pyrite, galena, and sphalerite. The Camwe "A" showing at Snow Lake Narrows also contains some tennantite (grey copper). The Morgan Lake gold deposit contains much more sphalerite and chalcopyrite than it does galena, and does not seem to be typical of either this or the preceding group.

The gold deposits characterized by arsenopyrite are mainly concentrated between Snow and Squall Lakes and the east edge of File Lake map-area, and in a narrow belt south of the Snow Lake fault. A few others lie close to the Morton Lake fault, near the west border of the area. All these deposits are associated with veins of quartz contained in rocks that have been intricately folded and faulted, but the quartz itself commonly contains very little, if any, gold. Most of the gold is contained in silicified wall-rock or inclusions, or at the contacts between vein and wall-rock or inclusions. So far as the writer is aware, no gold has been found actually in the quartz at the Nor-Acme mine. Carbonate is a common, though not abundant, constituent of ore at the Nor-Acme, and appears to have exerted a strong influence on localization of gold there. Similarly, a little carbonate occurs in the more promising showings between Snow and Squall Lakes.

Gold appears to be late in the Precambrian sequence of the area, for gold-bearing veins carrying arsenopyrite cut all rocks except the biotite granites, and the galena-pyrite deposits are closely associated with the arsenopyrite veins. The age of the pyritic and pyrrhotitic deposits, however, is not so clear, but some are certainly older than the gold deposits. Thus, the vein at the Morgan Lake deposit cuts heavily pyritized rocks, and some of the sulphide deposits near Snow Lake have been sheared by faults that preceded gold mineralization. On the other hand, some sulphide deposits lie in shears that are thought to be related to the Berry Creek fault, which cuts biotite granite. Still others, near Morton Lake, are in basic rocks similar to those that intrude the 'quartz-eye' granite. Hence, there may be two periods of mineralization in which pyrrhotite was the characteristic sulphide formed.

Whatever the relations of these deposits to igneous rocks exposed in the area, some associations are fairly definite. Deposits of nickeliferous pyrrhotite are nearly all associated with basic intrusions, the chief exceptions being those at Tramping Lake and Berry Creek. The pyritic deposits are all contained in, or close to, rocks that have been altered by 'quartz-eye' granite. The gold-bearing pyritic deposits, which commonly contain galena, are mainly peripheral to the more usual pyritic bodies and to the deposits characterized by arsenopyrite, but are in rocks that have been subjected to late folding and faulting. The deposits at Fourmile Island are contained in sheared 'quartz-eye' granite. The arsenical gold deposits are either in rocks of the Snow group or within a mile of the Snow Lake and Morton Lake faults, in rocks of the Amisk group. In all places, late faulting and folding are characteristic. Further, nearly all gold deposits lie at, or near, contacts between two rock types.

WEATHERING OF SULPHIDE DEPOSITS

Many deposits carrying sulphides are so deeply weathered it is difficult to regard the process as having taken place since glaciation in such a rigorous climate. At several localities trenching has exposed thoroughly decomposed rock to depths as great as 8 or 10 feet, and in some of these trenches sulphides constitute no more than 5 to 10 per cent of the rock. However, rocks rich in sulphides can weather rapidly, a feature well displayed at the Dickstone copper property west of Morton Lake. There, boulder till covering the deposit has been cemented by weathered products of the sulphides to form a conglomerate that rests horizontally on the steeply dipping, mineralized schists. Heavily rusted and crumbled rocks at the Gordon Lake sulphide deposits likewise indicate postglacial weathering, for these deposits are exposed on high ground that could scarcely have escaped glaciation.

In contrast with these deposits, which carry much pyrite and pyrrhotite, are those about Snow Lake. There the most abundant sulphide is arsenopyrite, which rarely constitutes more than 5 per cent of the rock, but some of the deposits are weathered more than 8 feet below the base of the glacial drift. Trenches of the Snow group (Koona Lake) No. 3 deposit penetrate 3 to 6 feet of thoroughly rusted rock. Fractured, rusty quartz veins can be seen cutting through the weathered schist in which the trend is still discernible. The overlying boulder clay is not slumped and is free of rust. Similar conditions prevail both east and west of the Toots orebody of the Nor-Acme mine. In September 1945, a trench on the Snow group (Koona Lake) No. 11 showing passed through about 4 feet of fresh, unconsolidated gravel into thoroughly decomposed schist. The contact between the two is irregular, but sharp and clear, and at some places in the trench the upper limit of the schist is at a higher elevation than the gravel elsewhere deposited on it (Figure 3). Even so, the gravel is not rusted, as it almost certainly would be if disintegration of the schist had not been complete prior to deposition of the glacial material. It is worthy of note that only those deposits lying on the lee slopes of hills with respect to glacial movement, or those lying in gulleys transverse to glacial movement, are marked by deeply weathered zones in this vicinity. Deposits near Snow Lake that were clearly exposed to glacial erosion have only a slight coating of rust. It seems fairly conclusive that preglacial weathered products have been preserved in some localities, a condition also recorded by Wright (43, p. 31) in nearby parts of northern Manitoba. Preservation of preglacial weathered zones indicates that glacial erosion must have been shallow, a conclusion reached by Mawdsley (24) after a study of some deposits in northern Saskatchewan.

Numerous sulphide deposits near Snow Lake are marked by gossan that pans well in gold, but the underlying solid rock yields only small amounts of the metal. Indubitably then, the gold must have been concentrated, a process that has long been recognized at many places in the world. However, at many deposits in this area, the tail from panned gossan yields rather coarse gold, whereas the deposits beneath carry it in microscopic particles. An example is the Snow group (Koona Lake) No. 2 deposit where, so far as known to the writer, no gold was seen in fresh rocks, but pannings of gossan yielded gold in quite coarse, readily visible grains. It seems then, that not only can gold be concentrated in amount, but also into larger grains. As preglacial weathered products are locally preserved in this region, it is possible that secondary gold could be formed in much the same fashion as secondary sulphides are formed. This suggestion was first made to the writer by Mr. F. D. Shepherd during discussions in September 1944.

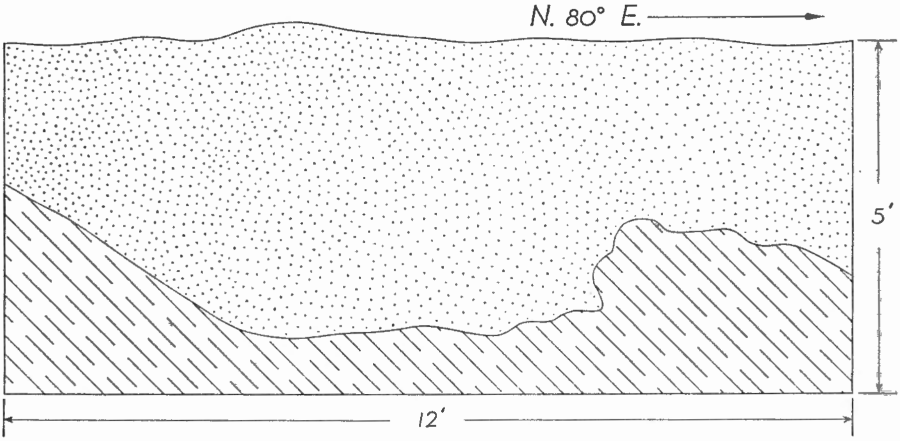


Figure 3. Sketch of part of trench wall at Koona Lake Mines, Limited, No. 11 showing. Unstained glacial till (stippled) overlies thoroughly rusted and decomposed schist in which the schistose structure is still apparent.

With this idea in mind some dozens of gold specimens from the Koona Lake property (Snow group) were studied with the aid of a binocular microscope using magnifications up to 45 diameters. Most of these specimens were kindly loaned by Dr. N. S. Beaton, but a few from other showings near Snow Lake were also examined. Koona Lake specimens were selected for the examination as many of the deposits on the property contain conspicuous amounts of coarse gold for a short distance below the weathered zone as exposed in trenches, but diamond drilling has so far failed to disclose like conditions at greater depth. In several specimens gold was found to fill small, but open, fractures in the rock. Some of it is crystalline, and some quite platy. This type of gold could be secondary. However, most of the gold particles seen were dendritic in appearance, and were locked in the rock in such a manner that a secondary origin appears improbable. So far as these specimens are concerned, most of the gold is clearly hypogene, although some of it may be secondary. Therefore, it appears that some other condition must prevail to account for the abundance of gold at, and near, the surface and its relative scarcity in depth as indicated by diamond drilling. It is, of course, possible that the drill misses the gold in veins where it is rather coarse and patchily distributed.

DESCRIPTIONS OF PROPERTIES, FILE LAKE MAP-AREA

Anderson Lake Sulphide Deposits (43)[1]

Some old workings expose two sulphide deposits along the portage leading southwest from the south end of Anderson Lake. One showing is near the south end of Anderson Lake, the other about 1,000 feet southwest along the portage. They were described by Wright (43, p. 109) as the Eagle deposit. Glacial till is thick in this region, and outcrops are small and scarce.

The deposits lie just northwest of the Anderson Lake fault. The rocks south and east of the fault are pinkish grey, garnetiferous, highly feldspathized and silicified basic lavas cut by much 'quartz-eye' granite, whereas those north and west of the fault are more normal basic flows that are irregularly feldspathized and silicified. The deposits themselves lie in coarse, garnet-chlorite schist.

The deposit nearer to Anderson Lake lies in the W.J. No. 3 claim. The enclosing outcrop consists of intensely sheared, dark green chlorite schist carrying large subhedral crystals of red garnet that contain veinlets of chlorite. Garnet crystals tend to occur in streaks that suggest original bedding, and the composition of the rock further suggests a sedimentary origin. Minor drag-folds plunge vertically to steep northeast, the shapes indicating right-hand, nearly horizontal movement on the fault. The shear trends about northeast and dips 85 degrees northwest. Irregular, small quartz veins are scattered through the outcrop, and small, heavily rusted zones of pyrite are common. The quartz in the outcrop, and in some scattered pieces of drill core, is barren except for local pyrite, and a few rather coarse grains of arsenopyrite were noted in some garnet crystals. Low assays in gold are said to have been obtained from diamond-drill samples. Wright reports that chalcopyrite is present, but none was seen here in 1945.

The more southerly deposit lies near the east side of the W.J. No. 2 claim. Test pits have been sunk at intervals for about 250 feet along the portage, beginning about 1,000 feet southwest of the deposit just described. Some scattered drill core was seen, and the pits are now largely caved and filled with water. Here again the rock is coarsely crystalline garnet-chlorite schist, but it has been intruded by a medium-grained, dark grey, garnetiferous hornblende diorite on the northwest side and northeast end of the showing. The rocks are somewhat sheared, especially the garnet-chlorite schist along the more southerly margin of the outcrops. The shear zone strikes about 50 degrees east of north and dips 80 to 85 degrees northwest. The rocks have been considerably silicified and contain a few large, irregular splashes of white quartz that hold chloritic inclusions. Quartz and inclusions are sparsely mineralized with chalcopyrite and pyrite, some parts of the basic rock containing enough disseminated chalcopyrite to

[1] Numbers in parentheses are those shown on the accompanying File Lake map, and serve to locate the properties.

assay 3 per cent copper. Wright (43, p. 109) estimates that the copper content averages less than 2 per cent across widths of 10 to 15 feet. Results of diamond drilling are not known.

Berry Creek Sulphide Deposits (47)

A sulphide deposit on the Grant No. 3 claim is about one-quarter mile north of Berry Creek, and about a mile west of the east edge of the map-area. It appears to be the deposit described by Wright (43, p. 109) as the Maple. The northernmost trench seen on the deposit lies about 300 feet south of a large sill of 'quartz-eye' granite. Trenches are scattered at intervals for nearly 500 feet farther south to a point about one-quarter mile north of the Berry Creek fault. Most of the bedrock is covered by drift.

The sulphides, as exposed by trenching, impregnate sheared, carbonatized, and brecciated andesite that has been intruded by irregular dykes of dark diorite. Locally these rocks have been silicified, and numerous, low-dipping, small veins of quartz are exposed in some trenches, particularly the southern ones. Shears, as exposed in the trenches, are discontinuous, and irregular in trend, but most of them strike about northeast and dip vertically to steeply northwest or southeast. Presumably, these are minor shears related to the Berry Creek fault. Pyrite occurs in silicified rock, and is the main sulphide. Pyrrhotite is common locally, and a little chalcopyrite was seen. Some specimens of rock lying about these southern workings contain a large proportion of dark brown sphalerite, less galena, and minor chalcopyrite. According to Wright (43, p. 109), assays of sulphide-bearing rock are reported to show some nickel in addition to small amounts of copper and gold.

Birch Lake Deposits (25, 26)

Two mineralized zones on which some exploratory work had been done were examined in 1944. One lies just north of the north boundary of the Howe Sound lease and about 250 feet west of Birch Lake; the other is on the east shore of the lake.

The showing on the east side of Birch Lake (25) is in sheared and carbonatized diorite and gabbro, through which small faults angle away from the main fault that passes through Birch Lake. The basic rock includes and intrudes altered greywacke and arkose. Sheared and silicified parts of it, exposed on a hillside a few feet from the lake shore, contain sparse, rather coarse blades of arsenopyrite, and some pyrite and pyrrhotite, but gold assays are low.

The westerly showing (26) is on the east side of a sharp, narrow draw that probably marks a north-south fault. Sheared rhyolite occurs as a band about 100 feet wide on the east side of the draw, and is apparently an interbed in recrystallized, fine-grained andesite. A pit about 8 by 2 feet and 3 feet deep has been sunk on a rusted zone in the rhyolite, which contains considerable carbonate and is sparsely mineralized with pyrrhotite and pyrite. Assays in gold are said to be very low.

Between Birch and Snow Lakes, near the east side of the Howe Sound lease, some trenching and drilling have been undertaken on sheared and mineralized basic rocks that probably are sills intruding the sedimentary rocks. These are on the south side of the Little Herb basin where structural trends are regular. Coarse arsenopyrite is characteristic of mineralized zones in both the intrusive and sedimentary rocks. Assays reported from drill samples are low in gold.

Chisel Lake Sulphide Deposits (44)

Two quartz zones on the Don No. 3 claim were trenched so long ago that moss has grown on rocks exposed by trenching. The quartz that outcrops on the south shore of Chisel Lake occurs as a series of small, white veins in a zone of dark, gneissic, garnetiferous rock. Veins and gneissosity trend about 25 degrees west of south and dip steeply east. Quartz has been exposed for about 150 feet from the shore, and both it and the silicified wall-rock contain a little pyrite.

About one-quarter mile south of Chisel Lake a quartz vein cuts siliceous, dark, massive, garnetiferous rock that was probably derived from basic lava. The quartz vein, as exposed, is about 150 feet long, strikes north-northeast, and dips 85 degrees westerly. It has a maximum width of only 6 to 8 inches, and tapers to 1 inch or 2 inches at each end, but the rocks for 12 to 24 inches on each side are so impregnated with quartz that they weather white, and viewed from the air appear to constitute a broad quartz vein. Pyrite is irregularly distributed through the vein in vuggy cavities, and the wall-rock is slightly pyritized to the limit of silicification. No information was obtained regarding gold content of this vein or the one at the lake shore.

Cook Lake Sulphide Deposit (41)

A small sulphide deposit occurs in dark green basic lava near the south end of the west shore of Cook Lake. The rocks a few hundred feet south of the showing are normal, dark green, amygdaloidal andesites or basalts, but become more altered to the north, and at the deposit are quite schistose. A short distance north and west of the deposit the andesite has been altered to a typical hybrid rock due to the intrusion of 'quartz-eye' granite. Schistosity at the deposit strikes north and dips 65 to 70 degrees west. Mineralization is confined to a zone about 3 to 4 feet wide that contains several small lenses of quartz. The rocks themselves are heavily rusted, and the only sulphide seen was pyrite. It occurs as small crystals peppered through quartz and silicified rock, and as irregular streaks in the rocks. Assay returns are not known.

Corley Lake Gold Showings (4, 5, 6)

These showings lie within a mile of the southwest end of Corley Lake. In 1946 they were covered by the G.M. claims, which had been staked for International Mining Corporation (Canada), Limited.

A few old trenches provide poor exposures for some showings about three-quarters mile north and west of Corley Lake on the G.M. No. 4 claim (4). The deposits occur in heavily sheared and contorted schists and gneisses that have been derived from interbeds of argillite and andesite cut by intrusive diorite. The rocks are included in a triangular shaped fault block, bounded on the north, southeast, and southwest by strong shear zones, and cut by many subsidiary shears. Mineralization is in evidence on steep hillsides that mark the smaller shears. Some quartz has been introduced, and sulphides consist mainly of pyrite, with subsidiary pyrrhotite, sparse arsenopyrite, and blebs of chalcopyrite. A little gold is said to have been panned from gossan.

A quartz vein on the G.M. No. 2 claim is exposed on the east shore of a small lake about a mile west of Corley Lake **(5)**. The quartz lies along a shear zone in a mass of dark diorite or gabbro. The shear strikes northwest and dips 65 to 70 degrees northeast. Striæ on slip surfaces plunge east at 55 degrees. In 1946 the deposit was grown over with shrubbery, and rusting had effaced the character of the rocks. Stockwell (30, p. 60) described the vein under the heading of the Senior group, as follows:

> "The deposit outcrops on the east shore of the small lake and has been traced by stripping and trenching for a length of about 400 feet along a strike of south 45 degrees east to the edge of a drift-filled depression. The normal, massive hornblende-rich meta-diorite is altered along the shear zone to a hornblende gneiss and biotite gneiss . . . Lenses and stringers of vein quartz follow the structure of the gneiss. One lens near the lake is about 100 feet long and commonly is from 1 foot to 3½ feet wide. Other quartz lenses lie adjacent to this large lens so that the combined width of quartz and gneiss is up to 5 feet. The quartz in the large lens carries a small amount of pyrite and arsenopyrite. For 250 feet southeast of the large lens the shear zone varies from one foot to 10 feet wide. Individual quartz lenses here are small and are generally scattered across the full width of the sheared rock. For a length of 50 feet at the southeast end of the exposed part of the deposit vein quartz generally constitutes over half of the material present across 5 feet and in one pit the quartz is essentially solid across this width. Some of the quartz in this pit is well mineralized with arsenopyrite and small amounts of pyrite and coarse gold. The sulphides and gold lie chiefly along dark streaks of schist and tourmaline in the quartz. The quartz here and elsewhere in the deposit is coarsely granular and varies from glassy to milky white. The owner of the property reports that a channel sample taken across 4 feet of the deposit assayed 0·70 ounce of gold per ton."

In 1946 a small quartz vein **(6)** was found about half a mile southwest of Corley Lake, near the south boundary of the G.M. No. 7 claim. This occurrence was not seen by the writer, but it is reported to be on the east slope of a hill where shears trend north and dip steeply east. The rocks are a mixture of fine-grained, dark sediments and basic lavas, and in places are strongly silicified and peppered with pyrite and some arsenopyrite. At the north end of the outcrop a small quartz vein angles northwest away from the shear, and contains sulphides and coarse gold.

Dickstone Copper Mines, Limited (15)

The Dickstone copper property comprises a group of claims that straddle the west boundary of the map-area. The deposit lies about ¼ mile north of a lake locally known as Beavertail Lake, and about 1¾ miles south of Norris Lakes. The deposit outcrops on the east side of the R.O.E. No. 2 claim. Surface exploration and diamond drilling were done by Sherritt Gordon Mines, Limited, in 1936 and 1937. When the property was visited in August 1946, all trenches were caved and rocks exposed in pits and on dumps were so thoroughly decomposed and rusted that little could be seen. In fact, weathering has been so intense that glacial till lying on the deposit has been cemented by iron oxides and carbonate to form a conglomerate. Information regarding drilling of the showing was kindly supplied by W. J. Farley, geologist for Sherritt Gordon Mines, Limited.

The deposit lies in a heavily sheared zone that cuts fine-grained andesite. The andesite has been partly, but irregularly, converted to a more siliceous rock that is very similar to some hybrid types formed from basic rocks by action of 'quartz-eye' granite. However, in places, it appears to intrude, and include, parts of the basic flows. Some small dykes of diorite cut both the basic and acidic rocks. The contact of the andesite with a massive intrusion of diorite is 100 feet or so to the west, and the rock to the east is typical greenstone.

Trenches were sunk at regular intervals for about 200 feet along the sheared and mineralized zone, which strikes about 10 degrees east of north and dips 80 degrees east to vertically, and twenty-five holes were diamond drilled at intervals along a strike length of about 800 feet.

Some of the rock on the dumps consists of dark green, soft, fissile schist, but slightly carbonatized siliceous and felsitic material is also common. Pyrite was the chief sulphide seen, and occurs mainly in streaks. Some vuggy, crystalline marcasite was also observed. Chalcopyrite is quite common in specimens; most of it occurs with pyrite, but some forms narrow streaks through the rocks. Pyrrhotite is intergrown with some of the vein pyrite.

Drilling is reported to have disclosed an elongate, lens-like mass of sulphides that averages about 9½ feet in width, and contains approximately 200,000 tons assaying 3·13 per cent copper to a depth of 350 feet. The deposit strikes and dips parallel with the trend of the enclosing schist. Near the surface the lens is quite straight, except for a rather abrupt warp near the middle of the ore section. This warp becomes more of a roll with depth and 300 feet below the surface the zone has the shape of a flat "M". Near the surface the lens is about 770 feet long, but at a depth of 300 feet it is about 535 feet long. It pinches and swells along strike and down dip, but on the average is wider at depth than near the surface. The grade of the ore, however, becomes lower in the deeper levels.

The ore is relatively massive and coarse grained. It consists essentially of pyrrhotite, with less pyrite, chalcopyrite, and marcasite, although some of the narrower sections are nearly 50 per cent chalcopyrite. No other sulphides were noted, and values in precious metals are negligible. Occasional sections of disseminated sulphides occur in the andesite.

A few holes were drilled elsewhere on the property, but nothing of value was found. However, the Sherritt Gordon officials contemplate more exploration in this vicinity.[1]

Dummy Bay Sulphide Deposits (7, 8, 9, 10)

Dummy Bay is the long, narrow bay at the west side of File Lake. Near it, several deposits rich in pyrrhotite and other sulphides lie in, or close to, shear zones that mark faulting.

The most northerly deposit (7) lies about half a mile north of Dummy Bay, and can be reached by a good trail. The main showing, on the east side of a deep valley that marks the northward continuation of the Morton Lake fault, extends north from the junction of the Doe Nos. 1, 2, 3, and 4 claims. The rocks east of the valley are basalt or andesite, and those

[1] Early in 1948 it was reported that a new drilling campaign, and a geophysical examination, were under way.

to the west are mainly medium-grained diorite. At the showing the lavas are converted mainly to heavily rusted and silicified chloritic schists carrying irregular, small stringers of iron-stained carbonate, but some of the rock is quite slaty. Schistosity trends north and dips 75 to 80 degrees west. Pyrrhotite and pyrite are the main sulphides, and locally are abundant, and occasional specks and splashes of chalcopyrite were also noted. Assays in gold are low.

A few other, smaller showings are scattered at intervals along the east side of the valley north of the deposit just described. All are similar to it, although a few contain considerable quartz.

Two small test pits **(8)** noted at the north end of Dummy Bay on the Bob No. 2 claim, are also on the east side of the fault valley. The andesite at this point has largely been converted to a sericite-chlorite-carbonate "paper" schist, in which the schistosity trends about north and dips 80 degrees east to vertically. Disseminated grains of pyrite are abundant where the schist has been silicified, but deep rusting has obscured the minerals in the rest of the rock.

A showing **(9)** near the junction of the Pilot Nos. 1 and 2 and the C.H. Nos. 1 and 4 claims is characterized by heavy sulphide mineralization. It lies about a quarter mile west of Dummy Bay, and about a mile north of Morton Lake. The deposit was described by Stockwell (30, p. 61) as the Whynot claim, but more trenching and diamond drilling were done in May and June 1946. The vein lies on a west-facing slope of sedimentary rocks, on the east side of the Morton Lake fault. The sediments are cut by dykes of dark diorite, and a large mass of diorite lies to the west across the valley. Rocks are strongly sheared at angles of 10 to 20 degrees east of north, and dips are steep west to vertical. A vein of milky white, granular quartz is exposed by trenching for about 250 feet along the strike of schistosity. It varies in width from 7 feet, near the middle of the exposed length, to less than 2 feet at each end. The quartz is mostly barren of sulphides, but locally contains a few scattered specks of pyrite and chalcopyrite. The wall-rock is partly silicified and sparsely mineralized by thin, irregular streaks of pyrrhotite and pyrite, plus a few grains of chalcopyrite. Assay values in gold and copper from drilling and trenching operations are said to be low.

Some old trenching **(10)** was seen about 100 yards west of Dummy Bay near the boundary between the Pilot No. 4 and 6 claims, about ½ mile south and east of the showing last described. The rocks are a mixture of several types of diorite containing inclusions of altered sedimentary rocks. A trench about 60 feet long follows a quartz vein, which has a maximum width of about 7 feet and narrows abruptly to less than 2 feet at each end. The wall-rock is a carbonatized and rusted hornblende-rich schist that passes to gneissic gabbro within a few feet of the vein. The vein, and sheared wall-rock, strike 10 degrees east of north and dip 70 degrees west. Distinct striæ on sheared surfaces plunge 50 degrees to the south. Irregular stringers and lenses of coarsely crystalline to massive pyrite, arsenopyrite, and marcasite are present in the vein, but comprise only a small percentage of vein material. A little pyrite occurs in the wall-rock. A few crystals of arsenopyrite are three-tenths inch or more in length. Tourmaline is also present as needles, clumps, and rosettes of acicular black crystals and, with the sulphides, is especially abundant around what appear to be recrystallized inclusions of black hornblende.

Edwards Lake Deposits (46)

Two deposits lie in granitized basic volcanic rocks west of Edwards Lake. One, which is a little more than half a mile west of the lake, is in the Wow No. 1 claim; the other is slightly more than a mile west of the lake, in the Chance No. 3 claim.

The showing on the Wow No. 1 claim consists of an irregular vein of white, glassy quartz that trends about northwest and dips steeply northeast to vertically. It follows roughly along a contact between a dyke of 'quartz-eye' granite and feldspathized basic lava. The rocks for more than 200 feet east and west of the vein consist of a mixture of 'quartz-eye' granite, pink felsite, and feldspathized andesite. A rather hurried examination of the vein revealed only some sparse pyrite, but the owners reported (August 1945) that some scheelite is present. The vein pinches and swells abruptly, and was traced for less than 100 feet.

The deposit on the Chance No. 3 claim consists of some heavily pyritized and sheared rock on the south side of a low hill composed of basic lavas that have been more or less feldspathized and are cut by many irregular dykes of 'quartz-eye' granite. The mineralized shear zone strikes nearly due west, and dips north. Gossan is thick, and pyrite was the only sulphide seen.

Gaspard-Anderson Lakes Gold Deposits (38, 39, 40)

Numerous small quartz veins carrying gold lie south of Snow Lake between Gaspard and Anderson Lakes, and some of them are near the south shore of Snow Lake. Only a few are indicated on the map, but all are in the block of claims that were being prospected for the International Mining Corporation (Canada), Limited, in 1945. The claims include the Groundhog, Angus, Caribou, Camp, and J.D.G. groups, and much information concerning them was kindly supplied by W. L. C. Greer and P. Stewart.

All the deposits occur on the east side of the Threehouse syncline between the Snow Lake and Anderson Lake faults. All, except those just north of Gaspard Lake (40) lie in the zone of shearing along the two faults, or in small shears that branch from these faults. Most of the showings lie in basic fragmental rocks, but some are basic lavas both north and south of the fragmental band. A sill of 'quartz-eye' granite about 2,000 feet thick separates basic flows on the south from the pyroclastic types. The basic rocks are altered locally to a light grey, feldspathic, hybrid variety. Bedding trends about north 60 degrees east, and dips north at high angles. Regional schistosity strikes about north 30 degrees east, and lineation plunges in the same direction at 45 to 50 degrees. Shears are mostly parallel with the main faults, but smaller shears that trend nearly north are common near Snow Lake, where the main fault is east-west. Most of the showings trend nearly north and dip steeply east or west, but some near Snow Lake lie nearly east-west in shears parallel with the eastward extension of the Snow Lake fault.

All the deposits are small, and narrow, disconnected veins of quartz are characteristic. Rocks at the showings are sheared, carbonatized, and amphibolitized to a greater or lesser degree. Pyrite and pyrrhotite are the main sulphides, and some arsenopyrite was observed. The wall-rocks of the veins are silicified, and the bulk of the sulphides occurs in the rocks near the vein margins. Rather coarse gold is common at the margins of narrow veins at Gaspard Lake.

Gordon Lake Sulphide Deposits (12)

These deposits lie near the east side of Gordon Lake, a small lake about a mile west of the north end of Morton Lake. They were described by Wright (43, p. 68) and results of subsequent exploration were covered by Stockwell (30, p. 71). In 1946, workings were caved and filled with water and the rocks were heavily rusted; as a result, nothing of importance was observed that had not already been recorded. Wright described it as follows:

"This deposit is about 500 feet south of Gordon Lake.... A syndicate of residents of The Pas did some surface work on the property during the summer of 1929. A shaft was sunk about 50 feet and trenching was done at several points south and east of Gordon Lake. The bedrock is slightly schistose andesite. The shaft is sunk in a zone of chloritic schist about 4 feet wide. Some of the schist on the dump contains abundant light-coloured pyrrhotite, specks of chalcopyrite, quartz veinlets, and iron carbonates. The schist zone was not traced more than 500 feet south of the shaft. North of the shaft the drift is thick. Other nearby zones of schist carry only small quantities of sulphides and vein quartz."

Between 1930 and 1934 more work must have been done on these deposits, for Stockwell added (30, p. 71):

"A trench on the east side of Gordon Lake near the south end crosses 40 feet of iron-stained schist carrying disseminated pyrrhotite, concretionary balls of pyrite, and a few small lenses of vein quartz. The schist in the trench is crossed by a dyke of basalt porphyry.

Another trench on the east side of Gordon Lake near the north end crosses 13 feet of massive aplitic rock and rusty schist. Both of these rocks are well mineralized with disseminated grains of pyrrhotite. The rusty schist is crossed by stringers of pyrrhotite and holds a lens of quartz carrying pyrite and small amounts of pyrrhotite, feldspar, and carbonate. Another pit lies 170 feet north along the strike of the schist. Material on the dump at this northern pit includes sericite schist well mineralized with pyrrhotite and pyrite, pieces of pyrrhotite a foot across, and fragments of vein quartz carrying pyrite."

Schistosity in the sheared and mineralized zones trends about 25 degrees east of north and dips steeply southeast to vertically. Striæ on slip planes plunge about 70 degrees south.

Herblet Lake Deposit (19)

A large quartz vein in diorite about 2,000 feet west of the most westerly bay of Herblet Lake was hurriedly examined in September 1945. Trenching disclosed a milky white quartz vein cutting the diorite. The vein was exposed for about 100 feet, and varied in width from a few inches to a few feet. The wall-rock is only slightly silicified, and carries coarse blades of arsenopyrite. There is little definite evidence of shearing or gneissosity, but the quartz vein appears to follow a linear structure that plunges east at about 20 degrees. Assay returns in gold are said to be low.

Howe Sound Lease (28, 29, 30, 31)

The Howe Sound lease comprises a block of fifty-two surveyed claims and fractions on Snow Lake. The most important deposit on the ground is that being developed as the Nor-Acme mine **(30)**, and is discussed under that heading. Some other showings are known on the property, and these are described under the name of the claim in which each occurs.

Dick No. 16 **(28)**. The Dick No. 16 claim is the most northwesterly claim on the property. The showing on this claim lies about 100 feet south of the north boundary and about 300 feet west of the northeast corner of the claim. Considerable work was done on the showing, but workings have long since caved and are grown over with shrubbery. Some high-grade material is rumoured to have been taken from this deposit, which is thought to have been once known as the "Maxwell". The only rock exposed at the showing is on the southeast corner of a trench, and is sheared, fine- to medium-grained, recrystallized andesite. Rocks exposed on all sides are similar. About 150 feet east of the showing stripping has exposed pillow lava cut by irregular, barren veins of quartz; 50 to 100 feet farther east a fault runs north. The shear zone exposed in the trench strikes about 50 degrees west of north and dips 45 degrees northeast. It may represent a branch of the fault to the east. Some slabs and pieces of rock on the dump contain rusty quartz mineralized with fine, granular arsenopyrite, and local concentrations of pyrite and pyrrhotite.

Keewatin **(29)**. A large test pit has been sunk on a silicified zone in the north-central part of the Keewatin claim. The showing lies on the crest of the Nor-Acme anticline, about 3,700 feet north-northwest of the main ore zone at the mine. The test pit, plus stripping, has exposed brecciated and silicified rocks for about 100 feet along strike and across a width of about 12 feet. The showing occurs in quartzose greywacke or rhyolite, with interbeds of dark greywacke. A drift-covered valley to the west of the showing may mark a fault. A contact between dark greywacke and medium-grained hornblende is exposed about 25 feet north of the showing, but the contact is gradational across a width of about 3 feet, due to small, irregular apophyses of hornblendite in greywacke. Tourmaline is concentrated in particular lamellæ of the greywacke. At the showing the rock is fine-grained, siliceous, partly sericitized, brecciated material, cemented by an irregular stock-work of quartz. Structural data in the vicinity are scant, owing to brecciation and poor exposures, but at the east end of the showing a banding in the silicified rock dips 50 degrees northeast and poorly developed striæ plunge parallel with the dip.

Sulphide minerals are confined to the silicified rocks in the brecciated zone at the crest of the fold, and comprise finely divided pyrite, pyrrhotite, and arsenopyrite. The quartz itself appears barren. Grab samples from this deposit are said to have returned low to moderate assays in gold.

In many respects this showing is structurally similar to the Nor-Acme mine. Both occur at the crest of the Nor-Acme anticline, have similar brecciated zones cemented by a quartz stock-work, and the same sulphides. However, the fold here is sharp, and the mineralized zone, as exposed, is confined to the feldspathic rocks near the contact with basic rocks. At the Nor-Acme the fold is more open, and mineralization straddles the contact between the two rock types.

Parson No. 12 **(31)**. Some old trenching exposed a shear zone at the south side of Parson No. 12 claim. The workings are about 4,500 feet southeast of the main zone of the Nor-Acme mine, and extend a short distance south into the Tobruk claim.

The shear zone strikes about 10 degrees north of west, dips 60 to 65 degrees north, and is exposed only in the two trenches, which are separated by about 700 feet of drift. It cuts feldspathic sedimentary rocks, or lavas, which are bounded by gneissic diorite or gabbro on the south, and by a mixture of medium-grained diorite and basic breccia on the north. The outcrop of diorite extends about 300 feet south of the showing to a drift-covered, south-facing slope that descends steeply to swamp. Staurolite schist outcrops in the swamp about 800 feet south of the showing, and is probably separated from the basic rocks at this point, and from the acidic type farther north, by a fault. The shear zone in which the showing occurs may be a branch from this fault, but lack of outcrop prevents tracing it westward to a possible junction. Basic breccias on the north side of the showing have no apparent stratigraphic connection with other bands of similar rock exposed farther north along the Nor-Acme anticline, and thus may be upfaulted so that they are exposed through a window in the feldspathic rocks.

The two trenches that expose the showing are partly caved. The western trench is about 60 feet long, of which the south 30 feet is caved, and is 12 to 20 feet wide. It crosses about 30 feet of sheared, silicified, grey, felsitic rock that is well mineralized with fine pyrite and arsenopyrite. Strong shearing also characterizes the rock in the eastern trench, which is about 30 feet long, 5 to 15 feet wide, and as much as 12 feet deep. Rocks in the south half of the trench are strongly sheared, siliceous, and feldspathic, and contain considerable amounts of fine pyrite, pyrrhotite, and arsenopyrite. Those in the north half are heavily rusted schists that are badly weathered to the bottom of the trench. Less weathered, siliceous remnants contain much pyrite. At the north end of the trench a narrow zone of indeterminate rock passes abruptly to medium-grained diorite or gabbro.

Under the microscope the mineralized rock from the trenches is seen to consist mainly of albite and carbonate, some of the former being porphyroblastic. Quartz and sulphides each comprise about 15 per cent of the rock in the slides examined, and one minute grain of gold was seen in contact with a small crystal of arsenopyrite. Grab samples from these trenches are reported to have given low to moderate assays in gold.

In 1944, traverses were run at intervals of 50 to 100 feet across this zone with an Ascania magnetometer. A strong anomaly connected the two trenches and extended for nearly 300 feet west of the more westerly trench for a total strike length of about 1,000 feet.

Several other showings, most of which are characterized by coarse crystals of arsenopyrite, are scattered here and there on the ground covered by the Howe Sound lease, but little exploratory work has yet been done on them.

Koona Lake Mines, Limited (Snow Group) (20, 21, 22, 23, 24)

Koona Lake Mines, Limited, was formed early in 1946 to take over exploration and development on most of the Snow group of claims, jointly controlled by Northern Canada Mines, Limited, and Pioneer Gold Mines, Limited. Koona is the Cree Indian word for 'snow'. The Snow group adjoins the Howe Sound lease on the northwest and comprises the L.C., Vee, Par, Wilma, Snow Lake Nos. 1 to 4, and Mofin groups, and the Nanabrosha claim, a total of thirty-two claims. All but the nine Mofin claims, which are the northernmost claims of the group, are included in Koona Lake Mines, Limited. At least eleven different gold showings are known on this ground, and all seem to be more closely related to faults than to folds. N. S. Beaton, Chris. Riley, G. P. Crombie, and A. Mosher all aided materially in the examination of this property. The geology shown on the Snow group of claims has been taken largely from a detailed map prepared and supplied by Dr. Beaton, but faults and other structural interpretations are those of the writer.

The area covered by these claims is structurally complex, and its interpretation is made more difficult by lack of beds that can be used as horizon markers. The chief rocks in the claim group are altered basic flows and equivalent intrusive diorite. Contacts between flows and diorite are vague, and in many places are gradational across several feet. Minor amounts of rhyolite are interbedded with the basic flows, and these rocks are separated by faults from staurolite schist, altered basic breccias, and arkosic gneisses. The northwest corner of the claims includes the rocks at the nose of the McLeod Lake syncline. The west side of the claims covers the faulted upper contact of staurolite schist for nearly 2 miles. A branch from this fault trends northerly through the middle of the claims, and the Cleaver Lake fault cuts rocks in the northwest part of the group. Numerous other smaller faults branch off the main faults. Carbonatization and silicification characterize sheared zones in the volcanic rocks, and a drill-hole that crossed the fault at the upper contact of staurolite schist passed through about 6 feet of graphitic schist.

Of the eleven showings seen, one lies in basic breccia and the others in diorite or basic flows at or near their contacts.

Snow group showing No. 3 near the west corner of the Vee No. 7 claim, is in sheared, carbonatized, and silicified basic breccia **(24)**, on which several test pits have been sunk at intervals for about 900 feet. Two abrupt slopes, marked by strong shearing, face southwest, and the mineralized zone of sheared rocks lies in the step between the slopes. The northeastern fault separates the breccia from basic flows, and the southwestern fault separates it from staurolite schist. A feature of the mineralized zone is the angle between quartz veins and schistosity, the latter striking about 10 degrees west of north and dipping 50 degrees east, whereas the quartz veins trend 45 degrees west of north and dip northeast. That is, the veins are parallel with the shear zones along the fault scarps, but schistosity within the block is at an angle of about 35 degrees to the direction of movement. The main fault is that following the staurolite schist, and the acute angle it makes with the direction of schistosity in the block probably indicates that movement on the main fault is right-handed.

Quartz veins exposed in the trenches are rather small but numerous across widths from 2 to several feet. Trenches cut through a weathered zone that reaches a depth of 8 feet and generally extends 2 or 3 feet beneath the glacial drift. As a result it is difficult to determine mineralized widths and the sulphides present, but arsenopyrite, pyrite, and pyrrhotite have been recognized. The results of diamond drilling done in 1943-44 were said to be inconclusive; only one hole had consistent ore values, about 0·17 ounce in gold a ton being reported for 38 feet of core length. Values in the other nine holes were said to be spotty, and no mineable widths were of ore grade.

The Snow group No. 9 showing is about 300 feet north of the south side of the Par No. 5 claim **(23)**. It lies on an east-facing slope that is essentially a dip slope. Rocks are quite schistose and silicified, and contain more or less carbonate. They may be in part the finely bedded tuff that marks the upper limit of the middle band of basic breccia, but rocks a short distance west are typical basic flows. The mineralized outcrop probably is a fault plate. The schistosity trends about north 10 degrees west and dips about 35 degrees east. Small, but numerous, quartz stringers follow a zone that strikes about north 35 degrees west and dips northeast. Strongly marked fluting and ridging of the rock plunge south at a low angle. In places an angular breccia of basic fragments is cemented in a matrix of quartz. Finely divided arsenopyrite is the main sulphide, and little clusters of acicular tourmaline occur here and there. Assays in gold from surface sampling are said to be encouraging.

The Snow group No. 2 showing occurs in diorite in the Vee No. 6 claim **(22)**. No faulting or shearing is evident, and cleavage in the rock is indistinct. Trenches cross the outcrop from east to west and for 100 feet north to south, ending in diorite at either end. About 10,000 square feet of mineralized and silicified rock were thus exposed. The rock is fine grained, rather dark pinkish grey, and massive. It contains finely disseminated sulphides of which arsenopyrite is the most abundant, though pyrrhotite is nearly as common. At the north side of the workings cleavage dips at angles as low as 10 degrees to the northeast, but at the south side dips are in the order of 30 to 40 degrees. Assays from samples in the trenches returned good values in gold, but diamond drilling showed the deposit to be basin shaped, extending only a few feet beneath the surface.

The Snow group No. 8 showing lies a short distance south of the No. 2, near the south corner of the Vee No. 6 claim. It, also, occurs in diorite, but along the edge of a shallow draw trending east and west. The draw apparently marks a small fault that dips about 45 degrees north, and dragging of the rocks along it indicate nearly horizontal, left-handed movement. Arsenopyrite crystals are common, and considerable amounts of coarse gold were disclosed by trenching. This gold occurs almost entirely at the margins of quartz veins or silicified inclusions in the veins. Drilling failed to find similar conditions at depth.

The Snow group No. 7 showing **(20)** lies in medium-grained diorite and fine-grained basic lava on the west edge of an outcrop on the Par No. 6 claim. A swampy valley trends northwest along the edge of the outcrop. Shearing in the rock trends about north 20 degrees west and dips 35 degrees east. One quartz vein, exposed by trenching for about 40 feet, strikes 10 degrees east of north and dips vertically. It pinches and swells along strike from about 3 inches at the south end of the exposure to a maximum of 30 inches. At the north end the vein pinches to a crack where it passes into massive diorite. Other, smaller veins occur here and there; all are probably controlled by fracturing in the hanging-wall of a small fault. The wall-rock is silicified, and arsenopyrite is the main sulphide. Considerable amounts of coarse gold occur at the margins of quartz veins in the trenches, but drilling failed to disclose similar conditions at depth.

Practically all the other mineral deposits in the Snow group occur on the edges of outcrops of sheared and silicified diorite or andesite **(21)**. Arsenopyrite is the main sulphide, but is mostly quite coarse grained. Coarse gold is common locally along the margins of some quartz veins, and in one or two places occurs in quite spectacular amounts. Sulphides and gold are rare in quartz, occurring mainly in silicified rock. Tourmaline was noted in the Snow group No. 1 showing, which is the strongest vein of those included in this account. Heavy gossan and drift handicap observations for structure, but all deposits seem to occur along, and near, small faults. Drilling completed to the end of 1945, when work was temporarily suspended, failed to prove any ore.

Loonhead Lake Sulphide Deposits (1, 2, 3)

Several old prospect trenches are located about Loonhead Lake. Some are sunk on mineralized zones in the gneisses, others in sheared and altered basic lavas of Amisk type. All are heavily rusted in areas of poor exposures.

A showing near the northeast shore of Loonhead Lake **(1)** is in silicified and granitized hornblende gneisses that lie on the northeast flank of the Loonhead dome. The gneisses are cut by dykes and sills of granite-pegmatite. The trend of the rocks and their schistosity is essentially northeast. Pyrrhotite is the main sulphide, with lesser pyrite and a little disseminated chalcopyrite. Wright (43, p. 66) reported a shallow shaft sunk on a drag-folded and faulted zone, but this working was not seen. He also reported that no mineralized zone was traced more than 100 feet along strike.

A short distance south of Loonhead Lake a considerable amount of shallow trenching has been done **(2)**. The principal trenches are confined to a north-facing hill off the south side of the fault that passes through Loonhead Lake. Here the basic lavas and interbedded sedimentary rocks are contorted, rusted, and strongly sheared, and are cut by small dykes of massive pegmatite. The shears trend about 20 degrees north of west and dip steeply north. Ridging and striæ on the rocks plunge east at about 45 degrees. An occasional splash of vein quartz is exposed. Pyrite was the only sulphide seen, but Wright (43, p. 67) reported some pyrrhotite and chalcopyrite.

Some trenching has been done on a pyritized zone **(3)** that lies on the west shore of a little lake about 2,000 feet south of Loonhead Lake. The pyritized zone occurs in a fine-grained, pink to grey weathering, silicified rhyolite. The rock is quite massive in outcrop, but contains irregular laminæ of material rich in biotite. Small amounts of pyrite and magnetite are disseminated through the rock.

Moore Lake Gold Deposits (45)

Two quartz veins are known south of Moore Lake, just west of the portage between Moore and Edwards Lakes. In 1945 the ground was controlled by Consolidated Mining and Smelting Company of Canada, Limited.

One deposit, on the Con No. 5 claim, is about 300 feet south of the lake in a small outcrop of highly feldspathic and garnetiferous grey rocks that have no apparent structure. Some white crystalline quartz of irregular outline cuts the felsite. A few crystals of pyrite were noted in the quartz and disseminated in the wall-rock.

The other deposit is in the Con No. 4 claim, about a quarter mile south of the first. Here the rocks are more typical basic lavas, although they fade into a hybrid type a short distance north. The vein, as exposed in three trenches, is as much as 8 feet wide and is more than 125 feet long. It follows a fracture plane that trends about east-west and dips steeply north. The vein contains small inclusions of silicified chlorite schist, and the rocks adjacent to it are also silicified. Minor disseminated pyrite is contained in the quartz, but is somewhat more abundant in the silicified rock and inclusions. Gold assays are said to be low.

Morgan Lake Gold Deposit (50)

A zone of quartz veins was discovered in 1944 on the largest island in Morgan Lake. It is known as the Finlayson find, and outcrops on the Dot No. 5 claim, one of twenty staked for the joint interests of Northern Canada Mines, Limited, and Pioneer Gold Mines, Limited. More than 8,000 feet of diamond drilling were completed from February to June 1945, when exploration work ceased. The writer examined the property in July 1945, and is indebted to Dr. C. Riley for the information he supplied.

A narrow zone of small quartz veins lies in a band of basic tuff near the east contact of a sill or dyke of medium-grained, nearly massive, hornblende diorite. The diorite cuts volcanic rocks that include flow breccias, tuffs, and pyroclastic breccias. All have been rather strongly sheared, and a rude foliation, partly marked by streaks rich in garnets, has been developed locally. The diorite has an arcuate trend, parallel with the structure of the enclosing rocks. At the south end of the island the trend is about 15 degrees east of north, and at the north end is 20 degrees west of north. Dips in all places are 65 to 80 degrees easterly (Figure 4). The diorite is exposed at intervals for only about 200 feet north from the southwest tip of the island, but is reported to have been intersected in drill-holes for some distance north and south of the outcrop. Volcanic breccia in the northwest bulge of the island is cut by rather abundant, small, irregular, felsitic and granitic dykes that are similar to some phases of 'quartz-eye' granite. Hybrid varieties formed by 'quartz-eye' granite occur on the mainland northeast of the island, and 'quartz-eye' granite is exposed a mile or so northwest of it. Contacts between basic volcanic rocks and the hybrid type are sharp in some places, gradational in others. Rather strong shear zones follow the east and west shores of Morgan Lake and may mark faults (*See* Plate IV B).

The general structure of the rocks in the lake can only be inferred. The trends of rocks suggest that the thickening of pyroclastic rocks in the lake may be due to a large isoclinal drag-fold, which would plunge

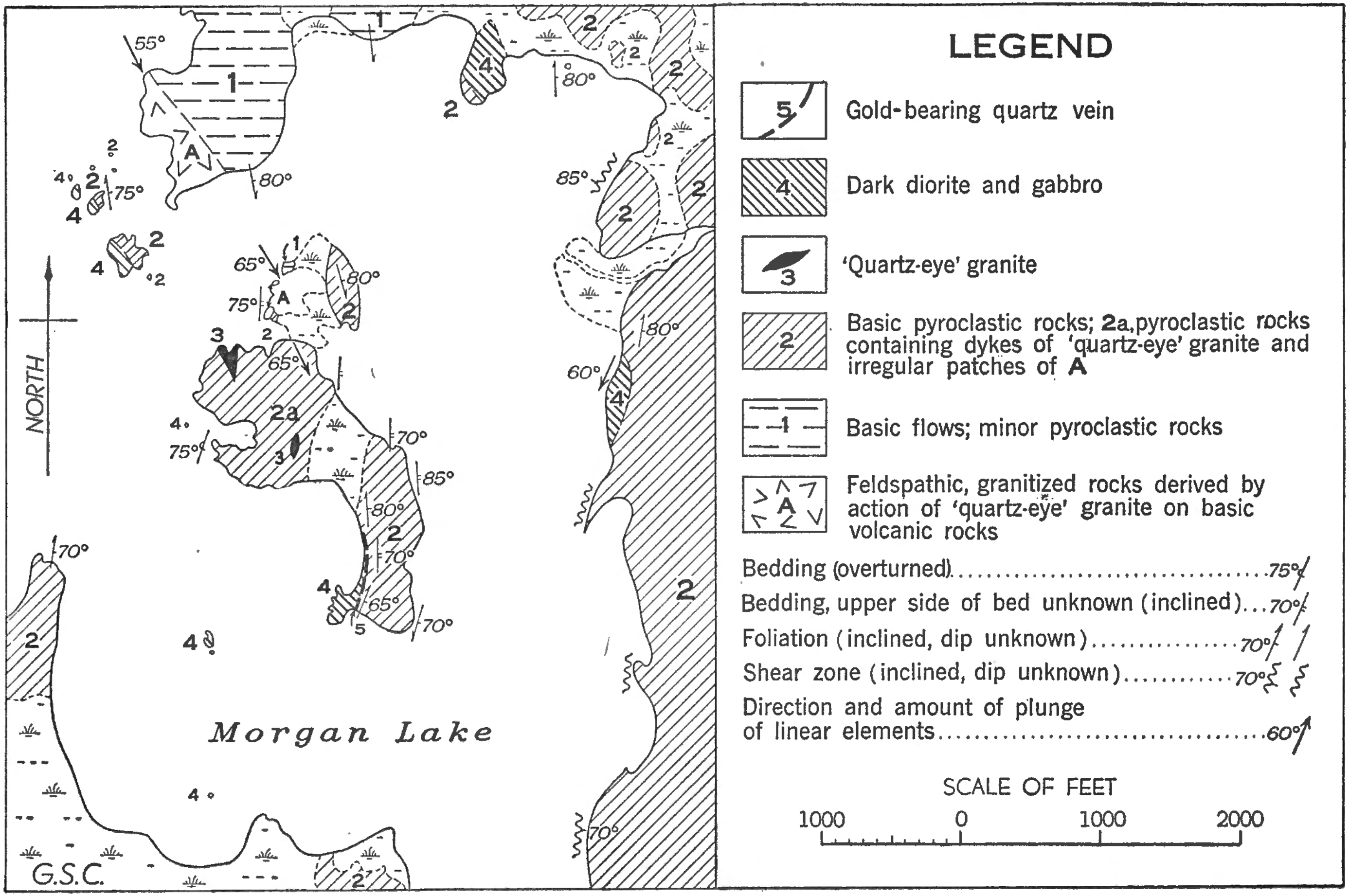


Figure 4. Detailed geology near the Morgan Lake gold showing.

southeasterly at a steep angle and be overturned to the southwest, that is, axial planes and limbs dip steeply northeast. If this be so, the Finlayson deposit lies on the flank common to both the anticlinal and synclinal components of the drag-fold. This interpretation would be in accord with top determinations and with the arcuate shape of the vein zone.

The vein zone is a narrow strip in a tuff band near the east contact of the diorite dyke. Quartz occurs as narrow lenses and stringers across a width of 2 or 3 feet in a heavily pyritized zone that extends as much as 60 feet farther east. Quartz quite definitely cuts pyritized material that appears to have been sheared. The pyrite-rich rock holds little gold, and probably represents a distinctly earlier period of mineralization. Minerals associated with the quartz are pyrite, chalcopyrite, sphalerite, galena, and gold. In places small concentrations of these sulphides are developed in the pyritized rocks, but it is reported that they carry very little gold.

Press reports indicate that sampling of trenches showed two shoots that yielded encouraging assays in gold. They are separated on strike by a short length of low-grade material. The southern shoot is 330 feet long, and is reported to assay 0·56 ounce in gold a ton across an average width of 2·3 feet. The northern shoot is 120 feet long, and assayed 1·38 ounces in gold a ton across an average width of 2·1 feet. Diamond drilling during the winter extended the mineralized zone for about 800 feet south beneath the lake, but assay returns were low across narrow widths. Drill samples from below the south surface showing provided some good, but irregular, gold assays across narrow widths. Drilling beneath the north surface showing gave only low values except where one hole intersected two very narrow zones of good-grade material. It is reported that no further work is contemplated at present.

Morgan Lake Sulphide Deposits (48)

Two sulphide deposits about a mile west and a little north of Morgan Lake were seen in June 1945. The northerly one is near the northwest corner of the J.B. No. 14 claim, and the southerly one in the D.R. No. 12 claim. Outcrops in this vicinity are small and widely scattered as low hummocks in a large swamp. The deposits lie in a silicified and pyritized complex of fine-grained felsite, altered lavas, and a coarsely garnetiferous rock that is probably derived from basic lava. 'Quartz-eye' granite is exposed about 100 yards west of the northerly deposit. Heavy rusting is characteristic of all outcrops in this vicinity, and quartz is common as veins, stringers, and splashes. No structure is apparent beyond a faint gneissosity trenching slightly east of north. The deposits themselves appear merely to be zones in which pyrite is more abundant than in the surrounding rocks. The northerly, J.B. deposit contains considerable coarse pyrite, but pyrite in the D.R. showing is fine grained. A very little chalcopyrite was noted.

Morton Lake Sulphide Deposits (11, 13, 14, 16)

These deposits lie near Morton Lake. The most northerly deposit **(11)** lies about half a mile north of Morton Lake, and was described by Wright (43, p. 67) as the Copper Valley sulphide deposit. In 1930, apparently only one showing had been opened by trenching, for two other trenches were seen in 1946. All are badly caved and rusted. They are in basic lava, which is intruded and enclosed by dark diorite. The rocks are much sheared, silicified, and carbonatized, and their diversity of trends suggests branching shears. The showing seen by Wright is on the west side of a swamp west of the Morton Lake fault; the others are on the east side of the swamp, about 400 feet from the first. Schistosity in the westerly showing trends at about 55 degrees west of north and dips 70 degrees northeast. At the more northerly of the other two showings strong shears trend about 40 degrees east of north and dip 80 degrees southeast. Just to the south, across a small draw, a shear in the third showing trends north and dips steeply west to vertically. Heavy pyrrhotite mineralization characterizes all three showings, and the sulphide forms 70 per cent of some fragments found on the dumps. Quartz is prominent in the remainder of the fragments. Chalcopyrite is locally associated with pyrrhotite as irregular blebs and stringers, and some occurs as a filling of small tension cracks. Pyrite is common; some is intergrown with pyrrhotite; some occurs as concretion-like blebs; and some forms crystals in vuggy quartz. The degree of mineralization varies greatly in each of the trenched zones. The pyrrhotite is reported to carry some nickel.

The more northerly of the deposits near the west shore of Morton Lake **(13)** lies in grey, gneissic, sedimentary rocks. Cleavage and bedding strike about 20 degrees east of north and dip westerly at 80 to 85 degrees. Stockwell (30, p. 70) described the deposit, then called the White Star No. 2, as follows:

> "The deposit is exposed in a trench at a locality 100 feet from the shore of the lake. The trench is 6 feet deep and crosses about 28 feet of grey, biotite gneiss cut by a few stringers of white quartz and rhyolite. The quartz carries blebs of chalcopyrite and is said to assay high in gold, but the quartz constitutes a very small part of the material in the trench and the veinlets are widely spaced. The gneiss across the full length of the trench carries disseminated grains of chalcopyrite and a few of pyrite and is crossed in many directions by small veinlets of chalcopyrite. Chalcopyrite is abundant across a zone 3 or 4 feet wide near the middle of the trench. A specimen of the mineralized gneiss is said to have assayed 0·07 ounce of gold per ton. A small outcrop 12 feet south of the heavily mineralized zone in the trench carries abundant chalcopyrite across 1½ feet. Another outcrop 30 feet farther south is heavily stained with iron oxide."

A few euhedral grains of arsenopyrite occur with the chalcopyrite.

A sulphide deposit **(14)**, described by Stockwell (30, p. 70) as the White Star No. 1, lies about half a mile south of that just described. This deposit, now heavily rusted, consists of fine-grained, well-bedded quartzite and greywacke, which are brecciated and crossed by a network of small fractures carrying pyrrhotite and pyrite. Fine grains of pyrrhotite are disseminated through the quartzite. Dark gabbro lies about 40 feet to the west. Samples from the deposit were said to assay 0·05 ounce in gold a ton.

A sulphide deposit **(16)** lies in a shear zone on the east side of Morton Lake about 1½ miles from the north end. The deposit is in sheared, silicified, and carbonatized quartz diorite. Pyrite was the only sulphide noted, and occurs in irregular thin stringers parallel with the shearing, which strikes about 25 degrees west of north and dips 65 degrees to the southwest.

Nor-Acme Gold Mine (30)

History. The original claims, which form the nucleus of the present group contained in the Howe Sound lease, were staked by C. N. Parres in 1927, and in 1938 Nor-Acme Gold Mines, Limited, was formed to develop the property. In September 1940, Mr. Frank Ebbutt made a brief examination of the property for the Howe Sound Company. The following spring five X-ray holes were diamond drilled under Ebbutt's direction, and as a result of returns from this drilling an intensive drilling program was undertaken and approximately 50,000 feet completed (16). Meanwhile, the Howe Sound Exploration Company, Limited, was formed as a wholly owned subsidiary of the Howe Sound Company, and in 1941 the new organization made a lease agreement with the Nor-Acme Company. Fifty-two claims and fractions were staked and surveyed, and these comprise what is now known as the 'Howe Sound lease'. Mineral deposits contained on this ground, other than the Nor-Acme mine, are described under that heading.

Diamond drilling of the mine area, which is largely covered with drift, outlined two orebodies. As reported to the press by the Howe Sound Company, these orebodies are estimated to contain nearly 5,000,000 tons of ore averaging 0·15 ounce in gold a ton. The two orebodies are known as the Dick and the Toots: the Dick is reported to contain 4,661,000 tons of ore averaging \$5.20 in gold (at \$35 an ounce), of which 3,370,300 tons averages \$6.21; and the Toots orebody contains 200,000 tons averaging \$6.43 in gold, of which 137,500 tons averages \$7.79. The Dick orebody outcrops in the extreme south part of the Chums claim, and derives its name from the fact that the claim originally staked was the Dick No. 1. The Toots orebody outcrops on the Toots claim, about 1,200 feet west and a little south of the Dick outcrop.

Wright (43, pp. 93-95) first described the deposit. Little rock was then exposed, and relations of rock types to each other and to ore were obscured. He noted, however, from parts of the ore zone that were exposed that: "No definite vein or single large body of quartz has been uncovered in the workings on the property. The quartz on this property is markedly different in appearance from the characteristic gold-bearing quartz of the district".

Nothing further appeared in the literature until Shepherd (27) described the activities resulting from the general knowledge of ore at the Nor-Acme. He also gave a brief résumé of the geology. Ebbutt (16) presented a brief description of the deposits and their relations to the enclosing formations.

Most of the writer's investigations of the Howe Sound lease were made in August and September 1944, but some additional data were collected in 1945 and 1946. Until September 1945 the camp at the Nor-Acme mine consisted of four or five cabins and a similar number of tent frames (Plate I A), built to house the construction crew. Buildings for the mining plant were begun the following winter, and when the property was visited by the writer in September 1946 temporary housing units had been built, the headframe for a five-compartment shaft was being erected, roads were being constructed, and the site for the town was being cleared.

Figure 5. Detailed surface geology at Nor-Acme mine, Snow Lake, Manitoba.

By the end of 1947 building of the plant and town were well under way, and the mine is scheduled to be in production by the end of 1948 at a proposed milling rate of 2,000 tons a day.

Most of the writer's observations and interpretations are based on data collected from surface mapping, but useful material was obtained from diamond-drilling records kindly supplied by the Howe Sound Company. Discussions with F. Ebbutt and F. D. Shepherd were of material assistance in understanding the problems. C. H. Stockwell spent 3 days at Snow Lake in September 1945 and aided greatly in clarifying the structural relations at the mine.

General Geology. Feldspathic sedimentary rocks, with some interbedded acidic flows, and basic breccias, each form two layers in the stratigraphic succession of the mine area. Both rock types are cut by irregular basic intrusions ranging in composition from diorite to hornblendite, and a few small dykes of granitic rock were also noted in the basic breccias. These rocks are separated by faults from staurolite schist on the south and west, and from basic flows on the north and east. The orebodies of the Nor-Acme mine are at the contact between the two lower layers of basic breccia and feldspathic sedimentary or volcanic rocks (Figure 5).

In the vicinity of the orebodies the normal, hornblende-rich, basic pyroclastic rocks are locally much lighter in colour and have a bleached appearance. This is due to albitization, for the normal andesine has been converted to much more abundant albite-oligoclase. In places both normal and bleached types are impregnated with needles and rosettes of black tourmaline. At other localities the basic rocks have been transformed mainly to fine-grained epidote enclosing a few remnants of hornblende. A few small, sheet-like dykes fill tension cracks in the hanging-wall. They have a superficial resemblance to granite, but consist mainly of coarse, acicular to platy zoisite, subordinate quartz, and minor chlorite, cloudy plagioclase, and bluish mica (var. gilbertite). Alteration of the feldspathic foot-wall rocks is not so apparent, partly because exposures are more scarce, and partly because they normally contain large amounts of quartz and sodic plagioclase. However, silicification is distinct locally.

Structure. The claim boundaries of the Howe Sound lease wholly enclose the known extent of the Nor-Acme anticline, the major controlling structure for the orebodies. This anticline is isoclinal, and has been overturned to the southwest—that is, both limbs and the axial plane dip northeast at 45 to 50 degrees. The fold plunges north 30 degrees east at an angle of about 50 degrees. This structure lies on the southwest flank of the basin-like structure that is centred in Herblet Lake. Many faults intersect the rocks, and a large part of the southwestern limb of the anticline is cut off by a fault that follows roughly the contact of adjacent staurolite schist. North and west of the mine the fault pattern is much more intricate.

The Dick orebody lies at the crest of the Nor-Acme anticline at the contact between a foot-wall layer of feldspathic sedimentary and volcanic rocks and the lower band of basic breccia, which constitutes the hanging-wall. The ore dips and plunges with corresponding structures in the folded rocks. The Toots orebody occupies the crest of a small crumple on the southwest flank of the main anticline, which occurs at the same stratigraphic horizon as the Dick zone, and dips and plunges parallel with it. The two orebodies are connected by a narrow zone of silicified and mineralized schist that passes through basic breccia in the intervening, small syncline. Figure 6 presents an idealized picture of the ore structure, determined mainly from surface data.

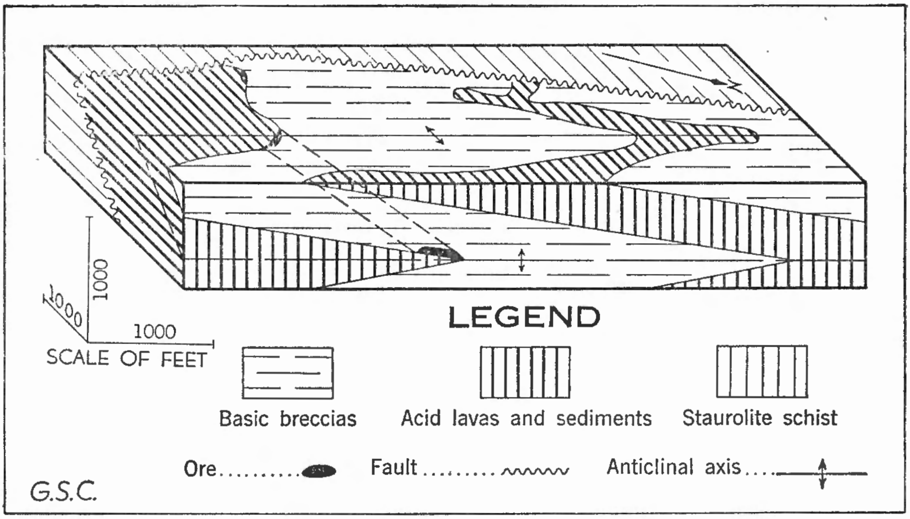


Figure 6. Idealized stereographic sketch, showing relations of ore to structure at the Nor-Acme mine.

The shear zone connecting the two orebodies, and indicated by Ebbutt (16, p. 10) as being ore, strikes north 70 degrees east and dips about 50 degrees north-northwest. Dark grey, cherty quartz is common locally, but caving of the trenches along the shear precluded detailed observations. Actual displacement along it seems to be small, although evidence for faulting in this area of few exposures is rather scarce. However, three diamond-drill holes at the west end of the Toots orebody intersected staurolite schist, and the contact between the schist and basic breccias is shown projected to the surface in Figure 5. The surface trace of this contact strongly indicates a fault with left-handed displacement. Striæ in the mineralized shear zone connecting the two orebodies plunge about 50 degrees in a direction about 40 degrees east of north. It is probable that these striæ were formed during faulting and indicate the relative direction of movement. If so, the movement on the fault was essentially parallel with the plunge of the Nor-Acme anticline, and the trace of the fault follows a line tangent to the apex of this anticline and that of the minor, Toots fold. So far as can be deduced from diamond-drill logs, this condition obtains at least to the maximum depth of drill coverage.

Further evidence of this shear being a fault is obtained from the orebodies themselves. Ore in them consists of an autoclastic breccia cemented by quartz, which indicates that the fault movement sheared the rocks where it passed through only the basic breccias, but where it intersected the contact between two rock types, at the crests of folds, it became a zone of brecciation. It also appears that the axial plane of the Toots anticline has been displaced, although silicification and brecciation have obscured the lithology.

In summary then, ore is located at, and near, a brecciated contact between basic pyroclastic rocks and feldspathic, siliceous, sedimentary or volcanic rocks. The main (Dick) ore zone lies on the crest of the Nor-Acme anticline, and the Toots orebody on the crest of a minor anticline on its southwest flank. The orebodies are connected by a small fault that angles away from a larger fault, and probably aided in localizing ore-bearing solutions (*See* Figure 5).

Orebodies. The general outline of the Dick orebody, in plan, as described by Ebbutt (16, p. 10) is "roughly the shape of a scimitar blade with the convex edge facing north and the wide end at the east. Its length is about 1,000 feet and part of it is over 100 feet wide". A trench extending northeasterly from the north side of the Dick No. 1 fraction claim gives a fair cross-section of most of the Dick orebody. At the south end of the trench the rock is a sparsely mineralized feldspathic and gneissic type cut by small, irregular stringers of quartz. The rock carries a few garnets, and small fragments or pebbles, similar in composition to the matrix, are still discernible. North along the trench the amount of quartz gradually increases, and silicification of the rock becomes more intense. About 80 feet from the south end of the trench vein quartz constitutes 30 to 40 per cent of the rock, and forms a cement for silicified fragments that are peppered with small grains and stringers of carbonate. The fragments also contain numerous, tiny "needles" of arsenopyrite and minor amounts of pyrrhotite and pyrite. Another 50 feet north, at the north end of the trench, the rock is mainly quartz. Fragments in it are silicified, but are still so dark that it is probable they represent basic breccia (Plate I B). The fragments are impregnated with tiny crystals of arsenopyrite. In this, as in all exposures of ore, sulphide minerals are confined almost exclusively to the silicified rock, the quartz itself being barren except for rare crystals of pyrite.

The next trench west, which is about 110 feet long, shows much the same gradation from south to north, but does not extend so far into the foot-wall, and the north 30 feet of the trench is caved. Just north of the trench a very small exposure shows rather pale basic breccia containing much quartz and albite, a little carbonate, and rather sparse sulphides. From these exposures it appears that the effects of mineralization fade into both hanging- and foot-walls, and that the most intensive brecciation, silicification, and mineralization were confined to the rocks nearest the contact between the hanging-wall basic breccia and the foot-wall feldspathic rocks.

The Toots orebody shows similar relations to the enclosing rocks, but on a much smaller scale. However, this orebody also contains a considerable proportion of dense, grey, cherty quartz, which is barren of sulphides and gold.

Mineralogy. Thin sections of several specimens from the orebodies were examined. They consist dominantly of fine-grained intergrowths of quartz and subsidiary albite, cut by stringers of coarse quartz. Occasional remnants of plagioclase fragments are recognizable. Carbonate constitutes less than 10 per cent of most slides, occurring as small stringers and disseminated grains that replace the coarse quartz, and a little fine quartz appears to be associated with it. Sulphides comprise 5 to 15 per cent of the slides, and are mainly very fine grained. Many grains are veined, or partly replaced, by carbonate. In some sections all other minerals are veined, or partly replaced, by coarse quartz. A thin section of a specimen from the quartz stock-work that encloses silicified fragments shows these fragments to be enclosed by rather coarse, granular, barren quartz. The coarse quartz is cut by carbonate and a little fine quartz. The fragments contain a considerable amount of fine carbonate and all the sulphides, except for a few grains enclosed in carbonate near the periphery of the fragments. Remnants of hornblende and plagioclase enclosed in fine quartz and chlorite are all that remains of the fragments.

Ten polished sections from the ore zone were carefully examined. In eight of them, one or more particles of gold were seen, the two sections that lack gold being from low-grade ore. In all the sections arsenopyrite is much the most abundant metallic mineral, and in most occurs as grains 2 mm. or less in longest dimension. The finer and more abundant the arsenopyrite, the better the gold assay (16, p. 10). Pyrrhotite is not abundant, but is common as ragged individuals partly replaced by carbonate. Pyrite is present in some specimens as euhedral crystals intergrown with arsenopyrite, and locally the boundaries between these two sulphides are indistinct, a characteristic of materials in solid solution at the contact. Sphalerite is quite common as small disseminated grains, and as stringers peripheral to pyrrhotite. Chalcopyrite is less common, and occurs mainly with pyrrhotite. In one section cubanite occurs as tiny ex-solution rods in pyrrhotite. All the sulphides are cut by minute veinlets of carbonate and quartz, and they are most abundant where carbonate is most plentiful.

Thirteen grains of gold were seen. Of these, eight were in contact with crystals of arsenopyrite, one with pyrrhotite, and four were in siliceous or carbonate gangue. The largest of these was 0·1 mm. in largest dimension, the smallest 0·003 mm. None was seen in cracks or fractures in arsenopyrite, although such occurrences have been reported by Warren and associates (40, p. 28), with three photographs to illustrate them. However, in at least two of the illustrations the gold is in tiny veinlets cutting arsenopyrite, and relief due to polishing strongly suggests that the veinlets are carbonate. In the other illustration the gold particle does seem to be locked in arsenopyrite, even though the sulphide is partly replaced by gangue. However, there is unquestionably a pronounced physical association of gold with arsenopyrite, a feature brought out by Warren's studies. He estimated (40, p. 28) that, if the ore were crushed to minus 200 mesh, the gold would be distributed as follows:

	Per cent
Free gold	40-50
Gold included in arsenopyrite, with some pyrite	50-55
Gold included in other sulphides and gangue	5-10

It is probable that much of the gold freed by grinding would be released from association with arsenopyrite, but that the 50 to 55 per cent remaining with the arsenopyrite is too fine to be freed by minus 200 mesh grinding. From the polished sections studied it can be estimated that at least 75 per cent of the gold is associated with arsenopyrite that has been pitted and cut by carbonate.

Ebbutt (16, p. 10) suggested that gold was deposited in cracks developed in arsenopyrite by micro-brecciation. It is true that some of the gold does occur that way, but most of it occurs in carbonate stringers or blebs at the contact with a crystal or crystals of arsenopyrite, and some of it occurs in carbonate veinlets where no sulphides are evident. It seems probable that small-scale brecciation occurred at a late stage of mineralization and the cracks thus formed were filled with carbonate from solutions that also carried gold. As most of the gold is physically associated with arsenopyrite, and that sulphide forms only about 5 per cent of the average ore, it seems clear that the sulphide must have exerted some influence on the gold-bearing solutions. Inasmuch as most of the gold lies at the periphery of crystals where they are in contact with carbonate stringers, it is logical to infer that arsenopyrite induced precipitation of gold from the carbonate-bearing solutions.

The paragenetic sequence for the orebodies, as determined from field and laboratory studies, and Warren's report (40), can be illustrated as follows:

Brecciation and silicification.....————————
Quartz veining.................................————
Fine quartz + carbonate + sulphides.................————
Carbonate + gold (+ quartz?)...........................——————
Coarse quartz...————

Genesis of the Ore. The mineral assemblage and the wall-rock alteration are characteristic of deposits formed at considerable depths and high temperatures. The time of mineralization is probably late in the Precambrian sequence for this area. Basic intrusions are younger than all rocks except biotite granite, and they have been folded, sheared, and contain similar assemblages of sulphides and gold. If the ore is genetically related to any intrusive rock exposed in the area, it can only be to the biotite granites, which constitute a batholith about 6 miles to the east of the mine, and a boss or stock about 5 miles to the north of it. However, no pegmatites, or other intrusive rocks that appear to be related to these granites have been found within 3 or 4 miles of the mine. The pegmatite-like, sheeted intrusions composed of zoisite, quartz, and mica that cut the basic breccias just north of the mine are not the kind normally associated with granites. The chief suggestions of underlying granitic rocks are the local abundance of tourmaline, and the albite-quartz alteration of the wall-rocks. If a magma from which the biotite granites were derived was also the source of the ore, it must be far removed in depth.

Noteme Sulphide Deposits (37)

The deposit indicated on the map, about 800 feet east of Noteme Lake on the Northern No. 7 claim, is one of three or four sulphide deposits in this locality. All consist of irregular zones of quartz filling small shears that are probably offshoots from the Snow Lake fault. Shears trend at various angles, but are most commonly nearly east-west, and the basic volcanic rocks are locally amphibolitized and carbonatized. Quartz is barren of sulphides, but the enclosing rock contains disseminated pyrite and pyrrhotite, the latter in places being sufficiently abundant to cause extreme magnetic deflexion of a compass needle. The gold content in these deposits, and others of similar type, is said to be very low.

Photo Lake Gold Deposit (36)

A small quartz body lies about 2,000 feet northwest of Photo Lake in the How No. 4 claim. The surrounding rocks are partly feldspathized basic lavas cut by small dykes of quartz porphyry, felsite, and, about 350 feet west of the deposit, by a sill of 'quartz-eye' granite. A shear zone about 500 feet east of the showing separates the enclosing andesite from complexly folded and interbedded basic flows and breccias. It trends about north and dips 50 to 60 degrees east. Rocks within this fault zone near Tern Lake are partly sheared, but become more recrystallized to the south.

The quartz occurs as a plug that fills a small drag-fold in highly biotitized basic lava. The rock is quite schistose, the schistosity trending about north and dipping 55 degrees east. The shape of the vertically plunging drag indicates left-handed movement on the shear. The quartz body is about 3 feet across, and is sparsely mineralized with pyrite, chalcopyrite, and galena. Samples are said to have returned good assays in gold. Tennantite has been reported, but none was seen there by the writer.

Snow Lake Narrows Deposits (32, 33)

Several, small, gold-bearing veins lie on the south side of Snow Lake Narrows, west of the Howe Sound lease. They are on claims of Camwe Gold Mines, Limited, which were optioned by American Smelting and Refining Company, Limited, in 1945. A program of exploration, trenching, and drilling was then carried out, and work was stopped in July 1946. Diamond-drill data were kindly supplied by A. Kirby, Jr., of the optioning company.

All the deposits occur in small shears that branch south from the Snow Lake fault, or in shears along the fault. Rocks south of the fault are basic flows and fragmental rocks intruded by related diorite. These are cut by bodies of gabbro, hornblendite, and garnetiferous diorite. The basic volcanic rocks are altered locally to felsitic types resembling sedimentary rocks, and all have been amphibolitized, carbonatized, and partly silicified along the Snow Lake fault and the many smaller shears that extend south from it. Argillite, greywacke, and staurolite schist extend north from the fault, the less highly metamorphosed rocks being nearer to it. Diamond drilling shows that most of the shearing is confined to the southernmost 50 feet or so of the sedimentary rocks, where they are carbonatized argillite and greywacke. The Snow Lake fault dips north at angles between 50 and 70 degrees, and striæ on fault plates plunge 50 degrees or so to the northeast. Subsidiary faults branching south dip east at angles between 60 and 70 degrees, and striæ on these fault plates plunge northeasterly at widely varying angles. Bedding on the north shore of the narrows dips 40 to 50 degrees north, and long axes of fragments in volcanic breccia at the south shore plunge about 45 degrees northerly. However, assuming that the contact of the Snow sedimentary and the Amisk volcanic rocks, which extends through Snow Lake Narrows, is no more than 10 to 50 feet off the south shore, and that diamond-drill holes are constant in dip and strike throughout their length, the fault must dip not less than 50 degrees, and in places not less than 70 degrees. It appears, therefore, that bedding in the sedimentary rocks, which dip less than these amounts, and elongated fragments in the breccia, which plunge at lower angles than the dip of the fault, assumed their positions before faulting, and are probably related to Herblet and the Threehouse syncline respectively.

Seven showings are exposed on the S.D. Nos. 7, 8, and 9 claims, but only two localities are indicated on the map, the more easterly locality including two showings.

The Camwe "A" showing **(32)**, in claim S.D. No. 7, is about 900 feet west of the west boundary of the Howe Sound lease on the south shore of Snow Lake Narrows. Schistose volcanic breccia is cut by a small quartz vein that is exposed for about 15 feet back from the lake shore, and attains a maximum exposed width of 6 to 8 inches. The volcanic rocks are carbonatized and show a distinct banding, due to shearing, that strikes north 50 degrees west and dips northeast at a moderate angle. Long axes of fragments plunge in a direction about 25 degrees east of north. The vein trends northeast and dips steeply northwest. The most abundant sulphides are galena and nearly black crystalline sphalerite, plus local concentrations of grey copper (tennantite) and chalcopyrite. Pyrite is present in minor amount. Assays in gold and silver were low. This is the only locality in the map-area where tennantite was seen, although prospectors have reported it elsewhere. The deposit is probably the "Galena Showing" mentioned by Alcock (3, p. 38).

The Camwe "C" showing **(33)** lies on the west shore of a small bay near the middle of S.D. No. 9 claim. Rocks there are sheared, amphibolitized, and carbonatized basic flows and diorite. The shear zone along the shore trends about 25 degrees east of north and dips 60 to 70 degrees southeast. Small quartz stringers parallel the shear zone. Pyrrhotite is the chief sulphide, but some pyrite and arsenopyrite are present. Diamond drilling of this prospect showed that the shear persisted irregularly southwards, but the gold content is said to be low.

A small quartz vein, known as the "B" showing, lies about 500 feet south and slightly east of the "C" zone. The vein strikes about north and dips vertically. The quartz is barren, but the wall-rock near the vein contains considerable pyrrhotite.

Some shear zones rich in pyrrhotite cut basic volcanic rocks on slopes that face the narrows. Some contain sparse, rather coarse arsenopyrite, but values in gold are said to be low in all of them.

Squall Creek Sulphide Deposits (27)

Some old pits expose a rusted zone in coarsely recrystallized, basic Amisk lavas about half a mile north of the west end of Snow Lake. The zone extends about half a mile north of the locality marked on the map, on the east side of a steep slope that faces the creek and is probably on, or near, the dip slope of the northern extension of the Snow Lake shear zone. The rocks in the pits are badly fractured and rusted, and locally show evidence of strong shearing. The shears trend about north and dip 40 to 50 degrees east. In places quartz veins up to 2½ feet wide are exposed, but the quartz mainly occurs as irregular, small lenses with a general trend parallel with the shear zone. Much of the vein material contains a considerable amount of feldspar. Arsenopyrite, pyrrhotite, and pyrite are the sulphides; the arsenopyrite occurs chiefly as small blades and blocky crystals associated with the other sulphides in the wall-rock near, or at, the margins of quartz veins.

Squall Lake Gold Mines, Limited (17, 18)

Squall Lake Gold Mines, Limited, owns a group of claims about McLeod and Squall Lakes, where gold-bearing quartz veins have been known for years, but intensive exploration did not begin until the latter part of 1944. In that year Wekusko Consolidated Mines, Limited, optioned several claims, and staked others. Diamond drilling was started in March 1945, and in November of the same year the present company was formed to take over forty-six of the claims. Intensive drilling and geological examination was continued to the beginning of 1947, when operations were temporarily halted. The writer mapped the region in 1944, and made brief visits to the property in 1945 and 1946. G. B. Tribble, in charge of operations, and W. T. Boyes, geologist, kindly supplied much detailed information about the deposits.

All the showings occur on the northwest flank of the McLeod Lake syncline, where it plunges 5 to 15 degrees northeast. Beds there dip 25 to 40 degrees southeast, and those on the opposite limit dip 40 to 60 degrees northwest. Thus the axial plane of the syncline is tilted slightly and dips steeply southeast. The Cleaver Lake fault cuts out a large part of the southwest limb, and a fault may follow staurolite schist beneath Squall Lake. The important rock, from the viewpoint of potential ore, is a sill of biotite-hornblende diorite that follows closely the contact between staurolite schist and arkosic gneisses. This sill forms a high ridge between Squall and McLeod Lakes and around the nose of the fold. All showings so far discovered occur in and near the hanging-wall of the sill at its contact with arkosic gneisses.

Gold values occur in mineralized shear zones in, or near, the upper contact of the sill, and several deposits are known on the ridge between the showings indicated on the map (17). Most of the showings are small, but all those thoroughly drilled are parallel with each other. Lenses of mineralized basic sill that carry about 0·20 ounce in gold a ton across a width of 4 feet have been reported on the Margaret and K Nos. 1, 5, 7, 10, and 11 claims. A broad mineralized zone (18) was discovered on the Gertie and Moon No. 1 claims in the latter part of 1946.

The showings exposed on the Margaret and K claims have approximately the shape of flattened cigars, dipping about 25 degrees southeast and plunging 5 to 10 degrees northeast, parallel with similar structures in McLeod Lake syncline. The most important body known to date is the Margaret, which has been traced by diamond drilling for 4,000 feet to the south end of McLeod Lake (Locality A, Figure 7). The most consistent section of it is the 2,000 feet nearest the lake where, for a down-dip distance of 600 feet, drill-hole sections averaged 4·9 feet in width, and 0·265 ounce in gold a ton. Shearing and mineralization continue beneath the lake, but values so far obtained there have not been as good nor as regular. Other mineralized zones that outcrop northeast along the ridge for 4 or 5 miles are smaller, and potential ore sections reported are narrower and somewhat lower in grade.

The close structural association of mineralization and the McLeod syncline indicates that the shears that act as loci for mineralization were formed by slippage between formations in the syncline during folding.

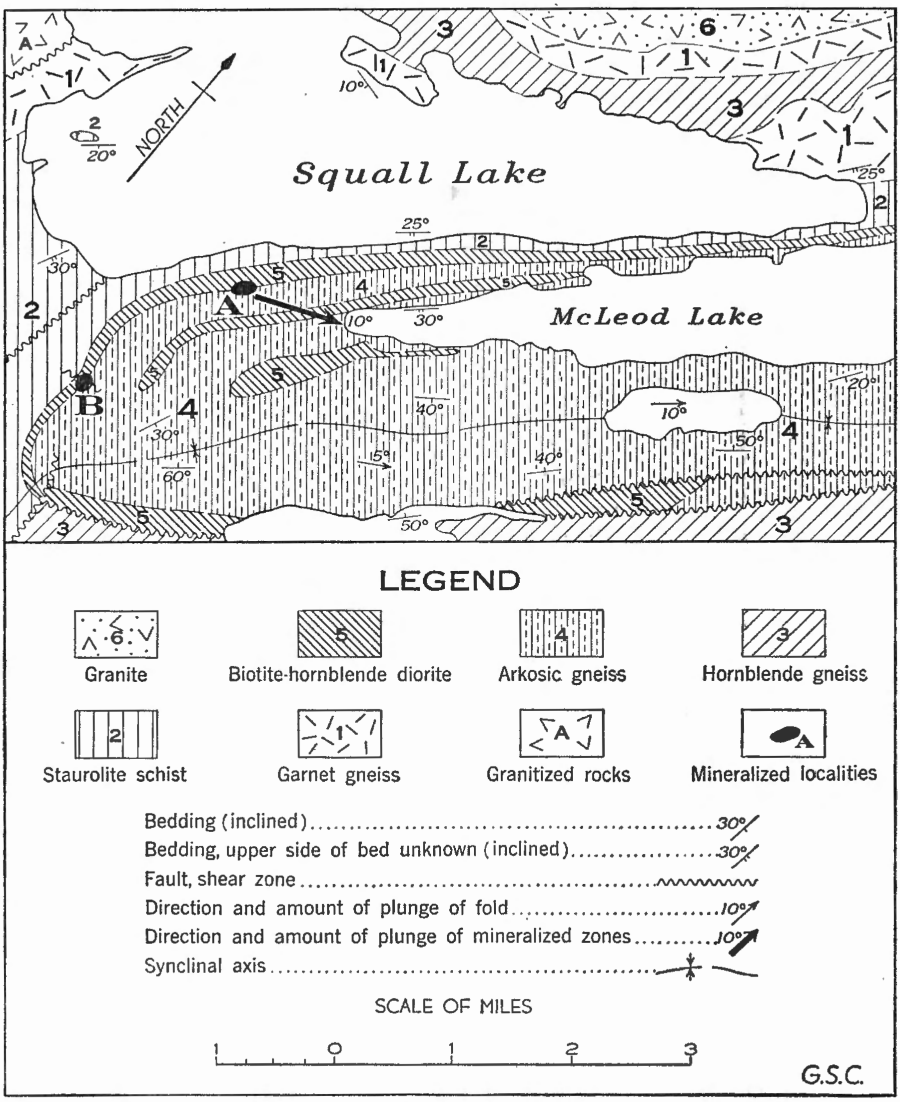


Figure 7. Mineralized zones, Squall Lake Gold Mines, Limited.

Detailed mapping by W. T. Boyes indicates gentle warps in the diorite arkose contact, and gold deposition may have some relation to the minor flexures. Within the mineralized zones the diorite is silicified and slightly carbonatized, and where good values have been most consistent the diorite contains much albite. Fairly coarse arsenopyrite is the main sulphide, and where quartz and chlorite are also present gold is associated with it. Pyrite and pyrrhotite are locally common.

The deposit outcropping on the Moon No. 1 and Gertie claims differs from the others in structural relations. It was not seen by the writer, but is reported to lie in a steeply dipping, broad shear zone trending 10 to 20 degrees north of east, and which probably marks a fault (Locality B, Figure 7). Values in gold were obtained from altered diorite near its upper contact. At the surface the deposit was sampled across a width of 70 feet, and gave a reported cut average of 0·225 ounce in gold a ton. Drilling reported up to December 1946 had encountered only a spotty gold content.

Tern Creek Showings (35)

Two deposits about half a mile west of the outlet of Tern Lake were examined in August 1945. One lies on the south shore of the creek just north of a cabin on the J.M. No. 4 claim, and the other is about a quarter mile south of the cabin on the J.M. No. 2 claim. Both deposits lie in hybrid rocks of the type formed from basic volcanic rocks by the intrusion of 'quartz-eye' granite, and relicts of the basic rocks are present here and there. 'Quartz-eye' granite is exposed just across the creek from the north showing, and another mass of it extends south of Tern Lake about 2,000 feet to the east. It is possible that these two exposures are faulted segments of the same intrusive mass.

A distinct foliation, or banding, in the hybrid rocks trends about northwest and dips about 40 degrees northeast. Gneissosity, or lineation of minerals, on the other hand, strikes about 20 to 30 degrees east of north and dips steeply southeast to vertically, which is characteristic of regional schistosity in the Threehouse syncline. At most places near these deposits gneissosity is better developed than foliation, and quartz veins tend to follow it, but in some places veer to follow the foliation for short distances. The change in strike from gneissosity to foliation is always to the left, producing a 'stepped' appearance to a vein outcrop.

The northern deposit lies on the south side of the sheared zone that extends along the creek draining Tern Lake. Sparse quartz and disseminated sulphides follow an ill-defined zone in silicified and biotitized rocks that are probably derived from basic volcanic breccia. Shears here trend about north 60 degrees west, and dip 40 degrees northeast, but pronounced lineation and pencil structure are the most prominent structural features. They plunge about 35 degrees north-northeast. In some places mineralization appears to follow the plunge, in others the shearing. The deposit has been trenched and stripped for about 50 feet south from the creek. Considerable amounts of brownish carbonate are exposed locally, and quartz tends to occur in small pods and lenses that lie parallel with the plunge. Sparsely disseminated pyrite, and possibly a little galena, occur in the silicified and slightly sericitized wall-rock.

The more southerly showing is marked by three zones along which trenching and stripping have been done. These workings begin on the J.M. No. 2 claim about 800 feet south of the cabin and continue at irregular intervals for about 600 feet farther south. The southernmost workings are about 20 feet long and 5 feet wide, following an irregular vein of quartz that cuts silicified basic rock carrying small amounts of pyrite. To the north, 70 feet of drift is followed by 70 feet of trenching and stripping across about 10 feet of highly silicified garnet-hornblende gneiss and felsite gneiss. Alternate bands of quartz and wall-rock strike north-northeast and dip 70 to 80 degrees east-southeast. Quartz veins are concentrated in the central part of the exposed area, and occupy a width of 10 feet. They are irregularly mineralized with cubes of pyrite up to ⅛ inch a side, and contain small remnants of chloritic material. The northernmost zone of trenching and stripping is separated from the middle one by about 250 feet of drift. It begins due north of the middle zone, is about 200 feet long, and varies in width from 5 to 20 feet. Quartz veins are abundant in white weathering, silicified felsite. The main vein, exposed nearly the entire length of the workings, varies in width from a few inches to 3 feet, and numerous smaller veins branch from it. Discontinuous quartz lenses are abundant. The zone trends due north and dips steeply east, whereas gneissosity strikes 20 degrees east of north, a feature due to offsetting of veins along planes of foliation. Striations on gneissic and sheared surfaces plunge 40 degrees north-northeast. The wall-rock is sparsely mineralized with pyrite, and the veins contain irregularly distributed crystals, stringers, and small masses of pyrite. Some crystals of pyrite are ¼ inch across. Much of the pyrite is associated with crystalline galena, less chalcopyrite, and minor sphalerite, and very small amounts of tennantite may also be present. These minerals tend to occur in narrow stringers, particularly where the quartz contains chloritic inclusions. The gold content is said to be low.

Much of the quartz contains heavily kaolinized pink feldspar, which, combined with the massive, milky appearance of the quartz itself, suggests that the veins may be pegmatitic in origin.

Tern Lake Portage Showing (34)

Strongly sheared and mineralized rocks are exposed by trenches on the N.O. No. 3 claim on the south shore of Snow Lake about ¼ mile east of the portage to Tern Lake. Trenching and drilling were undertaken in the autumn of 1943 by Macassa Gold Mines, Limited, who had optioned some claims in this vicinity. This option was subsequently dropped. Diamond-drill records were kindly supplied by M. H. Frohberg, of the optioning company.

The rocks in this region are complexly sheared, and related carbonatization has produced conditions favourable for a heavy growth of underbrush so that outcrops are sparse and poorly exposed. The shearing is probably related to the Snow Lake fault, which bends abruptly northward in this locality. Dark hornblende diorite is exposed about 350 feet south of the deposit, and a large intrusion of garnetiferous diorite, in part amphibolitized, lies about 1,000 feet west. Basic volcanic rocks to the south and west are partly converted to garnetiferous felsitic rocks, and the rocks in the deposit may be, in part, these altered types. No argillite or staurolite schist is exposed near the showing, but diamond-drill records indicate that argillite occurs about 20 feet below the surface in some places. It is possible that the deposit actually occurs in argillite, but the rocks are too altered for positive identification.

At the deposit rocks are sheared in a direction north 55 degrees east, and dip 65 degrees northwest. A distinct fluting in the rocks plunges about 50 degrees north-northeast. Trenches up to 50 feet long, 6 feet wide, and 6 feet deep have been sunk at irregular intervals along strike for more than 1,000 feet, and expose silicified, pyritized, and heavily rusted rocks. Some appear to be bedded, and the banding is parallel with shearing. Pyrite is the predominant sulphide recognizable on surface, but pyrrhotite is common in drill cores. The gold content is low.

Threehouse Lake Gold Deposit (42)

A small quartz reef on the Ern No. 5 claim lay just below the water level of August 1945 at Threehouse Lake. The reef is close to the west shore, on a blunt point in the south half of the lake. The deposit lies a short distance southeast of the axis of the Threehouse syncline, and is enclosed in basic amygdaloidal and pillowed lavas. A few interbeds of tuff and intrusions of diorite are also present. The lavas near the deposit strike about 70 degrees west of north, and shapes of pillows indicate they dip and face northerly. Cleavage strikes about 25 degrees east of north and dips vertically, and striæ on cleavage surfaces plunge north.

No bedrock is exposed at the deposit, and the quartz itself is in the form of angular rubble, which where weathered is quite rusty, but fresh surfaces are buff coloured and vuggy. It is very sparsely mineralized with pyrite, magnetite, and coarse gold, the gold occurring in the vugs. Galena has also been reported. Eight holes, totalling 1,440 feet, were diamond drilled early in 1945. Narrow veins of quartz were reported, and some returned fairly good assays in gold. However, there was no evidence of continuity to the veins.

Tramping Lake Sulphide Deposit (51)

This deposit is on the east side of the hammer-headed point that faces westward into the north end of Tramping Lake. Rocks on the point are difficult to classify owing to intense alteration. They are mainly fine-grained, dark greenish grey rocks that contain small intrusions of diorite. Rounded aggregates of epidote-rich material and a general green colour suggest derivation from basic volcanic rocks. Basic breccia does outcrop on the south end of the point, but at some other places the rock resembles an argillite. Both sides of the point are marked by strong shearing parallel with the shoreline, that on the east side dipping 65 to 75 degrees east, and that on the west side 70 to 80 degrees west. These shear zones appear to join at the north end of the point, suggesting that the rocks on the point represent either an up-thrust or down-dropped wedge, faulted against basic flows on the east and argillite on the west.

Pyrite occurs disseminated through the rock along the east side of the point, and across the north end. No special concentrations of minerals were noted, except that they are more abundant near the shore and the swamp edge. On the west side of the point pyrite occurs chiefly as narrow streaks along fractures in the rock. Pyrrhotite occurs with pyrite, but is not so abundant. Several test pits were dug on the north and east sides, but they have long since caved and rusted. High water in June of 1945 covered the bottoms of most pits. Three test holes are said to have been diamond drilled, and considerable widths of disseminated sulphides encountered. Low assays for nickel are reported.

Woosey Lake Sulphide Deposits (49)

Two mineralized zones marked by strong pyritization occur on islands in the southern third of Woosey Lake. Both lie in shears that cut argillaceous rocks and that strike a little west of north and dip vertically to steeply east or west. Pyrite, the only sulphide noted, occurs in irregular streaks and disseminated grains. It is more abundant in more highly schistose earthy argillite than it is in more massive and quartzose types. A few fragments containing talcose minerals were seen on the dump of the more westerly showing. Both zones are now so heavily rusted that only a little of the original material can be identified.

DESCRIPTIONS OF PROPERTIES, TRAMPING LAKE MAP-AREA

As most of the Tramping Lake map-area is underlain by granite and Palæozoic limestone, possibilities for mineral deposits are limited. The only deposits on which much prospecting and development work have been attempted are the sulphide deposit at Jackfish Lake and some quartz veins on Fourmile Island in Reed Lake. Descriptions of these workings are by M. S. Stanton.

Jackfish Lake Sulphide Deposits

The Jackfish Lake gabbro contains numerous deposits of disseminated and massive sulphides. These have long been known, and were described by Wright (43, p. 72) as the New Colony group. The claims were staked in 1928, and optioned to Manitoba Basin Mines the same year. Considerable surface work was done in 1928 and 1929 both east and west of Jackfish Lake. Oxidation has been intense, and yellow to brown limonite is common. In many places a coarse, regolithic mantle extends several feet below the surface.

Jackfish Lake is situated in the central part of a basic complex that varies in composition from pyroxenite to gabbro and quartz gabbro. Some norite is probably present. Coarse- to medium-grained gabbro and fine-grained basic rock commonly occur together in sharp contact. In places, angular blocks of the fine- and medium-grained varieties are included in the coarse; in other places, the medium-grained types are included in a fine-grained matrix. These probably all represent various phases of a common gabbroic magma. Many blocks of andesite are included in the gabbro, but only the largest are shown on the map.

Sulphides exposed by trenching are chiefly pyrrhotite and pyrite. Considerable amounts of massive sulphide occur in a large trench near the northwest shore of the lake. Pale marcasite, in crystalline and spheroidal aggregates, is the main mineral in a trench just north of the outlet of Jackfish Creek. Some copper has been reported in assays from this trench.

Minor amounts of chalcopyrite and sphalerite have been reported in trenches on the east side of the lake, half a mile north of the outlet. Sulphides in other trenches examined consist chiefly of pyrite and pyrrhotite, the latter reported to be slightly nickeliferous. Irregular contacts between quartz gabbro and andesite are exposed in several of the trenches, and to some extent at least these contacts appear to have been favourable loci for the deposition of sulphides.

Fourmile Island Gold Deposits

Several gold prospects have been explored in a small body of 'quartz-eye' granite that intrudes sheared andesite and volcanic breccia on Fourmile Island in Reed Lake. In 1937 and 1938 Reed Lake Mines, Limited, did considerable surface work, which included sinking a prospect shaft to a reported depth of 35 feet on the most westerly showing indicated on the Tramping Lake map.

In general, the gold deposits are similar to one another. They consist of milky white veins, stringers, and gash veinlets of quartz that are concentrated in zones where the 'quartz-eye' granite has been sheared, fractured, and silicified. The granite is typically greenish to pale purplish on freshly broken surfaces, but weathers white to pink. It varies in texture from dense, relatively fine grained to a rather coarse rock containing 'eyes' of quartz from $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. Towards the east end of the island the matrix is so fine that the rock is almost a quartz porphyry.

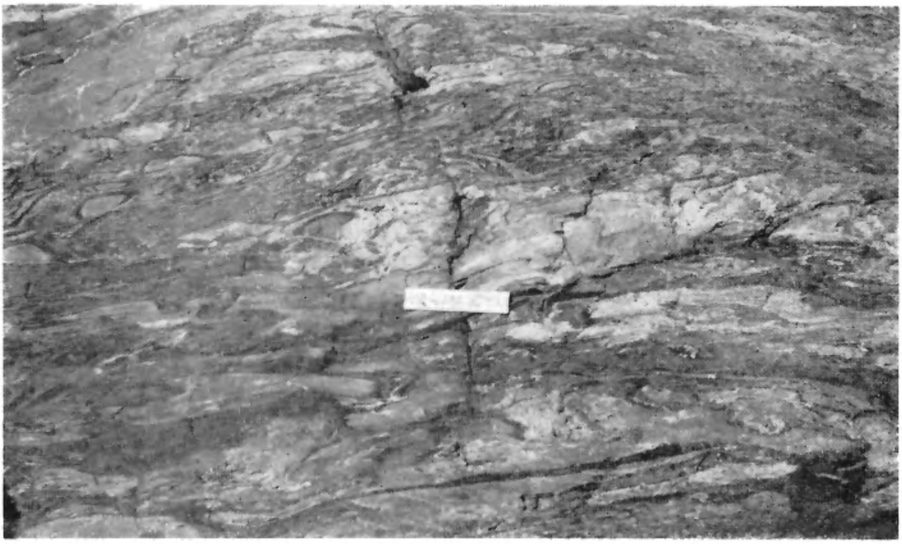
The shaft on the most westerly prospect is sunk in quartz veins contained in a narrow, chloritic shear zone that cuts the granite. The shear trends about 30 degrees west of north and dips vertically to steeply northeast or southwest. As exposed by trenches this quartz-bearing shear is 300 feet long, but may extend farther north. A second concentration of quartz veinlets lies in the granite about 15 feet west of the shaft, and has been exposed for about 100 feet along the strike. The granite is quite siliceous at these deposits and locally contains small stringers and cubes of pyrite. It holds numerous gash veinlets of quartz and small pits have been sunk at several places where the veinlets are concentrated. The quartz is milky white to vitreous and is locally pinkish or rusty. A small dump of quartz lies near the shaft and a little gold was seen in some of this quartz.

About half a mile east of the shaft, some workings expose a length of about 150 feet of veins, lenses, and stringers of quartz in silicified pink to greenish 'quartz-eye' granite. The veins are concentrated in an open S-shaped zone, which has an average trend of about north 25 degrees east. Ferruginous carbonate is common in the zone, and chalcopyrite occurs both as disseminated grains and as rather coarsely crystalline stringers. Sphalerite is also present, and visible gold has been reported.

The gold deposits at the isthmus on the island consist of veins, lenses, and stringers in a greenish, sheared, contorted, and highly chloritized and silicified phase of the 'quartz-eye' granite. In some places near these workings the granite is nearly a quartz porphyry. The shears, which are followed by the quartz veins, trend from north to 60 degrees east of north. The deposits themselves are *en échelon* so that they trend nearly east, whereas the individual zones, or groups of veins, trend generally northeast. Chalcopyrite, sphalerite, and ferruginous carbonate were seen, and visible gold has been reported.

The two most easterly prospects on Fourmile Island consist of small stock-works of quartz in a fine-grained, silicified variety of the 'quartz-eye' granite. Some pyrite is present, and it is reported that gold can be panned from such mineralized rock after roasting.

The trends of the individual deposits on Fourmile Island vary from northwest, through north, to northeast, whereas the granite itself is elongated east and west, features that suggest that the deposits are localized in areas of tensional weakness.



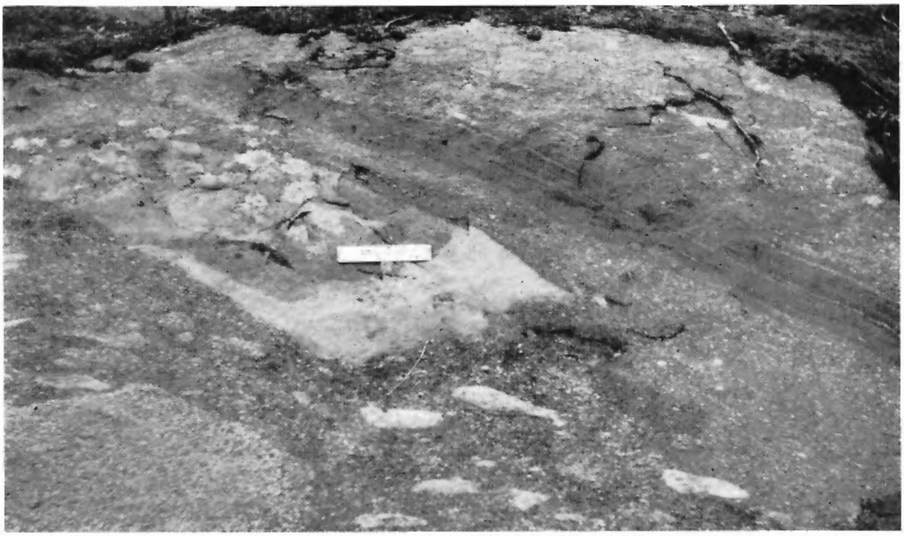
1-4, 1946

A. Flow breccia in Amisk rocks west of Woosey Lake. (Page 8.)

5-2, 1946

B. Sillimanite-quartz nodules south of Corley Lake. (Pages 11, 24, 28.)

PLATE III



98929
A. Coarse agglomerate and breccia of hanging-wall rocks, Nor-Acme mine. Note tuff beds lying to right of large block. Because large fragment has not affected bedding in the tuff, tops must be towards upper right corner. (Page 12.)

98927
B. Interbedded breccia and tuff forming matrix for coarse fragments. (Page 12.)

2-1, 1946
A. Foliation (banding) induced in originally massive, basic flows by metamorphism. West of Woosey Lake. (Pages 13, 34.)

98916
B. 'Fluted' structure along a shear zone on the west shore of Morgan Lake. Caused by elongation of greywacke pebbles in an argillaceous matrix. (Pages 40, 46, 64.)

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