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DEPARTMENT OF MINES

HON. PAUL LEDUC, *Minister of Mines* H. C. RICKABY, *Deputy Minister*

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By J. Satterly

INTRODUCTION

Sandy lake, which is an expansion of the Severn river, is situated in the Patricia portion of the district of Kenora on latitude 53° 00′ N. and lies between longitude 92° 20′ and 93° 40′ W. Small gold discoveries in the Northwest arm of the lake in July and August, 1936, aroused considerable interest in the area, and by the beginning of the 1937 season nearly a hundred recorded claims had been staked along the Northwest arm and another block of claims on Fishtail

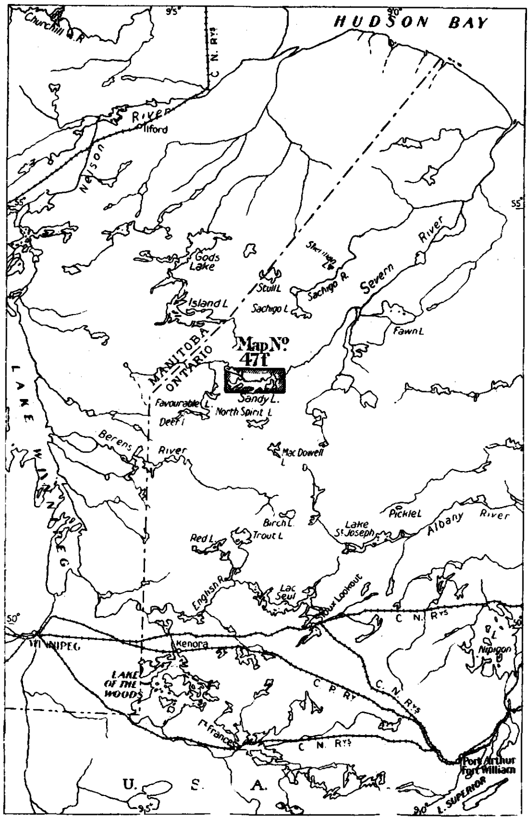


Fig. 1—Key map showing the location of the Sandy Lake area. Scale, 160 miles to the inch.

bay. During the summer several small finds were made, the main activity being on the north shore near Rahill lake, where over 40 claims were staked and recorded, between Fishtail bay and the Hudson's Bay Company post, and between the Northwest arm and Finger lake.

Present indications are that although gold is widely distributed along the whole length of the lake the deposits found to date are either too small or of too low a grade to be of any economic significance.

During the season of 1937 the entire belt of volcanics and sediments and the adjacent granite areas were traversed at half-mile intervals. The contacts shown on the accompanying map are based on the information derived from these traverses and from a detailed study of the geology along the shores of the lake. Owing to the prevalence of swamp areas, many of the contacts shown are of necessity only approximate.

Acknowledgments

The field assistants attached to the party were G. M. Robson, M. R. Brown, and G. L. Colgrove. To these men the writer is much indebted for their untiring efforts in forwarding the field work at all times. Mr. Robson, as senior assistant, at various times during the season carried on independently and is responsible for the entire mapping of the geology of the south shore of Sandy lake from the old site of the Hudson's Bay Company post[1] east to the outlet of the lake. He also mapped in its entirety the volcanic belt from the new post of the Hudson's Bay Company east to Fishtail bay, and the territory between the Northwest and West arms.

The white residents of the area were most kind to the party at all times. To Father J. Dubeau, Brother J. Dussault, and other members of the Ste. Bernadette Mission in the Northwest arm the party is much indebted for many courtesies and unstinted hospitality. To them and the residents of the Hudson's Bay Company post the party is indebted for handling mail.

The writer wishes to thank the many prospectors on the lake during the 1937 season for their kind hospitality and friendly co-operation, which did much to aid the progress of the field work. Prospectors T. J. C. and Harry Sandborn, Joe Hodgson and Stewart Staunton, D. H. Adams, and Karl Bayly, J. O. Lingman and Jack Lawson, J. A. Tully and P. Burton, C. Libert and A. Zeemel, C. K. Hansen, Allen McDonald, F. C. and Mrs. Bradley, P. White, C. Walters, and E. Shephard, all contributed in many ways.

To G. B. Langford and M. A. Peacock, of the University of Toronto, the writer is indebted for fruitful discussions.

Access and Canoe Routes

The area is most easily reached by airplane from such centres as Sioux Lookout, Kenora, Winnipeg, Berens River, Favourable lake, or Gods lake. Freight rates from Berens River on a full 'plane load are about $11.00 a hundredweight. The distance from Sioux Lookout to Ste. Bernadette Mission is 220 miles, and the flight takes a little over two hours.

The canoe routes to Sandy lake have been described by Hurst,[2] and the reader is referred to his report for details.

Several important routes lead out from Sandy lake. At its east end a portage of 115 chains leads to Rottenfish lake, which is the headwaters of the Sachigo River system of drainage. Rottenfish river drains northwards from this lake into Sachigo lake, and there are reported to be nine short portages on this route.

Bayly river, which empties into the north bay at the east end of Sandy lake, is used as a winter route to Island lake. At the west end of Sandy lake the route to Island lake is by the Severn river, Finger lake, Opasquia lake, and a 4-mile portage to the Sagawitchewan river, which flows northwards past the Indian village of Kechemutakwan through Cocos lake to Sagawitchewan bay of Island lake.

[1]The old site of the Hudson's Bay Company outpost is on the south shore of the lake about 5½ miles southeast of the present site.

[2]M. E. Hurst, "Geology of the Area between Favourable Lake and Sandy Lake," Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 2, pp. 49-51.

Southwards from Ste. Bernadette Mission, winter trails cut across points of land into Sandborn bay and Rat House bay, and southwest to Favourable and North Spirit lakes.

Routes southeast to the Dawson river leave Sandy lake either direct by a portage of 97 chains or via Niska lake by portages of 37 and 162 chains. From the Dawson river the route to the MacDowell river is believed to ascend the Roseberry river to Roseberry lake and by a chain of lakes to the McCoy river, one of the branches of the MacDowell river.

Previous Work

Sandy lake has undoubtedly been known to the Indians from a very early date. As it forms a part of the Severn River system, it was probably used early in Canadian history by fur-traders. Although the lake is not actually marked on the map accompanying Franklin's "Narrative of a Journey to the Shores of the Polar Sea," 1819-22, the Berens river is shown linked to the Severn river, indicating that it must have been known at that date.

The first report on the lake was made by Low[1] in 1886, and is reproduced in a report of the Ontario Bureau of Mines.[2] Map No. 1089 of the Geological Survey of Canada, published in 1910, incorporates Low's work in this area. Low noted the presence of Huronian (now called Keewatin) rocks on the lake, and the magnetic attraction along the north shore due to the abundance of iron. In view of the crops so successfully grown at Ste. Bernadette Mission, it is interesting to note his statement that "the greater part of the land . . . would make good farms."

No further work was carried out in the area until the reconnaissance survey by Hurst[3] in 1928, when the Northwest arm, West arm, and Rat House bay were mapped.

The base map used by the writer was that compiled in 1929 by the then Topographical Survey of Canada from oblique aerial photographs. This map was found to have a number of minor errors in the shore line, and in places the distances between certain lakes and arms of Sandy lake are incorrectly shown.

Topography

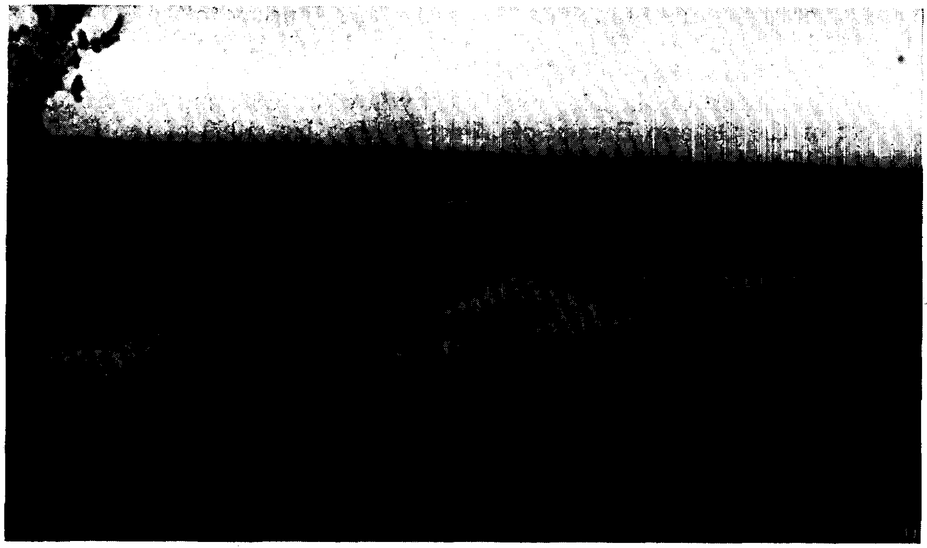
Sandy lake occupies a depression whose limits are in the main due to structural control. The present shore line is the result of a combination of the influence of the underlying rock structure and the masking effect of the glacial deposits. The altitude of the lake as determined by aneroid barometer is about 900 feet above sea-level. The country around the lake when viewed from any commanding height has the even sky-line so characteristic of the pre-Cambrian shield. Whether the peneplaned surface is represented by the low plain with an elevation slightly above that of the lake or a plain now represented by the tops of the concordant summits of the hills is uncertain. If the latter is true then the present hills and ridges are monadnocks, the residual remnants of former high land, which, owing to the harder nature of the rocks composing them, have resisted erosion.

The influence of structure is particularly noticeable in the Northwest and West arms, Sandborn bay, and along the north shore of the main part of the lake to its east end. The curve of the western part of the West arm follows the swing

[1] A. P. Low, Geol. Surv. Can., Vol. II, 1886, pt. F, pp. 1-24.
[2] Vol. XXI, 1912, pt. 2, pp. 94-106.
[3] M. E. Hurst, op. cit., pp. 49-84.

of the structure from a direction slightly south of west through northwest to north, to northeast, and then back again through north to northwest, like the end of a whiplash.

The West arm, where the topography is extremely rugged, has the finest scenery on the lake. The ridges, hills, and chains of islands made up of pillowed lava are, in part, due to the resistance of this rock to erosion. In some places, the shores of the islands rise sharply to a height of 50 feet above the lake; in others they rise gradually to a height of 100 feet. The range of hills forming the south shore of the narrows near the Hudson's Bay Company post is a continuation of these pillowed lavas and rises to a height of 125 feet above the water. The long, high ridge that forms the north shore of the West arm, west of longitude 93° 30′ W., is composed of amphibolite.



View looking north from the granodiorite ridge over the spruce muskeg traversed by Adams creek, which flows north into the west end of the West arm of Sandy lake.

Pillowed lavas form islands, a long point, and a range of hills in and along the north shore of Sandborn bay at its west end. Elevations range from 50 to 125 feet above the level of the bay. Extensive ridges and low hills of the same rock type or its metamorphosed equivalent occupy the area between the Northwest arm and Finger lake. Eastward these rocks form ranges of hills at intervals along or near the northern contact of the belt of volcanics and culminates in the fine range of hills that forms an arc in the territory north of the Bayly river and west of the Mort river at the northeast end of the lake.

The steep cliffs on the south shore of the western part of Sandborn bay, where a small remnant of lava is in contact with the granite batholith, are probably the result of the hardening produced in the lavas by the contact metamorphism of the granite. Hills, possibly of a similar origin, occur in the lavas adjacent to the granite contact just west of Granite bay.

Along Rat House bay and in the area between it and Sandborn bay, the granite forms hills and knobs rising, it is believed, to the greatest heights in the region, some of these hills being close to 300 feet above the level of the lake. One very striking knob of granite rises abruptly just east of the narrows in Rat House bay.

The south shore of the main part of Sandy lake is almost entirely underlain by granite and is, on the whole, rocky, but many of the large bays are low and bounded by clay banks or swamp with sand beaches showing in late summer at low water levels. Here and there a few isolated granite hills stand up above the general low relief.

A diorite hill on the southeast shore of the northeastern part of Sandborn bay, rises 230 feet (aneroid) above lake level and has very steep cliffs.

The string of islands in the main part of Sandy lake is part of a sill of resistant diorite, which extends eastwards from Sandborn bay to the granite batholith. The larger islands have considerable stretches of shore underlain by glacial deposits of clay, gravel, or boulders, and are being rapidly eroded by storm waves.

The deposits of glacial origin are largely varved clays. The flat clay areas between the high rock ridges are covered with swamp. Owing to the clay filling between the ridges, what must have been formerly an extremely hummocky and, in the western part of the lake, an extraordinarily rugged country prior to the deposition of the glacial debris is now fairly level. The clay capping frequently forms the shores of bays, and the sand-boulder beaches developed as the result of the erosion of these clay banks gave the lake its name.

Some of the gravel and boulder points on Sandy lake, such as the one in the south bay near the Dawson river and those projecting into Niska lake are eskers or kames.

Areas of sand and gravel, some lobate in shape, were found in the country east of Rottenfish lake. These sand hills rise to heights of probably 100 feet above lake level and may constitute kames or the termini of eskers.

Drainage

Sandy lake is the largest in the Patricia portion of Kenora district, having an east-west length of slightly over 50 miles and a width of from one-half to 4 miles. The western part consists of three finger-like arms, known as the Northwest arm, the West arm, and Rat House bay. The water area of the lake is slightly over 200 square miles. At its outlet at the east end the lake pours over a granite ledge as a 15-foot falls or chute.

The water-level varies considerably. The spring flood level in 1937 was reported to be the highest in ten years. From moss markings it appeared to be about 1½ feet above normal spring-flood level. The water fell 4 feet 2 inches from June 3 to September 15. Much of the water is nearly stagnant in August and excessively dirty. Owing to the abundant deposits of glacial clays around and on the bottom of the lake, the water is a deep yellow-brown colour and objects a few inches below the surface are quite invisible. The opaqueness of the water and the enormous number of reefs near the surface in mid and late summer makes Sandy lake much disliked by the pilots of the various airplane companies.

Three streams empty into the west side of the north-south section of the West arm. The southernmost, Adams creek, drains the South and North Trout lakes. It is believed, however, that the contributions from these streams are limited to spring floods, as much of the water of the West arm seems to be semi-stagnant by late summer.

Rat House bay receives the waters of the Flanagan (Duck) river, which drains North Wind, Whiteloon, Duckling (Duck), North Spirit, Margot, and other lakes, its headwaters being some 50 miles south.

The Dawson river and its important tributary the Roseberry river, which drains Roseberry lake 20 miles south of Sandy lake, empty into the south bay at the east end of Sandy lake. It is reported that they drain a low, flat, swampy area.

Along the north shore the chief rivers emptying into the lake are the Stain, with a tributary draining Kakapitam lake; the Fidler, which drains Fidler lake and an immense swampy area into Fishtail bay; and the Bayly, which drains a large muskeg area into the north arm at the east end of the lake.

Robert Fidler, chief of the Sandy Lake Indians, July 14, 1937.

Inhabitants

Most of the inhabitants of the Sandy Lake area are Indians, who under their chief, Robert Fidler, constitute a body of about one hundred and twenty-five people. During the winter they live in cabins scattered along the Severn river between Finger and Sandy lakes. During the summer part of the band use a camp site on the north shore of Rat House bay not far from the Hudson's Bay Company post. The Indians are stated to be descendants of a mixed stock of Cree and Ojibwa.

Some of the Indians cultivate small gardens, but the majority eke out their existence by fishing during the summer and trapping in the winter.

During the summer of 1937 the Hudson's Bay Company moved its post from the south shore of the lake to the narrows between the West arm and the main body of the lake.

At the east end of the Northwest arm a mission has been established by Father J. Dubeau and Brother J. Dussault.

Natural Resources

Climate

Excellent weather conditions prevailed during the field season of 1937. Rain fell on 23 days out of 104. No frosts occurred until late in August. Owing to the extreme shallowness of Sandy lake, rough water is frequent and may prevail for several days. Night travelling is therefore commonly adopted by prospectors and others on this lake.

Forests

The trees around Sandy lake are mainly of second growth, and comprise jackpine, spruce, and poplar. Big spruce timber is practically absent. The

"Apartments," Indian encampment on the east side of the Severn river at the outlet of Finger lake, June 14, 1937.

Hudson's Bay Company obtained some from an island for their new log cabins, the butt ends of which showed by a count of annual rings that the trees were over 100 years old.

Throughout the area there are small stands of jackpine with butt diameters from 8 to 18 inches. Such a stand occurs on the south shore of the Northwest arm and has been used by the Mission saw-mill for lumber. Much of the lumber is of poor grade, owing to red staining and a spongy texture.

It is understood that most of the Sandy Lake area was swept by fire about fifty years ago. Certain areas between the West arm and Finger lake must have been burnt within the last ten years.

Difficult bush for travelling was encountered between the West arm and Rat House bay, where very thick small spruce is found. Windfall brulé with second-growth alder, willow, poplar, or birch is widespread south of Finger lake between the West and Northwest arms and at the east end of the lake.

Bad swamp areas, which can only be crossed late in the season, are numerous. Many of these consist of various types of small second growth with semi-open to open moss swamps containing dead birch. Wet tamarac swamp is found in many areas north of Sandy lake.

Spruce muskeg at both low and high levels with frequent "islands" of jack-pine on small outcrops is a common type of bush at the east end of the lake.

Large stands of Balm of Gilead poplar and the common poplar with butt diameters up to a foot are found where a deep soil is present, as in Sandborn bay.

Stands of timber suitable for mining requirements were seen on the West arm, at the outlet of Sandborn bay; just south of Granite bay; on a granite island in the northern part of the West arm; and on the north shore of Sandy lake just southeast of Rahill lake.

Fish and Game

Owing to the muddy waters and the shallowness of Sandy lake the fish are of poor quality during the summer months and can only be taken by net, and then

Fifteen-foot falls, outlet of Sandy lake into the Severn river.

only in certain locations. The fish commonly caught are pike, gold-eye, white-fish, and pickerel. Sturgeon are reported to be not uncommon in the Severn river just below the falls out of Sandy lake, and at a narrows on Finger lake.

Practically no game is found except rabbit, weasel, and muskrat. Bear were seen twice by the party, but no moose were observed.

Duck are not abundant, although mallard, American golden-eye, teal, and fish-duck were seen breeding on the small reedy rivers coming into the West arm. Spruce partridge and ruffed grouse were noted but are not abundant.

Water Powers

The only falls of water are at the outlet of Sandy lake and at a number of rapids on the Severn river downstream from the lake. The falls at the outlet of Sandy lake are over granite capped on either side by unconsolidated sands and gravels of Pleistocene age. It is not thought that more height than the actual 15 feet of the falls would be available for water-power development. Owing to the low, flat nature of the country just below the lake, water-power development of the rapids immediately below the lake does not seem feasible.

Agriculture

On the well-drained clay soils at Ste. Bernadette Mission Father Dubeau and Brother Dussault have been most successful in growing all the common vegetables, such as potatoes, turnips, carrots, beans, peas, and lettuce. Garden flowers, such as cosmos, sunflower, petunia, also bloomed successfully.

Potatoes are grown by some of the Indians in their gardens along the Severn river between Finger and Sandy lakes.

GENERAL GEOLOGY

The underlying bed rock of the area is entirely pre-Cambrian in age. Throughout the region a heavy drift-mantle of Pleistocene age overlies the bed rock with a maximum thickness of 50 feet. Much of the drift is varved clay laid down in a post-glacial lake; towards the east end of Sandy lake the drift consists of sand and boulders as well as clay.

A series of lava flows constitutes the oldest rock assemblage in the area and is lithologically similar to others known to be of Keewatin age. The lavas have, therefore, been assigned to a division named Keewatin type. These lava flows are overlain by a group of sediments, which for reasons given later are believed to belong to the same age and are included under the same heading. Intrusive into these are gabbro-diorites, which are older than the granitic intrusives and have, therefore, been put in a separate group, Post-Keewatin. The granitic intrusives are tentatively classed as Algoman; and the youngest rocks in the area, represented by gabbro, diabase, and basalt dikes, which cut all the older rocks, are classified as Keweenawan.

The following table lists the formations recognized in the area, the youngest being at the top:—

PLEISTOCENE:	Varved clay; sand, silt, gravel, and boulders.
	Great unconformity
PRE-CAMBRIAN	
KEWEENAWAN(?):	Gabbro, quartz diabase, basalt.
	Intrusive contact
ALGOMAN(?):	Quartz feldspar porphyry, feldspar porphyry, felsite. Pegmatite, aplite. Biotite granodiorite, porphyritic biotite granodiorite, biotite hornblende granodiorite, pink granite.[1] Biotite tonalite, biotite hornblende tonalite, grey granite (in part gneissic).[1] Biotite hornblende diorite.
	Intrusive contact
POST-KEEWATIN(?):	Gabbro-diorite.
	Intrusive contact
KEEWATIN TYPE:	
Sedimentary group:	Conglomerate; arkose, quartzite; cordierite hornfels; chiastolite or andalusite hornfels; biotite-quartz schist; garnet-biotite schist; argillite, slate; iron formation; limestone.
	No discordance
Volcanic group:	Dacite porphyry (flows, dikes). Andesite; pillowed andesite and basalt; gabbro-diorite; diabase porphyry; amphibolite; hornblende schist; chlorite schist; talc-antigorite schist; volcanic conglomerate, tuff; iron formation; narrow belts of quartzitic or argillaceous sediments.

[1]The terms grey granite, pink granite, or granite gneiss are used in this report and on the map for granitic intrusives of a grey or pink colour which have not been studied in thin section.

Keewatin Type

VOLCANIC GROUP

Andesite and Basalt

The commonest members of the volcanic group are andesite and basalt, which form a monotonous series of flows throughout the area. The exposures, which frequently exhibit pillow structures, show alignment, and it is thought that at least a dozen flows are present in some sections. These belts of pillowed lavas may represent several horizons or one horizon repeated as a result of folding.

Pillowed lavas or their metamorphosed equivalents occur between the Northwest arm and Finger lake and are present all along the north shore of Sandy lake

Pillowed lava, burnt island near the entrance of the West arm, Sandy lake.

They form an arcuate range of hills north and northeast from the Bayly river at the northeast end of the lake. Another belt is well displayed along the south shore and on islands in the West arm and forms one range of hills along the south side of the narrows. A third belt is exposed on the north shore of the western part of Sandborn bay.

Amygdaloidal structures were rarely seen in the flows, having been noticed at only two localities, along the south shore of the West arm and in the northeast bay. Considerable carbonate is present in the lavas in the long narrow bay off the south shore of the West arm.

Owing to the varying degree of regional metamorphism the lavas have been deformed and altered. This metamorphism combined with the effects of the granitic batholith has altered them to amphibolite, feldspar amphibolite, and hornblende schist. Elsewhere they have been altered to chlorite schists or markedly serpentinized. These types are briefly noted in some of the following sections. It is interesting to note that northeast of the Bayly river all gradations were observed from well-preserved pillow structures in lavas to rocks in which deformation has been so severe that all that remains is ribbon-like bands, the selvages of the original pillows. These ribbon-like bands are a fraction of an inch to 1 inch apart, and the rock might be mistaken for a tuff.

An analysis by the Provincial Assay Office of a specimen of typical pillowed lava is given under No. 1 in Table I. For comparison two analyses of lavas from Ontario localities and two of average basalts from Daly are given.

TABLE I

	No. 1	No. 2	No. 3	No. 4	No. 5
	per cent.	per cent.	per cent.	per cent.	per cent.
SiO_2	48.28	48.70	53.90	49.06	48.80
Al_2O_3	13.32	15.21	19.67	15.70	13.98
Fe_2O_3	1.70	4.28	.71	5.38	3.59
FeO	10.47	8.35	10.21	6.37	9.78
MgO	10.41	3.76	.72	6.17	6.70
CaO	11.93	11.11	8.30	8.95	9.38
Na_2O	.78	3.23	2.78	3.11	2.59
K_2O	.88	.59	.58	1.52	.69
H_2O	1.52	.65	1.80	1.62	1.80
TiO_2	.26			1.36	2.19
P_2O_5	.06			.45	.33
CO_2	.59	2.25	.86		
MnO			.32	.31	.17
Total	100.20			100	100
Specific gravity	2.916				

Sample No. 1—Pillowed basalt, Sandborn bay, Sandy lake.

Sample No. 2—Ellipsoidal greenstone (basalt) from a point 15 chains west of mile post III, north line of Teck township, district of Timiskaming.[1]

Sample No. 3—Amygdaloidal greenstone (basalt), Amikougami lake, 15 chains north of mile post III, north line of Teck township, district of Timiskaming.[2] This rock shows ellipsoidal structure.

Sample No. 4—Average of 198 analyses of basalts.[3]

Sample No. 5—Average of 43 analyses of Plateau basalts.[4]

Grey Pillowed Basalt

On the "boot," 2½ miles west of Fishtail point, in the small bay just west of Fishtail point, and on the point itself, pillowed grey basalt flows outcrop, and the three occurrences may represent a single horizon. On Fishtail point one flow 25 feet thick lies south of an 11-foot band of iron formation and another on the north side of this band. In the bay to the west the band of iron formation in the flow is 7 feet in width. On the "boot" the pillows in the flow range from 8 by 12 to 18 by 36 inches and have light-grey, chert-like selvages, one-half to 1 inch in width. The centres of the pillows have a spheroidal texture with dark, indistinct spots from one-tenth to one-fifth of an inch in diameter forming the major part of the rock.

An analysis of this grey pillowed basalt by the Provincial Assay Office is given under No. 1 in Table II; for comparison an analysis of a somewhat similar greyish-green basalt from the Opeepeesway Lake area described by Laird is also given. These lavas also show pillow and spheroidal structures.

[1]Ont. Dept. Mines, Vol. XXXII, 1923, pt. 4, p. 8.

[2]Ibid, p. 8.

[3]R. A. Daly, "Igneous Rocks and the Depth of the Earth," McGraw-Hill Book Co., New York, 1933, p. 17.

[4]Ibid, p. 17

TABLE II

	No. 1	No. 2
	per cent.	per cent.
SiO_2	47.13	49.3
Al_2O_3	18.79	14.63
Fe_2O_3	.89	2.63
FeO	19.05	9.1
MgO	4.85	6.51
CaO	1.6	11
Na_2O	.95	.19
K_2O	1.05	.3
H_2O	4.04	3.07
TiO_2	1.2	.83
P_2O_5	.1	.14
CO_2	.67	2.1
FeS_2	.22	.34
Total	100.54	100.14
Specific gravity	3.089	3.031

Sample No. 1—Grey pillowed basalt, 2½ miles west of Fishtail point, Sandy lake.
Sample No. 2—Basalt, 20 chains east of the 3-mile post, north boundary of Benton township, district of Sudbury.[1]

Gabbro-Diorite

Throughout the area, but particularly in that part of the volcanic belt surrounding the north end of the northeast bay of Sandy lake, gabbro or diorite is frequently associated with fine-grained volcanic rocks. In a number of cases, such as those along the north shore of the lake, field evidence suggests that the diorites were the coarse phases, the more slowly cooled central portions of lava flows. Elsewhere, as south of the Bayly river, the frequent occurrence of massive altered diorite close to fine-grained volcanic rocks suggests intrusive relationships, and in one outcrop diorite was found to cut across the shearing in an andesite. Some of these diorites should, perhaps, be placed with the post-Keewatin gabbro-diorites, but sufficient evidence is not available to justify this separation and they have been kept in the volcanic group but distinguished on the map by a special symbol.

A typical specimen from an outcrop half a mile south of the mouth of the Bayly river is a medium-grained, dark- and light-green rock, which when examined in thin section under the microscope was found to consist of hornblende, plagioclase (altered almost completely to epidote or replaced by chlorite), quartz, some biotite, and calcite. It was probably originally a quartz gabbro.

Diabase Porphyry

The diabase porphyry is the so-called "leopard rock." It consists of yellowish-green feldspar phenocrysts set in a fine-grained, green groundmass. The phenocrysts have a maximum diameter of 3 inches but are usually less than 1 inch across. Microscopic study shows that the phenocrysts are now largely represented by a zoisite and white mica aggregate, set in a diabasic groundmass of secondary hornblende (uralitized augite), secondary chlorite, and lath-like or stumpy crystals of labradorite. The rock is, therefore, an altered diabase porphyry.

In the outcrops the feldspar phenocrysts are arranged in rows, or form bands 6 to 48 inches in width, or are so abundant as to constitute a major part of the rock mass. This rock type outcrops at a number of localities along the north

[1]Ont. Dept. Mines, Vol. XLIV, 1935, pt. 7, p. 10.

shore of the lake, the westernmost exposure being 5 miles east of the Hudson's Bay Company post, and the easternmost on the island 1½ miles east of the portage to Rahill lake. This rock seems to occur at more than one horizon, i.e. both south and north of the belt of iron formation bands, but it must be lenticular as it was not seen on the west shore of Fishtail bay. At a few localities similar yellowish-green feldspar phenocrysts were seen in the central parts of pillowed lava flows, and the diabase porphyry apparently represents the more slowly cooled central portion of a basaltic flow.

An analysis of a representative sample is given below under No. 1 in Table III, and for comparison analyses of two other similar porphyries from Ontario localities are also given.

TABLE III

	No. 1	No. 2	No. 3
	per cent.	per cent.	per cent.
SiO_2	46.06	42.12	40.3
Al_2O_3	22.38	24.95	28.94
Fe_2O_3	2.04	1.94	4.7
FeO	5.76	5.27	1.53
MgO	6.35	3.63	1.23
CaO	12.2	12.2	16.2
Na_2O	1.3	5.46	2.71
K_2O	.78	.35	.92
H_2O	2.43	1.9	2.99
TiO_2	.25	.63	....
P_2O_5	.04	.57	....
CO_2	.66	1.24	.64
Total	100.08	100.26	100.16
Specific gravity	2.761	2.989	....

Sample No. 1—Diabase porphyry, Rahill portage, Sandy lake.
Sample No. 2—Feldspar basalt porphyry from Kabikwabik lake.[1]
Sample No. 3—"Leopard rock," Cook township.[2]

A basalt porphyry composed of 80 per cent. feldspar as rounded crystals was seen by the writer north of Fry lake, in the Cat River–Kawinogans Lake area, Patricia portion of Kenora district. The phenocrysts of white feldspar usually range from half an inch to 2 inches in diameter, but occasional crystals measuring 2½ by 4 and 4 by 6 inches were found. In some exposures, the crystals were arranged in rows, as on Sandy lake. A similar rock has been described by Moore.[3]

Metamorphosed Equivalents

Many of the areas underlain by the volcanic group now consist almost entirely of amphibolite or feldspar amphibolite. In many cases it is now impossible to say whether the amphibolite was derived from an intermediate or basic volcanic or an intrusive. The development of amphibolite seems to be partly due to the proximity of the granite batholiths, but elsewhere may be due to regional metamorphism alone. Amphibolite is the prevailing rock type of the volcanic group in the area between the West arm and Colgrove lake, and north of the north shore between the Stain river and Rahill lake, and is found quite frequently in other areas. Where it is associated with fine-grained volcanics it

[1] Ont. Dept. Mines, Vol. XLI, 1932, pt. 6, p. 11.
[2] Ont. Dept. Mines, Vol. XXX, 1921, pt. 6, p. 42.
[3] E. S. Moore, Ont. Dept. Mines, Vol. XLV, 1936, pt. 6, pp. 5, 6.

must have developed either from a medium-grained, basic intrusive or the coarse phase of a lava flow.

Hornblende schist and chlorite schist were found at a number of localities where shearing had been intense.

Talc-antigorite schist occurs at two localities in Sandborn bay, on an island in the east bay and on the north shore in the west bay. At the latter locality carbonate is also present, and study of a thin section shows the presence of residual grains of olivine. This speckled, dark-green rock weathers at the surface to a soft, brown material. No evidence other than that derived from microscopic study was found to suggest that these rocks were originally ultra-basic intrusives, and at present it seems best to consider that they represent serpentinized volcanic rocks, possibly olivine basalts.

Sheared and drag-folded lavas on an island at the east end of Sandy lake, 4 miles south of the mouth of the Mort river.

Volcanic Conglomerate[1] and Tuff

In the northeast bay at the east end of the lake on two islands, on the points, and in the bush north of the mouth of the Mort river, there are outcrops of volcanic conglomerate, which are believed to represent a single horizon. The total length indicated by these exposures is 4½ miles. The volcanic conglomerate is best exposed on two points in the north end of the bay between the mouths of the Bayly and Mort rivers. Here it consists of subangular to well-rounded fragments, pebble to boulder size, the largest being 12 by 24 and 18 by 24 inches. The fragments consist mainly of a black-speckled, pale-grey to buff acid volcanic; a fine-grained, greyish-green porphyry; and greenstone. Associated with the conglomerate are coarse tuffaceous sediments. On a longer point just south of the exposures described above, banded chert-like fragments are also present in the

[1]C K. Wentworth and Howel Williams, "The Classification and Terminology of the Pyroclastic Rocks," National Research Council, Washington, Bull. No. 89, 1932, pp. 45-51; *Definition of Volcanic Conglomerate*—"Sedimentary, coarse pyroclastic material containing an abundance of large, chiefly rounded, waterworn fragments. In most cases they result from the erosion and the deposition of old volcanic rocks, but they may also be formed by volcanic mud flows and by the action of running water on freshly fallen *ejecta*."

conglomerate. On an island 1¼ miles south of the mouth of the Bayly river several volcanic conglomerate beds, about 20 feet in width, occur with interbedded tuffs, and also a greywacké bed, in which were found three well-rounded pebbles of white biotite granite. Bounding the volcanic conglomerate beds is andesite, which on the east side grades into a diorite, the coarse phase of a flow. At the south end of an island 1 mile south of that mentioned above, 150 feet of volcanic conglomerate is exposed in contact with pillowed andesite, and some of the conglomerate matrix appears to fill interstices between the pillows. The volcanic conglomerate here consists of subangular to well-rounded fragments, from granule to boulder size, of green, acid, aphanitic volcanic rocks; whitish chert(?); carbonated andesite; and porphyritic rocks in a fine-grained, green matrix. The largest fragment, 12 by 18 inches, is andesite. As on the island to the north the volcanics bounding the band on the east pass into a diorite-like rock.

Volcanic conglomerate, north shore of Sandy lake between the Bayly and Mort rivers.

Highly crenulated and iron-carbonated green schists, with interbedded nucrumpled bands, 6 to 24 inches in width, of dark-green, fine-grained andesitic tuff(?) form a reef in the northeast bay east and northeast of the above-mentioned islands.

In the West arm tuffs form a 5-foot interbed in andesitic volcanics. They are composed of paper-thin *laminae* and were probably water-lain.

Tuff beds, 6 and 12 inches in width, occur in andesites on the island 4 miles east of the Hudson's Bay Company post.

Sediments

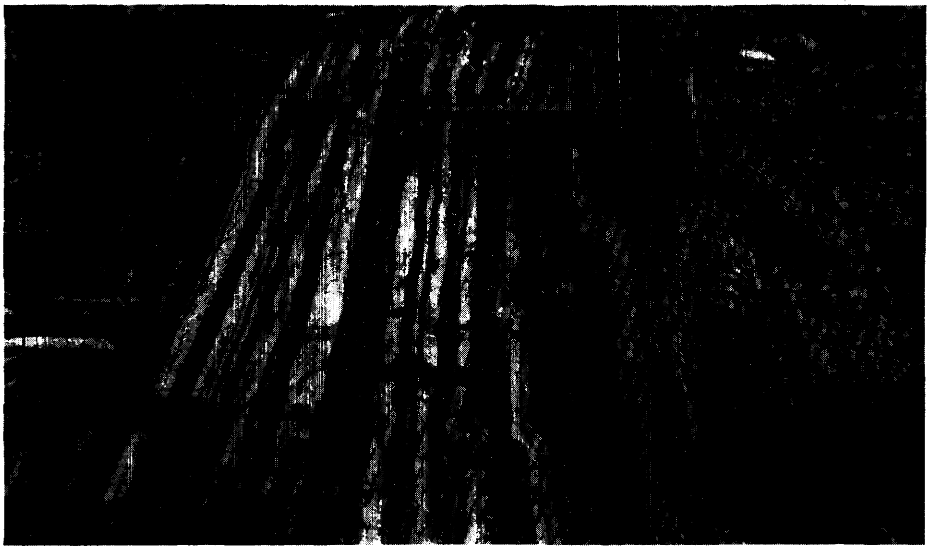
Normal clastic sediments mainly of arenaceous or argillaceous types are very common in certain parts of the area as narrow interbeds in the volcanics. They are particularly abundant along the south shore of the West arm. Although they generally have widths to be measured in tens of feet, they occasionally attain widths of as much as 150 feet. Owing to the almost universal mineralization of pyrite or pyrrhotite, or both, the sedimentary interbeds now form conspicuous rust zones.

On the south shore of the West arm west of Sandborn bay, typical varieties are sugary, white to grey to rusty-weathering, fine-grained quartzites, with bands of garnet amphibolite, garnet-mica schist, biotite-quartz schist, dark-grey biotite-rich schists, pyritized slate, and chert.

Iron Formation

Interbedded between andesitic flows or diorite (amphibolite?) are some half-dozen bands of iron formation. These bands range from a few feet up to 200 feet in width, but average 20 feet, and are particularly abundant along the north shore of the lake from the Hudson's Bay Company post to Fishtail point and were picked up at a few localities eastward on islands and in the northeast arm.

The iron formation is of three types, one composed of interbedded magnetite and white sugary quartz; another of magnetite, chlorite, and blue-grey quartz



Banded iron formation on a small island off Fishtail point, Sandy lake.

bands; and the third of black chert and magnetite. Some of the iron formation is so lean as to be merely a banded grey to black chert. The bands composing the iron formation range from paper-thin films to 1-inch beds.

A typical succession is shown by the exposures from north to south on Fishtail point, which showed the following formations in a total thickness of 1,000 feet.

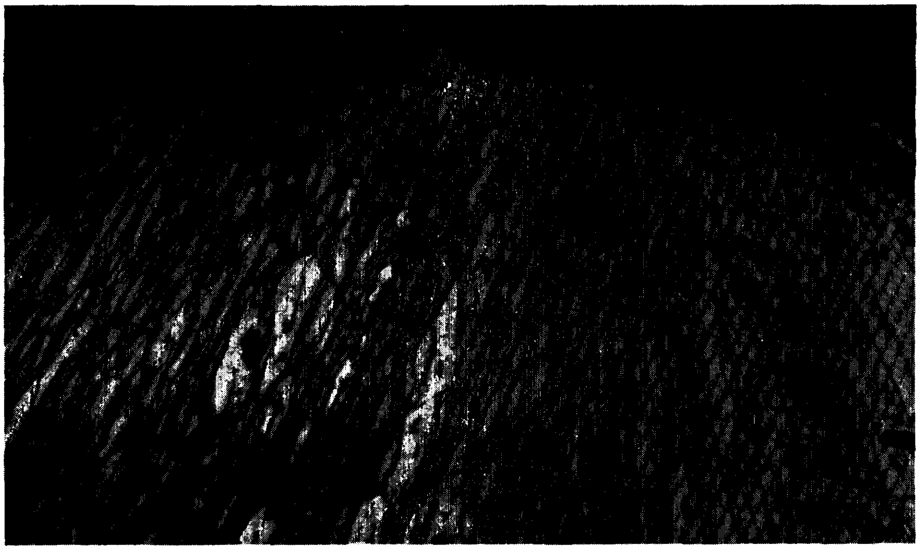
Black chert iron formation (12 feet).
Diorite.
Black chert iron formation and bedded black cherts (200 feet).
Diorite.
Iron formation (40 feet).
Diorite, fine-grained like andesite on south edge becoming coarser northwards.
Iron formation (100 feet).
Andesite.
Iron formation (15 feet).

The succession is continued after a slight gap on the west shore of the bay just west of Fishtail point, with a thickness of 1,100 feet.

Andesite.
Pillowed grey basalt.
Iron formation (11 feet).
Pillowed grey basalt (25 feet).
Andesite.

The diorites listed in the table may represent slowly cooled flows or perhaps sills. Elsewhere on the north shore andesite dikes cut across bands of iron formation and may represent feeders of flows or sills. The writer is still undecided whether or not the association of diorites and iron formation may not be explained by assuming that a given horizon of iron formation has been split up into a number of bands by sill-like injections of diorite.

Narrow bands of banded black chert, which in places attain a width of a few feet, were noted in several localities separating pillowed andesitic flows.



Dacite porphyry showing flow breccia(?) structure, south shore of the Northwest arm, Sandy lake.

Banded, paper-thin, red jasper and black chert form a 2-inch band in black chert iron formation on the chain of islands 2½ miles east of the portage to Rahill lake. This material takes a good polish and can be used as a semi-precious stone.

Dacite Porphyry

A belt of dacite porphyry, a quarter to half a mile in width, has been traced for 7 miles east from the granite contact along the north shore of the Northwest arm of the lake. Numerous dikes of the same rock are present along the north shore of the lake for a further 6 miles. Along the south margin of the mass the outcrops show fragmental structures, the fragments being essentially of the same material as the matrix, and a flow breccia origin seems possible. On the point jutting out from the south shore of the Northwest arm the fragments have weathered out and are well exposed at low water. These fragments are well rounded, and typical measurements of the larger ones are 4 by 24, 9 by 12, and 12 by 36 inches. Owing to metamorphism the fragments have been squeezed, and many are now lenticular or linear in shape, the most elongated fragment noted being 1 by 30 inches. This particular exposure is probably a volcanic conglomerate derived from the dacite porphyry. In the exposure are frequent interbeds, from 12 to 36 inches in width, of chlorite or hornblende schist, which are believed to represent metamorphosed tuffs. Along the north shore of the Northwest arm similar interbeds of green schist or fine-grained amphibolite occur, and a banded, aphanitic phase of the porphyry seems to be a tuff. These occurrences indicate the existence of many bands of the porphyry, and each of these is considered to be a flow. The succession from north to south, as far as it can be deduced from separated outcrops, is a series of porphyry flows with interbedded acid or intermediate tuffs, with flow breccia(?) near the top, and lastly volcanic conglomerate.

At the west end of the belt where it is cut off by the granite batholith, the rock is folded and the folds are cut off by the granite. This porphyry is, there-

Fold in dacite porphyry with *lit par lit* granitic material, hill west of the Northwest arm, Sandy lake.

fore, placed in the Keewatin-type division. Medium-grained phases represent central parts of thick flows, or possibly related intrusive masses, which occur abundantly as dikes along the north shore of the lake.

The rock is fine- to medium-grained, grey in colour, and characterized by small to large opalescent blue eyes of quartz. Studied microscopically, it is found to consist of quartz, oligoclase, and biotite with accessory apatite, sphene, zircon, secondary epidote, calcite, and chlorite. It is a dacite porphyry. The belt of porphyry is extensively mineralized throughout its length, and practically the whole of its outcrop has been staked. Hydrothermal alteration has changed parts of it to a cream-coloured schist.

An analysis by the Provincial Assay Office of what is considered to be a representative sample is given under No. 1 in Table IV. The analysis would seem to indicate that the rock has undergone considerable hydrothermal alteration. Two analyses by Bruce of altered granite and granite at the Orphan mine, Sturgeon River area, are given in Nos. 2 and 3 for comparison, and it is suggested that the type of alteration of the dacite porphyry was probably of a similar nature, namely a removal of some alumina, soda, and iron oxides, and perhaps some gain in the amounts of lime and magnesia, and a large gain in potash.

TABLE IV

	No. 1	No. 2	No. 3
	per cent.	per cent.	per cent.
SiO_2	67.33	68	66.68
Al_2O_3	15.8	10.95	16.33
Fe_2O_3	1.5	1.31	1.85
FeO	2.31	1.54	2.57
MgO	2.21	1.65	1.48
CaO	6.27	5.49	4.12
Na_2O	.5	.29	2.95
K_2O	2.31	2.74	1.51
H_2O	.61	1.51	.89
TiO_2	.34	.53	.62
P_2O_5	.16	.17	.11
CO_2	.7	3.74	.71
MnO	....	.6	.1
FeS_2	.3	1.41	....
Total	100.34	99.93	99.92
Specific gravity	2.777	2.759	2.76

Sample No. 1—Dacite porphyry, Northwest arm, Sandy lake.
Sample No. 2—Altered granite, near the vein, Orphan mine.[1]
Sample No. 3—Granite 200 feet from the vein, Orphan mine.[2]

Dacite porphyry of apparently the same age forms a small mass at the northeast corner of Fishtail bay.

Greenish quartz porphyry dikes, sheared in the same direction as the volcanics but cutting across the regional structure, were found on the island 4 miles east of the Hudson's Bay Company post. These porphyries are believed to belong to the Keewatin-type group. Somewhat similar "old" porphyries were found at a number of other localities on the lake.

SEDIMENTARY GROUP

Although there is structural evidence to indicate that some of the sediments overlie certain members of the volcanic group, there is not sufficient available to prove that these sediments are either younger than all the members of the volcanic group or that there is any pronounced unconformity between them. At the present time, therefore, it would seem desirable to consider the sediments as part of the series to which the volcanic group belongs, which for purposes of this report has been designated as Keewatin-type.

The sediments consist mainly of conglomerate, quartzite, and cordierite hornfels, with lesser amounts of arkose, biotite-quartz schist, andalusite hornfels, iron formation, etc. The main features of the more important types are described in the following paragraphs.

Conglomerate

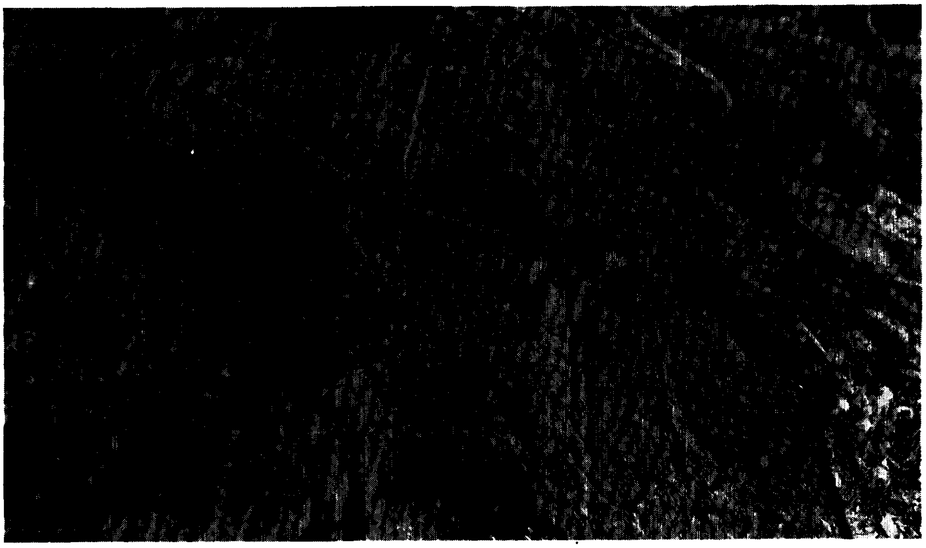
The conglomerate consists of pebbles and, more rarely, boulders which are mainly of chert but to a lesser extent of granite, diorite, and greenstone. The groundmass as seen under the microscope in thin section is a biotite feldspathic

[1]Ont. Dept. Mines, Vol. XLV, 1936, pt. 2, p. 50.
[2]Ibid.

quartzite. Some of the quartz grains in the groundmass are rounded, blue, and opalescent and occasionally reach diameters of 3 millimetres. Pyrite and pyrrhotite may occur in such abundance as to give rise to rusty-weathering varieties.

Quartzite

The quartzite is a dark-grey, fine-grained rock composed of quartz, abundant biotite, and a spotty distribution of blue opalescent grains of quartz from 1 to 3 millimetres in diameter. Pyrrhotite occurs as an accessory mineral. Cross-bedding was observed in only one exposure. As a general rule, bedding is not displayed within the quartzite itself, but owing to the frequent interbedding with the cordierite hornfels the attitude of bedding is quite apparent.



Cordierite hornfels on an island in the main part of Sandy lake, 3 miles from the Hudson's Bay Company post. The cordierite is resistant to weathering and stands out as small lumps. The marks on the hammer handle are an inch apart.

Cordierite-Biotite Hornfels

The cordierite-biotite hornfels is a medium-grained, grey rock composed of rounded to prismatic crystals of cordierite, from 5 by 5 to 5 by 10 millimetres in size, in a groundmass of books of biotite, quartz, etc. Studied in thin section under the microscope the large crystals of cordierite are seen to hold inclusions of quartz, biotite, and sericite, and to show yellow pleochroic haloes around zircon crystals or clusters. Biotite forms reddish-brown flakes showing sieve structure and contains quartz inclusions. The groundmass between the cordierite and biotite consists of a mosaic of quartz grains and minute flakes of sericite, with accessary andalusite, plagioclase, pyrite, pyrrhotite, apatite, and tourmaline.

The cordierite-biotite hornfels represents a shale that has undergone contact metamorphism. It is to be noted that granitic intrusives are present within 1 to 2 miles of all the occurrences of the hornfels. In some of the exposures studied, petrographic evidence shows that the rock has been subjected to a dual metamorphism,[1] first to a thermal (contact) metamorphism with the development of cordierite, and later to regional metamorphism with the development of garnet

[1]cf. A. Harker, "Metamorphism," Methuen, London, 1932, p. 338.

(a stress mineral), accompanied by the decomposition of the cordierite to a chlorite-sericite aggregate, which still retains the inclusions of quartz and biotite of the original cordierite. Fresh cordierite was only observed in samples from Sandborn bay, those from the main part of the lake having been altered. Near the diorite sills the cordierite hornfels has been altered to quartz-sericite schist.

The composition of a typical cordierite rock from Sandborn bay with a recast of the analysis into constituent minerals is given in Tables V and VI, and for comparison a number of analyses of shales and another cordierite rock are also included.

TABLE V

	No. 1	No. 2	No. 3	No. 4	No. 5
	per cent.	per cent.	per cent.	per cent.	per cent.
SiO_2	57.64	58.1	67.61	57.99	59.83
Al_2O_3	23.29	15.4	13.2	23.42	17.47
Fe_2O_3	.76	4.02	5.36	.49	4.09
FeO	6.45	2.45	1.2	5.06	3.93
MgO	4.1	2.44	3.2	1.2	3.7
CaO	trace	3.11	.11	1.65	.49
Na_2O	.31	1.3	.67	1.32	1.08
K_2O	3.34	3.24	4.45	3.5	4.42
H_2O	1.73	5	3.42	3.39	3.8
TiO_2	.88	.65	.56	.32	.93
P_2O_5	.15	.17	.05	....	.18
SO_3	....	.64	....	(S=0.91)	.13
CO_2	.68	2.63	....	1.12	....
FeS_2	.75	....	.03	....	....
BaO	....	.05	.04	....	....
C	....	.8	....	....	....
MnO	....	....	.1	....	....
Total	100.08	100	100	100.37	100.05
Specific gravity	2.761	....	....	....	....

Sample No. 1—Cordierite-biotite-quartz hornfels, Sandborn bay, Sandy lake. Analysis by Provincial Assay Office, 1938.
Sample No. 2—Composite analysis of 78 shales recalculated to 100 per cent.[1]
Sample No. 3—Red slate, near Hampton village, New York.[2]
Sample No. 4—Culm shale, Klausthal, Harz.[3]
Sample No. 5—Cordierite-quartz-biotite hornfels, Abbenstein (Harz).[4]

TABLE VI

	Per cent.
Cordierite	29.91
Quartz	26.22
Biotite	14.81
Sericite	15.97
Paragonite	3.83
Andalusite	4.71
Magnetite	1.16
Ilmenite	1.52
Pyrite	.75
Total	98.88

The chemical relation of the Sandborn bay rock to the shale-slate group is clearly indicated by the above analyses.

[1]F. W. Clarke, "The Data of Geochemistry," U.S. Geol. Surv., Bull. No. 770, 1924, p. 34
[2]Ibid, p. 554.
[3]C. E. Tilley, "Contact Metamorphism in the Comrie Area of the Perthshire Highlands," Quart. Jour. Geol. Soc., London, Vol. 80, pt. 1, p. 46 (analysis IX).
[4]Ibid, p. 37 (analysis I).

Chiastolite Hornfels

Chiastolite hornfels is beautifully exposed on the north shore of Rat House bay. Owing to weathering the chiastolite crystals are cream to brown in colour and stand out clearly from the almost black matrix. The crystals, which have a maximum diameter of 1 inch, show the characteristic cross of this mineral species. Associated with the chiastolite-biotite hornfels is cordierite-andalusite hornfels as interbeds. The andalusite forms pale-pink crystals as large as 5 by 20 millimetres.

Limestone

On the south shore of the east bay of Sandborn bay grey, faintly banded, fine-grained crystalline limestone outcrops. It has been considerably drag-folded, the beds being highly contorted. Microscopic study shows it to have recrystallized to a mosaic of calcite, with tremolite and lesser amounts of quartz, zoisite, microcline, and biotite.

Iron Formation

The variety of iron formation found as a member of the sedimentary group is very similar to that found in the volcanic group and is composed of alternating bands of sugary quartz and magnetite. On the south shore of Sandborn bay near the granite the rock consists of alternating bands composed of quartz and tremolite, and tremolite, actinolite, and magnetite, with gradations and variations between these two combinations.

The above types show that the sedimentary assemblage consisted originally of conglomerate, micaceous sandstone, and shale, with lesser amounts of other sediments. The interbedding of these three main varieties indicates oscillating conditions of sedimentation such as prevail in rapid streams in continental areas. The iron formation shows that basins of quiet shallow water existed locally, which gave the conditions necessary for its formation.

From the lithological character of the conglomerate and the abundance of chert pebbles present, it is concluded that much of it was derived through the erosion of a banded cherty iron formation, the chert forming the pebbles, and the iron sand being hydrothermally changed to pyrite or pyrrhotite. The presence, in two exposures, of boulders of chert-pebble conglomerate indicates the existence of older pebble conglomerates. These characters seem in keeping with their structural position.

Sandborn Bay Sediments

Sediments outcrop in the south bay of Sandborn bay and at its east end. The continuity of the belt is interrupted by the presence of three bands of diorite. Sufficient structural data were not found to determine to what degree folding may have repeated horizons.

The sediments consist mainly of interbedded quartzite and cordierite hornfels, with beds of conglomerate, probably lenticular, at several localities. Disseminated sulphides are locally present in such abundance that rusty-weathering rocks are now exposed; identification of the original rock type is almost impossible in such outcrops.

On the west point of the south bay of Sandborn bay a banded chert is exposed with black and white bands heavily mineralized with pyrite, which causes a marked rust zone. This is followed to the south by a conglomerate composed of angular, lenticular fragments of black chert and white chert and pebbles of soft, green rocks (andesite?); medium-grained diorite, 2 by 3 inches; and white, medium-grained granite. Southwards along the shore this chert conglomerate is well exposed. Ninety per cent. of the fragments are of chert, and amongst them is a banded black and white chert, 1 by 6 inches; a triangular boulder of dirty-white chert, 6 by 18 inches; a boulder of chert-pebble conglomerate, 4 by 10 inches; and pebbles of andesitic(?) composition. The association suggests that the conglomerate is made up of material derived mainly from a banded chert or the chert of a banded iron formation, and that the pyrite now present so abundantly is a later development from iron deposited initially as magnetite sand between the fragments. South of these conglomerates outcrop beautifully banded, grey quartzites, the banding ranging in width from paper-thin to 3 inches. Interbedded banded quartzite and conglomerate occur farther south. Dark-grey, fine-grained andalusite-biotite hornfels showing a banded structure (bedding) occurs interbedded with conglomerate back from the shore near the west point of this small bay. The total width of sediments exposed is slightly over 2,000 feet.

Chert-pebble conglomerate is exposed on a reef one mile southeast of the above-mentioned point, on the island in the bay, and on the southeast shore of this small bay. The last-named exposure is a boulder conglomerate with 1-foot chert boulders and a chert-pebble conglomerate boulder, 2 by 5 feet in dimensions, indicating the existence of a previous chert-pebble conglomerate. All these exposures are heavily stained with rust.

On the east shore of the bay and on the island are excellent exposures of cordierite hornfels interbedded with quartzite and two conglomerate beds.

In the east bay of Sandborn bay the exposures of the sediments are mainly micaceous quartzites with some cordierite hornfels, and on the big hill conglomerate is cut by diorite.

On the main part of the lake the sediments outcrop on islands, and these disconnected, yet aligned series of exposures indicate that the belt extends for 15 miles eastward, the last exposure being on a small island 1 mile due south of Fishtail point, giving a total exposed length of 25 miles.

The sediments consist mainly of interbedded cordierite hornfels and quartzite. The association of these two rock types has resulted in a marked banding, as the bands of cordierite hornfels, ranging in width from a quarter of an inch to 6 inches, occur between beds of micaceous quartzite or its more metamorphosed equivalent, a biotite-quartz schist. The knobby structure of the cordierite hornfels, due to differential weathering, is excellently displayed by many of the island outcrops.

Garnetiferous biotite-quartz schist is present on the south shore of the small island 1 mile south of Fishtail point. On the large island to the west several small sills of diorite occur in the band of sediments, which consists of quartz schists, interbanded slaty and quartzitic sediments, and interbedded quartzite and cordierite hornfels.

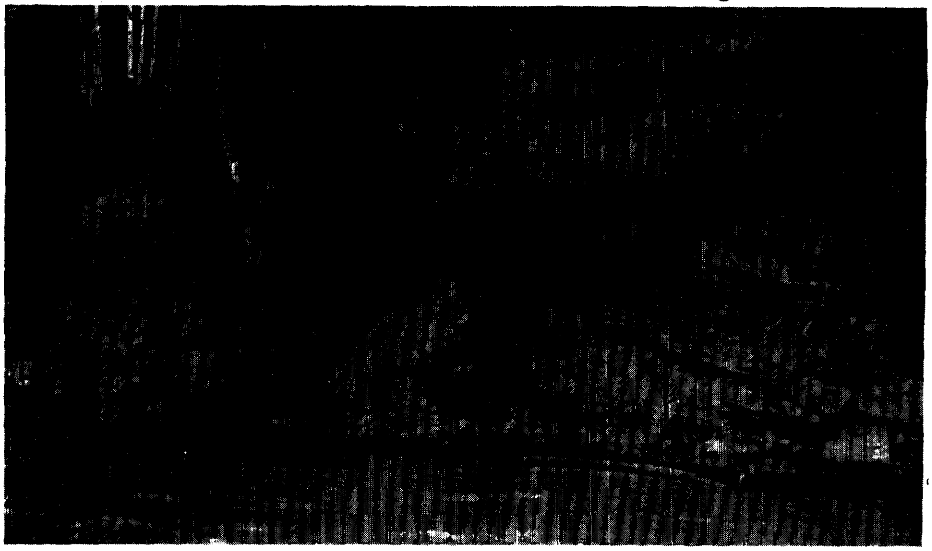
On a small island west of the large island mentioned above, quartzitic sediments are followed to the south by banded iron formation exposed on two reefs.

Cordierite hornfels with interbedded quartzite outcrops on two islands just west of longitude 93° 00′ W. Some chiastolite was observed. The contact between diorite on the north and sediments on the south is exposed at the west end of the westernmost of the two islands. At the contact the sediments consist of 6 feet of banded light- and dark-grey chert, followed to the south by quartzite, rusty-weathering sediments, and dark-grey, banded hornfels. On the north side of an islet half a mile southeast of this point there are outcrops of diorite and banded impure quartzite with a granule conglomerate lens, 4 by 15 feet in dimensions. The conglomerate contains two elongated, white, medium-grained granite boulders, 4 by 12 and 7 by 30 inches. The fragments, granule (a quarter to an eighth of an inch) in size, are of rounded white quartz in a chloritic groundmass.

On the islands and mainland at the mouth of Rat House bay, cordierite hornfels interbedded with quartzite is the prevailing sedimentary type, with a minor amount of arkose on the north side of the belt. On the south side of the belt on the mainland, along a shore line half a mile in length, is the magnificent set of exposures of chiastolite hornfels previously described.

Colgrove Lake Sediments

Sediments outcrop sparingly in an S-shaped belt north of the West arm, on Colgrove lake, and along the north shore of the extreme north end of the West arm.



Small anticline in the sediments on the north shore of the north bay of the West arm, Sandy lake.

On Colgrove lake the sediments are well-bedded with a banding half an inch to 2 inches in width and consist of interbedded dark-grey quartzites and biotite-quartz schists. Locally these sediments contain strings of quartz lenses, 2 by 3 inches in dimensions, parallel to the bedding, or are cut by granite dikes. The sediments on the lake swing from a strike of N. 25° E. to S. 30° E. and have variable dips from flat to 60° E. Drag folds indicate that they are on the west limb of a syncline, whose axis trends S. 30° E. and plunges 15° S.E.

Along the north shore of the bay at the extreme north end of the West arm sediments form a narrow band. They consist mainly of a pebble conglomerate, fine-grained grey quartzite, banded biotite-quartz schist, which in places is garnetiferous. The strike of this band ranges from S. 52° E. to S. 60° E. and the dips range from 50° S.W. through vertical to 65° N. The pebble conglomerate, which is exposed at intervals over a length of 100 chains, is composed of white chert or white sugary quartz pebbles from a quarter of an inch by 2 inches up to 1½ by 3 inches in dimensions. Many of the pebbles are like thin bricks in shape, and it seems most likely that they were derived from the break-up of a banded iron formation. The matrix consists of quartz and hornblende. This conglomerate is similar to that found on Sandborn bay.

At one locality the sediments are folded into a small anticline, with conglomerate forming the main arch. They are underlain by interbanded impure quartzites and amphibolites, and there is a small saddle of amphibolite at the centre. The axis of this anticline strikes S. 50° E., the north limb strikes S. 40° E. and dips 30° N., and the south limb strikes S. 58° E. and dips 70° S., indicating that the structure plunges southeastward, as does the band of sediments on Colgrove lake. The amphibolites that occur interbanded with these sediments are believed to represent flows, sills, or dikes of metamorphosed basic igneous rocks.

The easterly continuation of this belt of sediments is represented by a lenticular band that outcrops north of the north shore along the eastern part of the West arm, and on a chain of islands extending east-northeast. On the mainland the commonest member of the narrow belt of sediments is a pebble conglomerate. The rock is highly sheared and made up of elongated pebbles with a maximum size of one-half inch by 2 inches. They are composed of glassy quartz, and possibly an altered granite, in a sugary, micaceous groundmass of quartz and biotite. Associated with the conglomerate is a banded, fine-grained, grey siliceous sediment with *lit par lit* granite or pegmatite. These beds strike N. 43° E. and dip 80° S.E.

The sediments outcropping to the northeast form a chain of islands. The exposures on these islands will be described in some detail, as they show the transition between the sediments and volcanics. An island at the northeast end of the chain presents the evidence for the location of the north boundary. Here on the north edge of the island normal, fine-grained andesites carrying a little disseminated pyrite are in conformable contact with banded hornblendic quartzite, followed to the south by garnetiferous quartzite, the last two having a width of 5 feet. Sheared pebble conglomerate, striking N. 51° E. and dipping 70° S., forms the remainder of the island. The pebbles are mostly less than one inch in diameter and show an average elongation of 4 to 1. They are composed mainly of sugary quartz, fine-grained granites, and some aphanitic grey rocks, possibly acid volcanics. Some of the quartz is banded grey and black, a banded chert such as might be derived from a banded iron formation. An interesting feature is the presence of two boulders, one of amphibolite 2½ by 8 inches, the other of white granite 6 by 18 inches. On this island, four other small islands, and one larger one to the southwest, conglomerate is exposed; the sediments are cut by dikes or have *lit par lit* injections of granite, pegmatite, or aplite. The southern contact is also transitional and is exposed on the large island. Here a sheared pebble conglomerate with sugary quartz, glassy quartz, fine-grained granite, and acid volcanic(?) pebbles in a greenish groundmass, which is composed mainly of chlorite and hornblende, is followed to the south by micaceous quartzite with interbeds of grey quartzite, which resist erosion and stand out on a water-etched surface as ribs. This rock in turn grades into banded hornblendic rocks, and these are followed to the south by well-pillowed andesites, which outcrop at the southwest corner of the island. The banded hornblendic rocks represent a transition stage from conditions of volcanism to those of sedimentation, and whether they represent tuffs or tuffaceous sediments cannot be determined. The repetition of these beds on the north and south sides of the conglomerate beds might be construed as indicating the presence of a syncline but may merely indicate the transition into volcanic rocks again. Drag folds on the north edge indicate that the tops face south, but no information as to attitude is available for the southern half of the band, and the belt may, therefore, be just a sedi mentary interbed in a dominantly volcanic series.

Sediments were found on two small islands to the northeast. Biotite-quartz schists with interbeds rich in hornblende outcrop on one. These show a paper-thin to 1-inch banding, and probably represent the transition series of sediments. The other islet is composed of an intensely stretched pebble conglomerate. The pebbles are made up almost entirely of white to greyish, sugary quartz, ranging in size from small lenses half an inch by 1 inch up to stretched lenses a quarter of an inch by 6 inches. One highly altered, medium-grained granitoid pebble was found. The strike of the conglomerate is N. 70° E., and the dip is vertical. The structure swings from east to southeast, and one islet of sediments 2 miles to the

Water-etched surface of brecciated crystalline limestone with one well-defined bed, Severn river, 12 miles below Sandy lake. The contact with the greenstone is one foot to the right of the hammer head. The greenstone contains inclusions of the limestone.

southeast may be a part of this belt. This islet exposes poorly banded, fine-grained to almost aphanitic, grey, siliceous sediments with a 2-foot interbed of fine-grained biotite quartzite. The strike is N. 85° E., and the dip is vertical. Drag folds indicate that the tops face south.

Sediments at East End of Sandy Lake

At the east end of the lake, on four islands and the mainland to the northeast, well-bedded quartzites are exposed. They are a grey, gritty variety with opalescent grains of quartz from a twentieth to a tenth of an inch in diameter. Occasional pebbles of black chert or aphanitic volcanic rock have maximum dimensions of half an inch by 2 inches. Finer-grained quartzites occur as interbeds. On the mainland the quartzites have been intruded by various porphyries and in places it is difficult to differentiate between the two rock types.

Severn River Sediments

On the Severn river about 12 miles below the falls at the outlet of Sandy lake, volcanics and sediments outcrop. The sediments consist of andalusite-biotite hornfels and grey limestone. The limestone is in contact with greenstone, which contains abundant irregular limestone xenoliths as large as 6 by 24 inches. The limestone has been partially brecciated, but where the bedding is preserved it is well displayed owing to differential weathering. If the greenstone is an altered andesitic volcanic, then the limestone is pre-volcanic in age.

Post-Keewatin(?)

Diorite occurs at a large number of localities throughout the area, but in few places has it been possible to be certain of its age relations to the members of the volcanic or sedimentary groups.

The major occurrences consist of one large and several small sills lying parallel to the regional structure. The large sill has been traced from the 230-foot hill on Sandborn bay eastwards through a chain of islands to an island off Fishtail bay, a total distance of 23 miles.

The large sill has a surface width of approximately 30 chains and is best exposed on the 230-foot hill on the south shore of the east bay of Sandborn bay. On one of the islands in the main part of the lake it reaches a maximum width of 50 chains. On the hill on Sandborn bay, it varies from an almost coarse grained, grey rock, with dark-green hornblende crystals as large as 5 by 5 millimetres, to marginal phases, which are fine-grained and dark-green in colour. Under the microscope in thin section the essential minerals are seen to be basic andesine and hornblende with accessory quartz, sphene, titanomagnetite, apatite, and biotite. It is, therefore, a diorite. Specimens from the smaller sill-like masses are fine-grained and dark-green in colour like the marginal phases of the large sill. These sills range from 5 to 10 chains in surface width. Where they are close to granitic intrusives, microscopic examination shows that they have been metamorphosed, as indicated by the sieve structure in the hornblende, and they would more properly be called plagioclase amphibolites.

Along part of the north shore of Sandborn bay and at one locality inland, a coarse-grained diorite is found with hornblende crystals having a maximum diameter of 6 millimetres. A sample from the west point at the outlet of the bay is a uralitized quartz gabbro, which has lithological affinities with the rocks forming the hill in the east bay of Sandborn bay. The finer-grained marginal(?) phases of this rock are so similar to the coarse phases of the andesitic flows that it was found almost impossible to fix the boundaries of these masses with any degree of certainty. It is suggested that these northern masses represent the large sill repeated owing to anticlinal folding.

The age of the large sill is fairly well defined. On Sandborn bay it cuts off a narrow band of conglomerate, and on the main part of the lake is cut into and off by the granitic intrusives of the batholith of the south shore. Its age is, therefore, post-sedimentary and pre-Algoman.

Many diorite occurrences were seen in the country north and south of the Bayly river, but owing to lack of data, except at one occurrence, it is impossible to state whether the diorites represent intrusives or coarse phases of lava flows. In the one occurrence mentioned, diorite was seen to cut across the shearing in the andesite. The strike of the diorite-andesite contact is N. 90° E., and the strike of the shearing in the andesite is N. 50° E. A medium-grained rock typical of this area was studied microscopically and appears to have been a quartz gabbro originally, although at present the primary minerals are represented by such alteration products as chlorite, epidote-zoisite, calcite, and hornblende.

Algoman(?)

GRANITIC INTRUSIVES

Although no detailed examination of the granitic rocks was made, eighteen typical specimens from various localities have been examined microscopically. Eleven of these are from the south shore between the site of the old Hudson's Bay Company post and the east end of the lake and are believed to comprise a fairly representative suite from the batholiths. The types represented are granodiorite, tonalite, and diorite. It would appear that the dominant type is a biotite tonalite, which by differentiation has given rise to a more acid phase of granodiorite; whereas the diorite represents either an early basic phase of the differentiation or a hybrid type developed by assimilation of volcanic material. Practically every gradation is found between these types.

The biotite tonalites are typically massive, fine- to medium-grained, light- to dark-grey, granitoid rocks. Five thin sections under the microscope showed oligoclase, quartz, and greenish-brown biotite. The approximate modal range of composition based on four sections is: oligoclase, 66 to 76 per cent.; quartz, 17 to 27 per cent.; and biotite, 5 to 10 per cent. One specimen represents a more basic type and has the following approximate composition: oligoclase, 47 per cent.; quartz, 30 per cent.; biotite, 23 per cent. Accessory minerals present are sphene, apatite, epidote, magnetite, and minor amounts of secondary calcite and potash feldspar. Biotite tonalites are well represented by exposures along the south shore of the lake, in Granite bay, and elsewhere.

By the additional presence of hornblende the biotite tonalites become biotite-hornblende tonalites and by decrease in quartz content, typical diorites. Some of these are believed, from the position of their outcrop, to be hybrid types, as they form the contact phases of the granitic intrusives. The biotite-hornblende tonalites have the following approximate composition; plagioclase, 57 to 67 per cent.; quartz, 16 to 17 per cent.; and biotite plus hornblende, 17 to 26 per cent. They are dark-grey, fine- to medium-grained, at times porphyritic, with plagioclase phenocrysts 2 millimetres in diameter; whereas the diorites are dark-green and fine- to medium-grained, and appear in thin section to be more altered than the tonalites, suggesting that they are older or, at least, an earlier phase of the granitic intrusives. Biotite-hornblende tonalites are present on the south shore, and occur as a contact phase of the granitic batholith on the south shore at the west end of the West arm. Diorite is also found on the south shore west and north of the portage to Niska lake and may possibly represent contaminated tonalite or an earlier differentiate of the tonalite batholith. The accessory minerals in these types are sphene, apatite, epidote, and magnetite, as found in the tonalites.

The more acid phase of the granitic intrusives is represented by granodiorite. In the eastern part of the lake on islands south of the portage to Rahill lake and on an island north of the portage to Niska lake a coarse porphyritic biotite granodiorite is exposed. The crystals of brick-red feldspar have a maximum size of 10 by 50 millimetres and are set in a matrix of grey quartz up to 12 millimetres in diameter, white feldspar, and clusters of biotite. In thin section the phenocrysts of red feldspar are seen to be microcline. White oligoclase, greenish-brown biotite, and aggregates of quartz showing undulose extinction surround the phenocrysts. Quartz stringers occur in the microcline, and closely spaced microscopic fractures in the microcline combined with other evidences of crushing indicate that the rocks have undergone considerable strain. A typical modal analysis of this type shows microcline, 36 per cent.; oligoclase, 37 per cent.: quartz, 22 per cent.; and biotite, 5 per cent. Accessory minerals are sphene, apatite, epidote, and magnetite.

Biotite granodiorites varying from unfoliated to slightly foliated, fine- to medium-grained, and cream, pink and grey, to pink in colour occur in all the granitic areas examined. From evidence presented later they appear to form the batholith adjacent to the north boundary of the volcanics from Finger lake east to the Bayly river, and a mass extending southeast from the islands south of the Rahill lake portage through Niska lake and across the Dawson river. Some are practically devoid of ferromagnesian minerals, and by increase in ferromagnesian content and decrease in potash feldspar these rocks pass over into tonalites. The range of composition as seen in five thin sections of biotite granodiorites is: plagioclase, 40 to 57 per cent.; microcline, 13 to 15 per cent.; quartz, 27 to 41 per cent.; and biotite, 1 to 6 per cent. Accessory minerals are apatite, epidote, magnetite, and sphene, although the last-named is sometimes absent. These rocks are the so-called pink granites. The pink and grey type is a biotite-hornblende granodiorite and is abundant in the West arm, where it is cut by the pink type. Biotite granodiorite was found at various places along the south shore from Rat House bay to the east end of the lake.

West Arm-Finger Lake

Between the West arm and Finger lake the outcrops of the granitic intrusives are mainly of the grey type, and a characteristic feature of this area is the abundance of coarse, pink pegmatite, which is present as dikes in practically every outcrop. Locally, some pink biotite granite is present. South of the Mission pinkish-grey granite is the prevailing type and is occasionally cut by coarse pegmatite dikes. This rock is probably a granodiorite and perhaps related to the batholith flanking the belt of volcanics on the north.

West Shore of West Arm and Islands

The west shore of the West arm presents an intermingling of grey and pink granites, as seen in the area between Sandborn and Rat House bays. Along some stretches of the shore grey biotite granite predominates, in others the pink; but in all cases the pink granite cuts the grey granite and is, therefore, apparently younger. In some of the outcrops pink granite or pink pegmatite is present abundantly as stringers, dikelets, dikes, and irregular masses cutting the grey granite. Similar relations were observed at the north end of this arm, and at some localities on the east shore of the north-south part of this arm, where granite interfingers with the volcanics. It is believed that all the grey granites are tonalites. The pink variety has frequently a low to negligible percentage of ferromagnesian minerals, and a specimen taken from the long ridge on Adams creek would technically be known as a leucogranodiorite. This possibly represents the northeastern extremity of a granodiorite batholith, and the area described above, a mixed zone formed adjacent to the boundaries of the batholith.

Rat House Bay

Away from the contacts with the country rock the granitic intrusives are medium-grained, foliated to massive, grey, pink, or grey and pink biotite granites. The two varieties, grey and pink, are often intimately associated, and quite frequently the outcrop presents a complex mixture of pink granite, grey granite, pink pegmatite, and greenstone inclusions. This mixture is present all along the shores of Rat House bay; in places one variety is more prominent than the other, and the contamination due to the proximity of greenstone material is equally variable.

At a point 3 miles northeast of the narrows, at the outlet of the triangular part of Rat House bay, on both the north and south shores a coarse, grey granite shows a highly developed sheeting, the flat sheets of granite being spaced 2 feet apart; but in a zone 1 to 4 feet in thickness, which consists of fine-grained, grey biotite granite, the sheeting is spaced more closely, at intervals of half an inch to 2 inches.

Coarse- to medium-grained, pink and grey biotite granite, weathering pinkish, is the prevailing type in the 3 miles to the narrows. Secondary(?) epidote is sufficiently abundant to be quite apparent in the outcrops. Dikes of coarse, pink pegmatite are common.

The south shore of Rat House bay is characterized by the abundance of greenstone schlieren and inclusions in foliated grey granite with pegmatite as dikelets and *lit par lit.* The abundance of greenstone material strongly suggests that the axis of Rat House bay represents the site of some former syncline of volcanics, the base of which lay at no great height above the present land surface.

In the area between Rat House and Sandborn bays the outcrops show a frequent intermixing of both pink and grey granites cut by pink pegmatite dikes. Biotite-hornblende granite occurs in a number of localities and is probably due to the assimilation of volcanic material.

Along the south shore of Sandborn bay, where the contact between the granite batholith and the volcanic assemblage is exposed at frequent intervals, a variety of rock types were found. The low hill at the narrows at the west end of the bay is a white-weathering, coarse granite. East along the south shore coarse-grained, blue-grey, massive biotite granite outcrops. Back of the cliff-like outcrop of volcanics 1½ miles east of the narrows at the west end of the bay the granite is foliated and has a vertical jointing parallel to the structure of the volcanics. In the small bay east of this cliff-like outcrop a greenish granite porphyry or granite outcrops 1½ chains south of the contact, and the rock at the contact is characterized by small, jasper-red feldspar phenocrysts. A quarter of a mile farther east pinkish granite occurs at the contact, but within a few feet passes into normal, white-weathering, coarse, grey biotite granite.

In the northeastern part of Sandborn bay on the north shore, granite forms an arcuate area, with a maximum width of 3 chains, surrounded by coarse amphibolite on the land side and has an exposed width along the shore of approximately 10 chains. It is a coarse-grained, grey biotite granite with a hornblende pegmatite as a contact phase next to the amphibolite. The development of this hornblende pegmatite shows very clearly how great the assimilation of volcanic material can be under favourable circumstances.

Granite Bay

The mass on Granite bay is best exposed on the shores, and on the hills just southwest of the bay; there are a few outcrops in the area to the southeast and one on the main part of Sandy lake.

On Granite bay the rock is normally a grey, medium-grained, fairly massive biotite tonalite cut by 1- to 2-inch dikelets of aplite and pegmatite. Occasionally, rounded inclusions of greenstone from 1 to 4 inches in diameter are present. Near the contact with the volcanics on the west shore of the bay angular fragments of greenstone from 1 to 12 inches in diameter occur in the tonalite. On the southwest shore the tonalite is cut by a small basalt dike.

In the bush southwest of Granite bay a few small outcrops were found. One was a massive biotite hornblende granite; another, biotite granite; and the third, a medium-grained, slightly foliated, chloritized biotite(?) syenite. On the main part of Sandy lake the single outcrop observed is a creamy-white, coarse-grained, massive, chloritized biotite granite.

These outcrops indicate the presence of a mass that consists of biotite tonalite and its allied phases, and appears to represent a satellitic stock related to the tonalite batholith of the southern and western parts of the lake.

South Shore, Adjacent Islands, and Niska Lake

Along the south shore from the site of the old post of the Hudson's Bay Company eastward to the portage to Niska lake, and on the islands adjacent to that shore, the prevailing granitic intrusive is a grey biotite granite. The varieties that have been studied in thin section under the microscope are biotite tonalites. The outcrops are frequently cut by or have *lit par lit* injections of pink pegmatite; and locally there is present some pink granite, which was in every case younger than the grey variety.

Diorite was observed at two places, on a point 6 miles west of the portage to Niska lake and on an island 2 miles slightly west of north of the same portage. As noted, the diorite appears to be a basic phase of the biotite tonalite.

East from the portage to Niska lake, and on Niska lake itself, pink biotite granodiorite is the common granitoid type, and phases of it, as seen on the islands south of the Rahill lake portage, are coarse-grained and porphyritic with phenocrysts of microcline up to half an inch by 2 inches in dimensions. This type is cut by dikelets of pink aplite. Pink granite also outcrops southwest of the narrow belt of volcanics that crosses the bay into which the Dawson river empties. These outcrops suggest the presence of a granodiorite mass with its long axis oriented in a northwest-southeast direction.

Finger Lake, Kakapitam Lake, Rahill Lake, Bayly River

On Finger lake both pink and grey granites occur and are frequently cut by pink pegmatite dikes. East from the Severn river past Kakapitam lake to Rahill lake only a few exposures of granitic intrusives were observed, owing to the extensive swamps and muskegs. On the Severn river and just east of it some coarse-grained phases of the granitic intrusives were found. These are pink, porphyritic biotite granites, which have phenocrysts of feldspar with a maximum diameter of half an inch. On the west shore of Kakapitam lake a coarse, pink biotite granite is exposed, and north of the Fidler river there are outcrops of pink, fine- to medium-grained biotite granite. The isolated outcrop between Fishtail bay and Rahill lake is a pink, porphyritic, biotite-poor granite with half-inch pink feldspar phenocrysts. The range of hills north of Rahill lake and outcrops to the northeast are composed mainly of pink biotite granite with marginal hornblende syenite phases. Some of the granite is porphyritic.

North of the Bayly river the granitic intrusives near or at the contact with the volcanics are grey, porphyritic biotite granite cut by pink granite dikes. Two miles north of the mouth of the Mort river there is believed to be a tongue of granite splitting the belt of volcanics. Only one large outcrop is known in this area, and it is a medium-grained, white-weathering, pink, biotite-poor granite.

The above summary shows an overwhelming predominance of pink granites in this stretch of territory. As such types from other localities that have been studied microscopically are found to be granodiorites in composition, this batholithic area is, therefore, considered to be mainly of granodioritic composition.

Rottenfish Lake Area

The granitoid rocks adjacent to the belt of volcanics east of the northeast arm of Sandy lake are grey, massive, medium-grained biotite hornblende or hornblende types, probably tonalites, and it appears that the presence of hornblende is characteristic of the marginal phase of the batholith. Some of the phases are low in or lack quartz and are probably diorites. The actual contact between the batholith and the belt of volcanics was seen towards the north end of the mapped area, and at that place the grain of the granitic intrusive remained medium-grained right to the actual contact. In this marginal area there is only a minor amount of pink pegmatite occurring as dikes.

On Sandy lake where the contact is again exposed, the marginal phase of the batholith is a banded, dark-grey, porphyritic biotite granite gneiss with *lit par lit* stringers and dikelets of pink pegmatite.

In the few outcrops observed on Rottenfish lake and the country to the east, the granitic intrusives are in part highly gneissic or extremely foliated, and it is thought that some of these igneous rocks are probably considerably older than the Algoman type. A typical outcrop is represented by a low hill east of Rottenfish lake, which is a well-banded, injected granite gneiss, consisting of bands of medium-grained, pink, ferromagnesian-poor granite, with a maximum width of 2 feet, as *lit par lit* in a biotite augen granite gneiss, the whole cut by pink pegmatite dikelets lying parallel to or across the gneissic structure.

West of the south end of Rottenfish lake, there is a foliated, medium-grained, chloritized biotite granite with pink feldspar augens 3 millimetres in diameter. On the east and west shores half a mile south of the outlet of the lake, foliated, grey and pink, aphanitic to fine-grained acid gneisses with bands of dark-green or grey hornblende feldspar porphyries occur. At the extreme north end of the lake and just west of the river are several outcrops. One forms a ridge rising about 40 feet above the river and consists of a fine-grained, white leucogranite and granite gneiss with linear inclusions. Somewhat similar acid, white-weathering, grey, highly sheared, fine-grained leucogranite outcrops in the bush to the west and is associated with highly sheared and minutely crenulated, dark-grey porphyritic granite gneiss.

The granitic intrusives found outcropping along the shores of the narrow part of Sandy lake for 8 miles above the falls at its outlet are massive, medium-grained, pink biotite granites or grey and pink biotite granite gneiss, frequently showing a marked twisting of the bands or minor drag folds and crumpling. Both varieties are cut by numerous dikelets or have *lit par lit* injections of pink pegmatite.

This area is one of some complexity, and although many of the granitic intrusives may be confidently assigned to the two main batholithic varieties the presence of certain gneisses strongly suggests the existence of older granitic rocks.

Economic Importance of the Intrusives

The relative economic significance of the granodiorite and tonalite batholiths is of some importance The occurrence of gold at a number of localities along the north shore of the lake and the showings near Rahill lake off the north end of a smaller granodiorite batholith suggest but do not prove that the granodiorite came from the gold-bearing magma of the region. Hurst[1] has drawn attention to the economic significance of the more acid granites in the Favourable Lake area. If only the acid granites were the source of ore deposition, then the lack

[1]M. E. Hurst, op. cit., pp. 65, 66.

of economic mineralization adjacent to the Granite bay stock of grey biotite tonalite and in the West arm, where the volcanics and associated sediments are enclosed by a batholith mainly composed of the grey granite (tonalite), is accounted for.

PEGMATITE, APLITE

As mentioned in the previous section dikes of pegmatite are abundant throughout many of the batholithic areas, and were also found at some localities in the belts of volcanics close to the granitic masses. Aplite, while not so abundant, is not uncommon. No special study was made of the pegmatites or aplites. They are nearly all pink in colour and vary considerably in the grain size of their constituent minerals. One specimen from the south shore was examined microscopically and was determined to be an alaskite. It occurred as a dike cutting grey granite (tonalite).

PORPHYRIES, FELSITE

Porphyries, presumably of Algoman age, are not widespread. They occur in two areas, at the outlet of Granite bay and on the narrows west of the Hudson's Bay Company post, and at the east end of Sandy lake. As previously mentioned, a large number of sheared porphyries are present in the area and these have been described under the section dealing with the Keewatin-type rocks.

At the outlet of Granite bay and along the narrows are a number of small dikes of quartz feldspar or feldspar porphyry. A number of the dikes trend nearly north and south, but others have various strikes. They range in width from a few feet to 75 feet. These porphyries are fresh-looking, fine-grained, grey rocks with blue-grey feldspar phenocrysts 1 by 3 to 5 by 7 millimetres in size. They are tonalite or dacite porphyries.

At the east end of the lake a number of different types of porphyries cut sedimentary rocks. They range from aphanitic to medium-grained types. Some of these rocks may be older porphyries and should possibly be classed with the Keewatin-type. A fresh rock outcropping as a dike in the same locality is very similar to those found in the narrows near Granite bay. When studied microscopically it is found to be dacite porphyry. It consists of blue quartz eyes and white feldspar phenocrysts in a dark-grey, aphanitic groundmass. Other types represented are buff-coloured, quartz-eye porphyries and white porphyries with grey quartz eyes. At the southeast end of this area, the porphyries form the major part of a *lit par lit* injected zone, which appears to have been andesitic volcanics, traces of which remain as bands from a few feet up to 20 feet in width.

Throughout the area a number of buff-coloured, white-weathering, aphanitic acid dikes were observed cutting the members of the volcanic or sedimentary groups. These dikes may be rhyolitic in composition, but owing to their very fine grain and alteration it is impossible to determine their true composition, and for the purpose of this report they are classified as felsite.

Keweenawan(?)

Igneous rocks lithologically similar to Keweenawan types elsewhere in the shield were found at a few localities in the area. All are dikes, and the most important are located as follows: (1) Northwest arm, (2) crossing the West arm, (3) crossing the south shore at about the middle of the lake, and (4) on the "boot" west of Fishtail point. A number of smaller aphanitic dikes were also found.

The dike in the Northwest arm has an average width of 150 feet, strikes N. 5° E., with a vertical dip, and cuts dacite porphyry, andesite, and probably

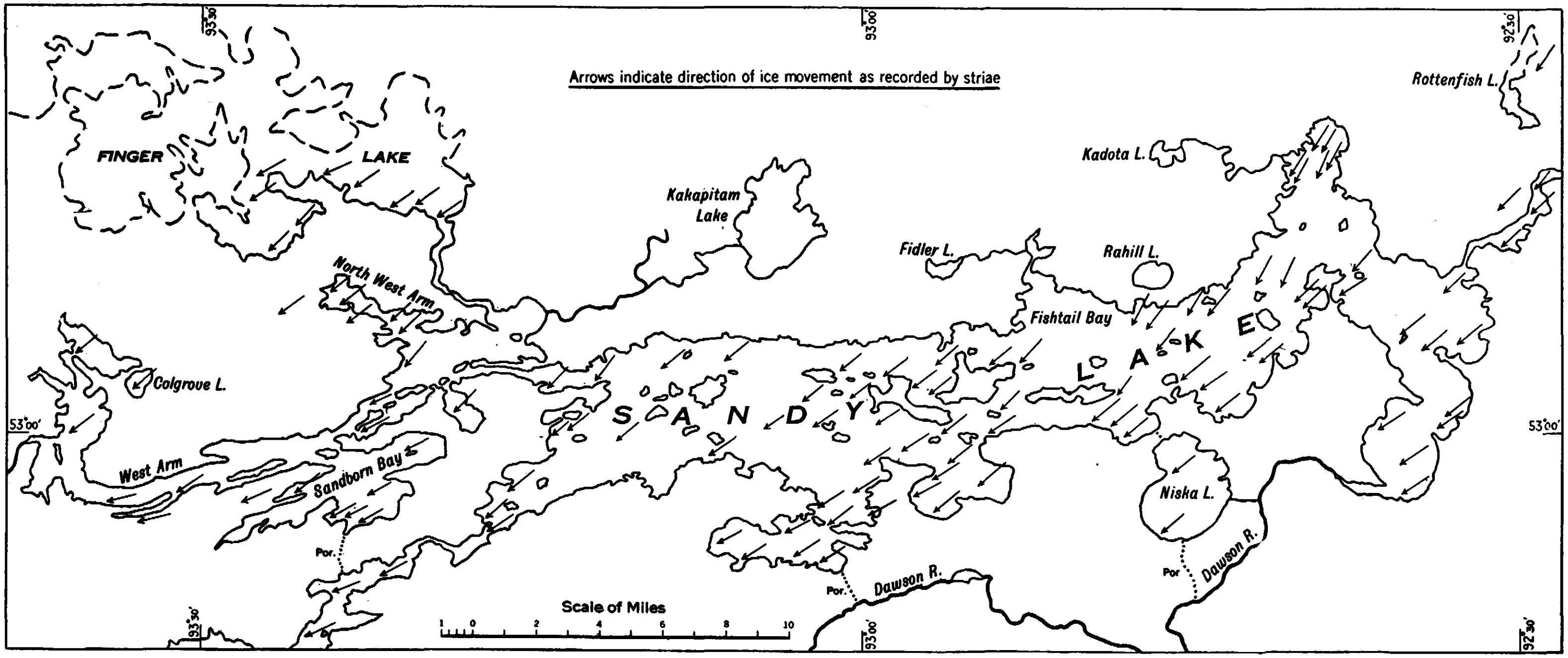


Fig. 2—Sketch map of Sandy lake showing the movement of the continental glacier as indicated by striae.

the tonalite. It is a dark brownish-green rock of medium grain, which under the microscope is seen to consist of plagioclase and augite in about equal amounts, with the following accessory minerals: ilmenite showing grid texture and alteration to leucoxene, red-brown biotite, epidote, and apatite. The rock has been considerably altered, the plagioclase crystals being crowded with grains of zoisite. Chlorite replaces the groundmass and some of the augite and plagioclase.

Crossing the West arm and trending N. 5° E. to N. 15° E. a gabbro dike has been picked up at intervals over a distance of about 4 miles. The width averages 100 to 130 feet, but the outcrop at its southern extremity shows a width of only 60 feet. The dike cuts and shows chilled margins against granite and sheared andesite. The contact with the granite is especially well displayed in a small bay of the West arm. The dike is lithologically similar to the one described in the Northwest arm.

On the south shore of the lake about 9 miles west of the portage to Niska lake two exposures indicate a dike 2 chains in width, trending N. 25° E. The rock is dark-green and fine-grained, and the microscope shows it to be a fairly fresh and very typical Keweenawan type of quartz diabase, such as could be matched in the Cobalt area or elsewhere. The minerals present are labradorite, augite, and micrographic intergrowths of quartz and an alkali feldspar, with iron ore as an accessory mineral.

About a mile east of the dike described above, a small, dark-green aphanitic dike 10 feet in width, striking S. 10° E., cuts the tonalite. Microscopically, it is seen to consist of small phenocrysts (half a millimetre in diameter) of augite, plagioclase, titaniferous iron ore, and a little pyrite. The rock is a porphyritic basalt and is probably related to the quartz diabase dike just described. Somewhat similar narrow, greenish, aphanitic dikes, 1 to 5 feet in width, were seen to cut tonalite and pegmatite dikes in Granite bay. The dikes have strikes of S. 62° E., S. 5° W., and S. 25° E., and steep to vertical dips.

One other diabase dike was found near the north shore of the lake in the heel portion of the "boot," 2½ miles west of Fishtail point. This dike cuts andesite and iron formation, varies in width, and is somewhat difficult to trace. It does not outcrop along the shore. It is rusty-weathering and very similar to the quartz diabase dike from the south shore described above.

On a burnt rock ridge at the northeast side of Fishtail bay, a 3- to 4-foot irregular dike composed of porphyritic quartz basalt cuts a metamorphosed andesite and Keewatin-type porphyry.

Pleistocene

Sandy lake during Pleistocene times was covered by the continental glacier, and on its retreat a large lake was formed in which varved clays were deposited. These varved clays as now exposed in the banks on the lake have thicknesses from a few feet up to 25 feet. Diamond-drilling by Prospectors Airways Company, Limited, in the Northwest arm showed thicknesses of 13 to 41 feet of clay, and in a number of cases this clay was underlain by 1 to 9 feet of gravel before bed rock was reached. On Rat House bay near the main part of Sandy lake, bed rock was found in one place to be overlain by 2 feet of sand, then by varved silts, which passed upwards into typical varved clays, the whole having a thickness of 20 feet.

The varves range from half an inch to 2 inches in thickness. Taking the greater thickness of the varves and a total thickness of 40 feet of clay, it is apparent that the post-glacial lake existed for 240 years, a figure in keeping with that noted by the writer in the Sachigo River area.[1]

The movement of the continental glacier (see Fig. 2), as indicated by glacial striae, based on an average of 110 readings, was S. 50° W. This figure applies to the whole lake except the east end; from the Rahill lake portage northeastwards into the north arm 18 readings of striae indicate that the movement was in a direction S. 32° W. Farther east in the country just east of Rottenfish lake, the striae, as indicated by 14 readings, trend S. 44° W.

At some localities readings were obtained very much "off" from the average, and in a number of cases these can be definitely assigned to the control exerted by the underlying rock structure, the directions of the striae and structure being essentially parallel. Such cases are found in the West arm.

In Sandborn bay striae on vertical cliff faces and on the under side of overhanging rock masses strongly suggest the existence of deep valleys prior to glaciation.

The figure of S. 32° W., obtained as an average for the Rahill lake–Bayly river part of the lake, may be correlated with the influence of the underlying rock structure, which has the same trend. This parallelism can only be accounted for by assuming that the ice followed a channel way already parallel to the rock structure, as the ice movement in the area to the east was S. 44° W.; it must also have been deflected more to the south in this one area, since in the bay into which the Dawson river flows the movement is S. 53° W., which is very close to the regional trend.

Toward the east end of the lake the glacial deposits consist of sand, gravel, and boulders, as well as varved clay. East of Rottenfish lake, gravel-sand ridges or hills have, in part, lobate margins and may represent kame deposits. A number of small boulder ridges, sush as those on Niska lake and the Dawson river bay are possibly portions of eskers.

STRUCTURAL GEOLOGY

Folding

Throughout the area members of the volcanic and sedimentary groups have been tightly folded and now stand with steep to vertical dips.

On Sandy lake, owing to the varying degrees of metamorphism, criteria for the determination of the attitude of the strata or flows are rarely available for interpretation. At some localities, apparently undisturbed pillow structures in the lavas were used to determine structure, but for the most part the attitudes of minor drag folds were the only sources of information available.

In the area underlain by the volcanic group between the Northwest arm and Finger lake, drag-folding in the dacite porphyry on a hill just west of the west end of the Northwest arm indicate that the outcrop is on the south limb of a syncline plunging S. 65° E. The dips of the flows are vertical or 85° S., indicating a tightly-folded syncline with a slight overturning of the southern limb. Where the syncline is truncated abruptly by the granitic batholith to the northwest, the flows have attitudes parallel to the contact, with dips of 65° to 75° S.E. The granite batholith to the south of this area would, therefore, occupy the core of an anticline, which noses out at the junction of the Northwest and West arms.

The area of Keewatin-type rocks occupying the West arm consists mainly of volcanics with a narrow belt of sediments. At the junction of the Northwest and

[1]J. Satterly, Ont. Dept. Mines, Vol. XLVI, 1937, pt. 4, p. 25.

West arms drag folds in the volcanics north of the sediments show that the tops face south. In the centre of the belt west of the outlet of Sandborn bay, pillow shapes show that the tops face north. On Colgrove lake, drag folds in the sedimentary schists indicate the presence of a syncline whose axis trends S. 30° E., with a low plunge of 15° S.E. On the south shore of the bay at the extreme north end of the West arm, a drag fold shows that a syncline lies to the north and plunges steeply southeast. These four determinations seem to show that the narrow belt of sediments probably represents the site of a synclinal trough. The rocks are tightly folded and in the eastern part of the belt have in the main steep dips; but north and south of Colgrove lake, the dips average 45 to 60 degrees. In the extreme north bay of the West arm the structure is probably more complicated, the frequent occurrence of sediments strongly suggesting repeated minor folding. This syncline peters out to the east in the bay south of the mouth of the Stain river; to the west it is cut off by the granite batholith.

In Sandborn bay structural data were only found in members of the sedimentary group. Cross-bedding in a quartzite bed and drag-folding in a limestone bed indicate that the tops face south. The axis of the syncline trends N. 75° E. and plunges steeply east. In the iron formation on the south shore of the bay, drag folds suggest that the tops are to the north, the axis of the synclinal fold trending S. 65° E. and plunging steeply northwest.

Owing to the presence of the gabbro-diorite sills, the structure may be more complex and more than one fold may be present. It would appear that there is a syncline of sediments with part of the south limb cut out by the granitic batholith. Across the whole belt of sediments the bedding dips 60° to 85° N., so that the north limb of the syncline is markedly overturned. The patches of sediments on the chain of islands in the centre of the lake as far east as Fishtail point may represent the extension of the axial portion of the fold. Two determinations show that the sedimentary beds have their tops facing north.

No data are available for the section between the West arm and the southern part of Sandborn bay, but from the above data it is inferred that there is an anticlinal structure and that the pillowed lavas present in Sandborn bay represent the same horizon as that in the West arm, repeated by folding. It is further inferred that the Granite bay tonalite mass occupies a domed part of this anticlinal fold. This doming is well shown by the attitude of the volcanic rocks, which swings from a strike of northwest to north to northeast around the west edge of the tonalite mass. It is not known whether this anticline continues eastward, but the small mass of tonalite south of the "boot," 2½ miles west of Fishtail point would, on the assumption of its continuance, occupy the site of a dome similar to that of Granite bay.

In Fishtail bay, pillow lava shapes indicate that the tops face south. No data for structural determination were found eastwards or westwards to the mouth of the Stain river. On the east shore and on islands of the northeast bay three determinations on pillow shapes, one of which showed the pillows passing into a coarse-grained flow to the east, indicated that the tops face west to northwest. As the belt of iron formation present in this part of the lake lies southeast of the belt of pillowed lavas, but is believed to be the same belt of iron formation as that exposed along the north shore of the lake west from Fishtail point, it is inferred that a synclinal axis lies in the water and trends southward from the mouth of the Mort river, swinging to the southwest and finally west and passing just north of Fishtail point. Strikes and dips in the lavas north of the Mort river conform to this interpretation of the structure, and the strikes swing around the granite mass with dips steeply to the east, north, and west. The granitic mass has possibly been intruded along the synclinal axis, but more detailed work may find further data to form a basis for other interpretations.

The above structural interpretations are summed up in Figure 3, which indicates the positions as deduced by the writer for the anticlinal and synclinal axes.

Fracturing and Shearing

Stresses in an east-west direction have resulted in the development of fractures or shear zones, or in drag folds with vertical axes.

The fractures indicate that the movement was such that the north side was displaced eastward with respect to the south side of a given rock mass. The fractures so developed trend N. 20° E. to N. 60° E. A few of these fractures have been filled by quartz veins or dike rocks. Fracturing along these lines of weakness was repeated more than once, as evidenced by the shattering or crushing of the filling material.

Many minor drag folds throughout the area have steep to vertical dips and from their shape indicate that the north side has moved east relative to the south side, the movement being one with a horizontal component and a negligible vertical component. These vertical drag folds are believed to be due to stresses later than those that caused the folding of the members of the volcanic and sedimentary groups

Where the rocks were incompetent, stresses resulted in shearing; and shear zones parallel to the structure of the metamorphosed lavas are very abundant along the north shore of the lake.

ECONOMIC GEOLOGY

During the summer of 1937, Sandy lake was actively prospected. The various types of mineralization found may be summarized as follows:—

1. Quartz veins, with or without tourmaline, showing varying amounts of sulphides (pyrite, pyrrhotite, chalcopyrite, sphalerite, galena), usually narrow and frequently showing visible gold.
2. Mineralized porphyry or rhyolite dikes.
3. Silicified zones in porphyry.
4. Calcite quartz veins in the volcanics.
5. Shatter or crush zones along fractures, or in dikes following fractures, trending N. 20° E. to N. 60° E. across the volcanics.
6. Shear zones in the volcanics or along contacts between members of the volcanic group and other rocks.
7. Rust zones in sedimentary interbeds in the volcanic group, or at certain horizons in the sedimentary group. The sulphide may be pyrite or pyrrhotite.
8. Mineralized iron formation.

Prospecting Possibilities

The discoveries indicate that gold is widely distributed on Sandy lake. The belt is a long one, and it would appear likely that its possibilities have not been entirely revealed. At the present time the showings lack either values or widths to make them deposits of economic importance. Further prospecting of the area underlain by the dacite porphyry in the Northwest arm may uncover economic mineralization. The most likely type of occurrence would appear to be quartz veins filling fractures that cut across the regional structure of the volcanics. It does not seem likely that mineralized shear zones in either the volcanic or sedimentary groups will prove important economically.

Clay Deposits

In this report mention has been made of the extensive deposits of glacial varved clays on Sandy lake. The deposits range in thickness from a few feet up to a known maximum of 41 feet.

Hurst[1] submitted a sample of the varved clay from a typical exposure on the north side of the West arm of Sandy lake to R. T. Montgomery, of the Ceramics Department, University of Toronto, and the latter's report is repeated here:—

> This clay is grey in the dry state and fine-grained, and contains no stones. Water required for plasticity is 34 per cent., giving a very smooth plastic mass, rather sticky if a slight excess of water is used, and so fine grained that it dries with difficulty. It would probably give trouble in rapid commercial drying.
>
> A sieve test gave a residue of only 0.15 per cent. on a 200-mesh screen. This residue was composed mostly of roots and plant remains with a little silica sand and miscellaneous rock fragments. The fusion temperature or pyrometric cone equivalent is 2,138° F. or cone 2, giving a dark-brown fused mass. Test with acid indicates a rather high percentage of lime. The drying shrinkage is 11.1 per cent., which is quite high. A normal shrinkage for this type of clay is from 6 to 8 per cent. This means that in working, a non-plastic, such as sand, would probably be necessary to reduce the shrinkage and allow safe drying. The clay burns to a buff colour because of the high lime content, and at cone 6 or 1,900° F. the burning shrinkage is 0.8 per cent. The low burning shrinkage is due to the lime.
>
> This clay is probably of glacial origin as suggested. It would be classed as a young, impure surface clay. It could probably be manufactured into buff common or possibly face brick and drain tile. It would require sand or other non-plastic to give a suitable body. Unless it is near some centre of population it would have verv little economic value.

DESCRIPTION OF PROPERTIES

Bernadette-Knoll Showings

Dubeau-Dussault

The Dubeau-Dussault group consists of 5 recorded claims, Pa. 3,158–3,162, and is located on the north shore of the Northwest arm of Sandy lake. This group, along with the Sandborn group, was optioned to the Prospectors Airways Company, Limited, in the autumn of 1936. The company did 1,500 feet of drilling from the ice in the spring of 1937. Results were disappointing, and the option was dropped.

There are two showings, both located on claim Pa. 3,158. The country rock is the somewhat sheared dacite porphyry, which locally shows a fragmental structure. The strike of the shearing in the porphyry is S. 53° E., and the dip 85° N.E. to vertical. At the shore the porphyry is cut by a 4- to 6-inch quartz vein striking N. 33° W. Trenching for 40 feet northwest along the strike exposes the vein, and it has been picked up again in a small bay at 55 to 80 feet from its first exposure. At these points its width is 6 inches and 3 inches, respectively. The vein consists of sugary, white quartz showing a poorly banded structure due to streaks of biotite schist. Mineralization is sparse, being confined to small cubes of pyrite. A character sample of this vein material assayed 0.39 ounces of gold per ton. Very high assay values are reported, as locally visible gold is present.

The other showing, approximately 300 feet west of the first, is a silicified zone in the porphyry. Drilling by the Prospectors Airways Company indicated a lenticular silicified zone with a maximum width of about 15 feet. Sugary, white quartz mineralized with pyrite formed from 10 to 50 per cent. of the zone, and the gold content is reported to have ranged from a trace to a high of 0.18 ounces per ton. The trend of this zone as indicated by the drilling is approximately north and south, and the length may be 100 feet.

[1]M. E. Hurst, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 2, p. 84.

Sandborn gold showing in NW ARM, not to be confused with Sandborn Bay VMS targets

Sandborn

The Sandborn group consists of 18 recorded claims, Pa. 2,965–2,981 and 3,030 in the Northwest arm of Sandy lake. There are two showings. This group was under option to the Prospectors Airways Company, but the option was dropped in July, 1937.

Cream-coloured, soft-weathering dacite schists, striking S. 75° E. and dipping 85° N., outcrop on claims Pa. 2,969 and 2,966 on the north shore of the Northwest arm. In these schists, parallel to the schistosity, a 5- to 6-inch cherty, blue-grey quartz vein carries a minor amount of pyrrhotite and pyrite in fractures. An assay of the quartz gave 0.03 ounces of gold per ton. For a width of 63 feet immediately south of this occurrence are alternating bands of grey and cream-coloured dacites. The last 10 feet are rusty-weathering and contain disseminated pyrite. A grab sample taken by the writer assayed 0.04 ounces of gold per ton. The cream-coloured dacite schists contain quartz-eye remnants and are believed to represent zones of the grey dacite that have been intensely altered by hydrothermal action.

On claim Pa. 2,974, at the mouth of a small stream at the extreme west end of the Northwest arm, a silicified zone has been trenched on the east and west sides of the stream. The country rock is an amphibolite representing a metamorphosed andesitic volcanic. On the east side a silicified breccia zone 7 feet in width trends S. 75° E., with a vertical dip. The quartz is sugary white and carries a little coarse pyrrhotite and pyrite, and chlorite cements the quartz fragments. A character sample of this material assayed 0.02 ounces of gold per ton. On the west side of the stream, on the above-mentioned strike, a siliceous, dark-grey biotite-quartz schist forms a 4-foot interbed in the amphibolite. In this interbed lenses and ribbons of greyish, sugary quartz occur parallel to the schistosity, which strikes S. 75° E. A little pyrite is present in the quartz and in the schist. An assay of this material showed only a trace of gold per ton.

Tully-Burton

Tully and Tully West Showings, NW ARM

The Tully-Burton group consists of 14 recorded claims, Pa. 3,041–3,051 and 3,146–3,148, situated between the west end of the Northwest arm of Sandy lake and Finger lake. There are two showings, the more important one being on claim Pa. 3,049. The country rock is a metamorphosed pillowed andesite forming a prominent east-west ridge. The showing is a mineralized silicified zone lying just south and west of the ridge. The zone has been trenched along the strike at 30, 130, and 210 feet west from the first trench. These trenches expose a banded chlorite-magnetite rock carrying lenses and ribbons of whitish and greyish to black quartz mineralized with splashes of pyrite and fine disseminated pyrrhotite. The zone ranges in width from 12 to 30 feet and is probably a variety of iron formation. Panning of the surface material was reported to show much visible gold. Grab samples taken by the writer from the above-mentioned trenches assayed 0.13, 0.02, 0.06, and 0.05 ounces of gold per ton.

The other showing is on claim Pa. 3,042 and consists of a quartz vein, which has been trenched for 90 feet. The country rock is a quartz-eye porphyry. The vein strikes north-south and ranges in width from 2 to 4 feet. The quartz is glassy-white and shows no sulphide. An assay for gold on a grab sample taken by the writer gave only 0.02 ounces per ton. The porphyry on the east side of the vein is slightly mineralized with coarse pyrite and is reported to pan gold. None, however, was found on assay of a grab sample taken by the writer.

Moar

The Moar group consists of 3 claims, Pa. 3,241–3,243. The showing is a highly silicified and heavily mineralized zone in dacite porphyry on the shore of the Northwest arm of Sandy lake on claim Pa. 3,241. The sulphide is pyrite, which occurs as coarse splashes, and the width of the zone is approximately 10 feet. A grab sample of this material assayed 0.01 ounces of gold per ton. The deposit was drilled in the spring of 1937.

Dubeau Galena Showing

On an island just southwest of the mouth of the Stain river, 2½ miles east of the Mission, there is a small galena showing. Dacite porphyry and greenstone outcrop on the island. Galena is present at several places, and galena-sphalerite float can be seen along the shores at low-water level. On the north side a silicified greenstone shows irregular lenses and stringers of rusty, sugary quartz carrying some pyrite and, locally, a considerable amount of friable galena. The deposit is very small and may indicate that perhaps more mineral may be present in the lake to the northwest. A grab sample of the quartz carrying galena assayed 0.03 ounces of gold per ton.

Walters-Shephard

The Walters-Shephard group consists of 6 claims staked on the "boot," a point on the north shore of Sandy lake approximately 3 miles west of Fishtail point.

The country rock is a pillowed andesite with interbedded iron formation and grey pillowed basalt. The regional strike is approximately east-west with a vertical dip. Cutting across the structure is a glassy, grey to white quartz vein, which has been traced by intermittent stripping for a length of about 400 feet. The trend of the vein varies from N. 40° E. to N. 55° E. One test pit, 4 by 12 feet and 1 foot in depth, exposes a 30-inch shattered zone in the pillowed andesite. Here the quartz vein, which ranges from 3 to 9 inches in width, lies on or close to the north wall of this zone. Mineralization in the vein is sparse, there being a little chalcopyrite and pyrite present as splashes and streaks. Visible gold was shown to the writer but is apparently scarce. Assays are reported to have been low. The vein peters out to the northeast against a band of iron formation.

White

Two showings are present on the White group. One of these occurs in a group of 16 recorded claims, Pa. 3,818–3,833, located on the west side of Fishtail bay on the north shore of Sandy lake. The country rock is a fine-grained, fairly massive andesite. On claim Pa. 3,822 at the shore a fracture zone with a maximum width of 15 feet, trending N. 28° W., occurs in the andesite. The fractures in this zone, which are mostly only a fraction of an inch in width, are filled with white calcite, and in one place in the centre there is a lenticular vein of coarse, pearl-grey calcite, with a maximum width of 6 inches. Pyrite is found sparingly as cubes and as a fine dissemination. In one pit the fractured andesite is cemented with glassy-white quartz forming a vein 6 to 9 inches in width. The quartz is heavily mineralized with pyrite, some sphalerite, and a very little galena. A grab sample of the best-looking material assayed 1.25 ounces of gold per ton. Much higher gold values are reported. The showing has been exposed by stripping, shallow trenches, and test pits spaced over a distance of 200 feet.

The other showing is in the northeast corner of Fishtail bay. The find is on a burnt rock ridge, which consists of massive, medium-grained amphibolite (metamorphosed andesite) intruded by a grey, fine-grained, white-weathering quartz-feldspar porphyry. Cutting both the amphibolite and the porphyry is a 3- to 4-foot irregular dike of Keweenawan basalt porphyry. Crossing this ridge is a fracture trending N. 20° E., which has been traced for 10 chains by small test pits and trenching and cuts across both the quartz-feldspar porphyry and the amphibolite. There may be some displacement along the fracture. Grey to white quartz fills the fracture and occasionally attains a width of 6 inches. Sulphide mineralization in the quartz is negligible, except on the vein walls, where pyrite, pyrrhotite, and chalcopyrite occur as irregular splashes and specks. The writer understands that gold was panned along the entire length of this fracture-filling.

Hansen

A group of 8 recorded claims, Pa. 4,081–4,088, was staked by C. K. Hansen in July, 1937, on the north shore of Sandy lake, south of Rahill lake. The showing is on claim Pa. 4,081, on the top of a burnt hill about one mile west of Rahill's old cabin.

The burnt hill exposes pillowed andesite cut by a number of narrow, dark-grey rhyolite or rhyolite porphyry dikes. The find consists of a mineralized shattered zone within or close to one of the rhyolite dikes. Stripping over a length of 95 feet and 9 test pits seems to indicate a continuous mineralized zone, 300 feet long and ranging in width from less than 1 inch up to 4 feet. From south to north the first 150 feet is a heavily mineralized zone from a fraction of an inch to 3 feet in width; for the remainder of the exposed length mineralized rhyolite constitutes the showing. The general trend of the zone curves from N. 20° E., for the first 50 feet, to N. 35° E., for the next 50 feet, to N. 50° E., for the last 200 feet. The dip is vertical. The mineralization is slight to heavy and consists of fine disseminated to coarse pyrite. Quartz is present in parts of the zone. Some sphalerite is present in the mineralized rhyolite. A grab sample of this material assayed 0.11 ounces of gold per ton. The andesitic wall rock is quite frequently mineralized with fine pyrrhotite and, more rarely, with chalcopyrite. Widths up to 3 feet were observed.

Adams

Two groups of recorded claims have been staked by D. H. Adams and C. K. Bayly on the north shore of Sandy lake, near Rahill lake. One of these groups consists of 10 recorded claims, Pa. 4,053–4,056, 4,059–4,063, and 4,068; and the other of 6 recorded claims, Pa. 4,055, 4,057, 4,058, 4,064, 4,066, and 4,067. The only showing is on claim Pa. 4,081. Trenching and test-pitting indicate a length of approximately 450 feet. The showing appears to be a mineralized shattered zone in a rhyolite dike, although little or no trace of rhyolite remains. The dike and mineralized zone trend S. 25° W. to S. 45° W. and cut across the structure of the pillowed andesites, which trend in an east-west direction. The mineralized zone ranges from 2 to 30 inches in width and pinches out in some places. Near the boundary line between the Hansen and Adams claims, i.e. the line between claims Pa. 4,068 and 4,081, the crushed rhyolite is heavily mineralized with pyrite and a lesser amount of sphalerite. A grab sample of this material assayed 0.10 ounces of gold per ton. To the south the sulphide mineralization is heavier, and in some of the test pits practically solid pyrite is present in widths up to 6 inches. Quartz occurs in some of the pits. It is reported that the best assays were obtained when quartz and sphalerite were present in the samples. Very low gold values are reported from the solid sulphide sections.

Three claims have been staked by D. H. Adams and C. K. Bayly on an island just off the north shore of Sandy lake, about 1½ miles east of the Rahill lake portage. These claims adjoin the recorded claims Pa. 4,067 and 4,057. The country rock is andesite, locally showing pillow structure. On the south side of the island the fracturing in the andesite trends N. 50°–70° E. and S. 55° E., and a 6- to 12-inch quartz vein follows a zigzag course for 31 feet. A carbonated, slightly mineralized, greenish-grey quartz porphyry dike, trending N. 45° E. and approximately 15 feet in width, cuts the andesite and is cut by the quartz vein. The quartz is glassy-white to grey in colour and is locally mineralized with coarse pyrite. In places small vugs are present in the quartz, and these are lined with pyrite. Most of the quartz is barren, but one edge of the vein will pan gold, and it is understood that this section of the vein gave good assays. Narrow stringers of quartz occur sparingly in the porphyry and contain a minor amount of chalcopyrite. Trenching and test-pitting were in progress in mid-September, 1937.

Other Mineralization

In a band of iron formation interbedded in a grey pillowed lava in the small bay just west of Fishtail point a considerable amount of chocolate-brown sphalerite and secondary quartz is present. A sample assayed for gold gave 0.08 ounces per ton.

Samples of the mineralized sedimentary interbeds found in the volcanics on the West arm of Sandy lake assayed a trace to 0.02 ounces of gold per ton.

Geology of the North Spirit Lake Area

By J. D. Bateman

INTRODUCTION

North Spirit lake lies in the Patricia portion of the district of Kenora between north latitudes 52° 10′ and 52° 35′ N. and longitudes 92° 35′ and 93° 20′ W. It is approximately 170 miles north of Sioux Lookout or Hudson on the transcontinental line of the Canadian National railway, and 40 miles southeast of Favourable lake, where an underground mining operation is now proceeding at the property of Berens River Mines.

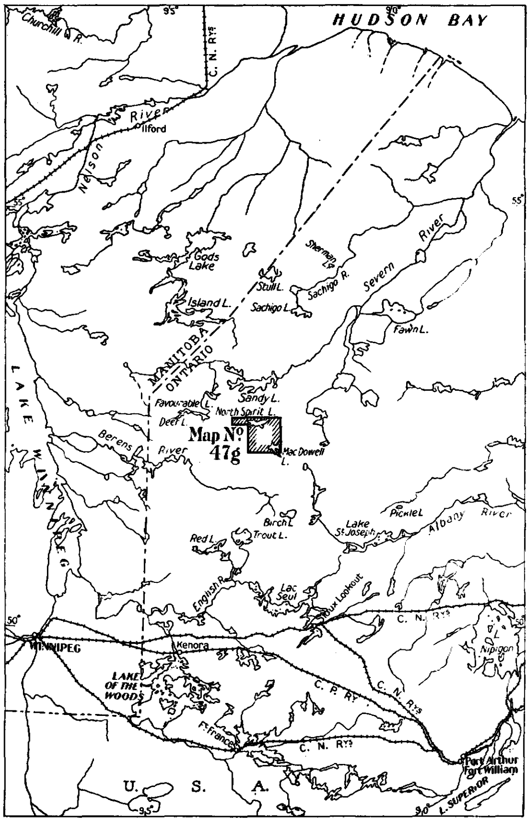


Fig. 1—Key map showing the location of the North Spirit Lake area. Scale, 160 miles to the inch.

As a result of reports of discoveries of gold-bearing arsenopyrite made in the vicinity of North Spirit lake in the early spring of 1936, the area was visited by representatives of a number of exploration and mining companies, and several groups of claims were staked, for the most part adjacent to the original discoveries. Subsequent investigations by prospectors disclosed a broad belt of sedimentary and volcanic rocks extending for some distance southeast of North Spirit lake.

In 1937 the writer, with three assistants, made a general reconnaissance geological survey of the area, the party being engaged in the field for almost four months, from early June until late September. The work resulted in defining the North Spirit Lake area as a sedimentary-volcanic belt, extending southeast of North Spirit lake, through Hewitt lake to MacDowell lake, a distance of 22 miles, and averaging 5 to 8 miles in width. Northwest of North Spirit lake the sediments extend as a narrow belt for at least 20 miles and pass south of the Favourable lake belt of volcanic-sedimentary rocks mapped by M. E. Hurst in 1928.[1] The North Spirit lake sedimentary-volcanic belt thus has a total length of at least 42 miles and has not yet been delimited to the northwest. It may connect with an extensive area of volcanics that is reported by prospectors and Indians to lie west of North Spirit lake and south of Favourable lake. The boundaries of the North Spirit lake area are geological, as the sedimentary-volcanic belt is surrounded by granite and granite gneiss.

Advance copies of maps issued by the Topographical Survey, Department of Mines and Resources, were used as base maps. These were constructed from east-west vertical air-photograph sections through the central and southern part of North Spirit lake, and from oblique aerial photograph sections for the remainder of the area. The photographs were taken by the Royal Canadian Air Force. Some additions and corrections were made to the base maps. The shore geology of the waterways was recorded in detail, and the intervening sections were covered by pace-and-compass traverses. The extensive magnetic iron formation east of South bay in North Spirit lake disturbs compass readings for a radius of about 6 miles, and the complex geology of that section was mapped with difficulty.

Acknowledgments

During the summer the party was dependent on the efficient and punctual aircraft transportation service provided by General Airways, Limited, and the many courtesies extended by the late J. H. McCoy, and by E. Waller and G. C. Nickels, pilots of that company, are gratefully acknowledged. The party is also indebted to officials of Spirit Lake Gold Mines for the use of their comfortable camp buildings as a headquarters during the summer and, in particular, to T. W. MacDowell and V. E. C. Odlum, president and general manager, respectively, for their generous assistance in providing the writer with information concerning development work at the company's property and other data pertinent to the field work. Grateful acknowledgment is made to officials of the Prospectors Airways Company and the Mining Corporation of Canada for supplying the writer with geological maps and reports on the holdings of these companies in the North Spirit Lake area. The writer would also like to thank Professors Adolph Knopf and A. M. Bateman of the Department of Geology, Yale University, for their advice during the preparation of this report.

John Low, Cameron Robertson, and H. S. Armstrong, as assistants, rendered efficient and energetic service and did much to advance the work of the season. Mr. Low is responsible for most of the mapping northwest of North Spirit lake, done while the writer was engaged in another area during the latter part of September.

Access

North Spirit lake, which is some 13 miles long and 2 to 3 miles wide, may be reached from Sandy lake, into which it drains by the Flanagan (Duck) river through Tallrice, Whiteloon, and North Wind lakes, by a good water route along

[1]M. E. Hurst, "Geology of the Area between Favourable Lake and Sandy Lake," Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 2.

which there are 13 short portages, the trip requiring about 3 days. There is also a canoe route from the south, passing north from Cat lake through Sucker lake, Tutu river, and MacDowell lake to North Spirit lake. Since travel over this route entails about 70 portages, some of which are as long as 5 miles, it is impracticable for the transportation of supplies.

The most suitable means of transportation to North Spirit lake is by airplane from Sioux Lookout or Hudson, the 170-mile trip taking about 1½ hours. The charges for air freighting from Sioux Lookout to North Spirit lake, from figures furnished by General Airways, are 9½ cents per pound and, for the return trip, 4½ to 5 cents per pound. Similarly the passenger fare is $30 per person to North Spirit lake and $20 to Sioux Lookout. These figures are the minimum rates and apply only to a "pay load."

Previous Exploration

Owing to the isolation of North Spirit lake and its remoteness from ordinary travel routes, there are only meagre references to it in the literature of the region, and there is no record of the lake having been visited by any of the early explorers. The nearest area in which geological mapping has been carried out is the area between Favourable and Sandy lakes,[1] which lies 40 miles to the northwest. A geological survey of the Sandy lake volcanic-sedimentary belt was made by J. Satterly[2] during the summer of 1937. There is a span of 70 miles to the south of North Spirit lake in which no geological mapping has been carried out. The first definite reference to the lake was made by Hurst in 1929, who stated:[3]—

> Duck [Flanagan] river is the largest tributary of the Severn within the area investigated. It empties into Rat House bay of Sandy lake and drains North Wind, Duck [Duckling], and many other lakes stretching for miles to the south and east. This is the route most commonly followed by prospectors in reaching the area of greenstones which outcrop in the vicinity of Spirit (Fairy) [North Spirit] lake, some 40 or 50 miles southeast of Setting Net lake.

Discoveries of gold and silver-lead-zinc in the Favourable Lake area in 1927 and 1928 led to an influx of prospectors into the region, some of whom were led to North Spirit lake by Indians, who reported mineralization in greenstones on the south shore of the lake. Among the prospectors visiting North Spirit lake in 1928 was A. F. Hewitt, discoverer of the Argosy gold mine, who was shown mineralized occurrences in the South bay section of the lake by James Linklater, one of the North Spirit Lake Indians. Specimens taken out at that time did not yield encouraging assays, but, in 1936, after obtaining financial backing through the Derby Gold Syndicate (now Spirit Lake Gold Mines, Limited), Mr. Hewitt returned and investigated some arsenopyrite occurrences, one of which turned out to be richly gold-bearing.

Inhabitants

The only permanent white resident in the area is a trapper, Ole Mattson, who lives on MacDowell lake, near the entrance to Annas lake.

The North Spirit Lake band of Indians, comprising 6 or 7 families, numbers about 50 persons. These, together with an additional 40 Indians from Duckling (Duck) lake and Whiteloon lake, constitute the permanent population of the area. The North Spirit Lake band is part of the Deer Lake or Sandy Lake tribe of Saulteaux Indians, descendants of Ojibway stock.

In 1936 the Hudson's Bay Company established a winter outpost from the Deer Lake post, near the west end of North Spirit lake on the south shore. The

[1] M. E. Hurst, op. cit.
[2] See pages 1 to 43 of this volume.
[3] M. E. Hurst, op. cit., p. 53.

post is open only during the trapping season, from late September until June, the supplies being brought in by the Indians themselves from Deer lake.

Natural Resources

Soil and Climate

There is little soil within the area that could be made immediately available for agricultural purposes. Much of the rock surface is covered by a thin mantle of boulder clay, and the numerous rock outcrops and abundance of boulders would soon discourage any attempts at cultivation. In the southern part of the area, between Hewitt and MacDowell lakes, the soil becomes sandier and the proportion of boulders increases, partly owing to boulder moraines. Parts of the low muskeg areas could, however, be drained and might be suitable for limited agricultural purposes.

In 1937 there were no frosts between June 7 and August 9, and the weather during that time was, for the most part, warm throughout the night as well as the day. In 1936 North Spirit lake became ice-bound between October 31 and November 4, the ice remaining until May 17, 1937. On June 6 the temperature of the lake was recorded as 48° F. and gradually rose to about 60° F. early in August.

Weather records from January to September, 1937, show that the winds are predominantly from the west and are accompanied by high barometric pressures and clear weather. East winds of more than 24 hours' duration are accompanied by lower barometric pressures and usually indicate approaching rains. The lowest recorded pressures accompanied thunder showers from the southwest. The minimum pressure recorded was 28.26 inches; the maximum 29.36 inches (aneroid readings). Changes of half an inch within 24-hour periods were not infrequent.

Precipitation in the summer of 1937 was moderate and was distributed in the early part of June, the latter part of August and September. There was almost no rainfall from the latter part of June until the end of July, although electrical storms were numerous. The winters are reported to be cold and severe.

In summary, the climate is vigorous and cyclonic with rapid changes in temperature, barometric pressure, and wind direction within short periods. The soil is poor; the growing season is short and only suited to the more hardy types of plants.

Fur-bearing Animals, Fish, and Game

Fur-bearing animals are moderately plentiful, although by no means abundant, throughout the region. Fox is the most common catch of the Indian trappers; about three-quarters of these are red fox and the remainder black and silver. Fisher and weasel are also taken, but there are few mink and no martin. Muskrat are scarce. Beaver are almost unknown in the area, although fresh cuttings were observed in one locality.

All the waters in the area abound in pickerel and northern pike, which may easily be caught with a hook and line. Lake trout are found in Nemakwis lake, which is clear in contrast to other waters, most of which are tinted a deep brown, although not turbid. In North Spirit lake and the larger waters the Indians net whitefish and the common sucker. No sturgeon are reported in the area.

Moose and bear are the only large animals in the region. A few black bear roam in the open burns extending from Hewitt to MacDowell lake and in the burns west of Tallrice lake. Moose, although not plentiful, may be found between North Spirit and Hewitt lakes and east of North Spirit lake. There are no deer nor woodland caribou within the area. Rabbits are plentiful and are snared by the Indians during the summer. Spruce hen and ruffed grouse are abundant. Some of the grassy bays offer breeding places for a few wild ducks.

Forests and Timber

With a few exceptions, only the low-lying muskeg and spruce swamp areas within the area have escaped the ravages of forest fires. Most of the sections east, north, and west of North Spirit lake, the region about Margot lake, and the area extending from Hewitt to MacDowell lakes have been burned in recent years. In 1937 there were a number of forest fires in the region, of which the most serious burned a section west of South bay in North Spirit lake. The area lies far to the north of the districts patrolled by the Ontario Forestry Branch. It is thought that lightning is the chief cause of forest fires in the area since, after the passing of electrical storms, smoke could often be seen rising from new centres.

In most of the older burned sections there is a vigorous new growth of small jackpine and poplar, and in the extensive muskeg areas stunted black spruce and small tamarac grow abundantly, but the maximum diameter of these is 8 inches. Along the banks of the larger streams, on some of the islands of North Spirit lake, and on parts of the lake shore, there are a few stands of large white spruce and large poplar suitable for mining purposes.

In summary, spruce and jackpine are the most abundant conifers, the latter growing extensively on the sandy and rocky areas. Balsam and tamarac are subordinate, and there are no red pine, white pine, or cedar within the area. Birch and poplar are the most common deciduous trees, the latter being the most abundant. Balm of Gilead grow on some of the stream banks. Raspberry and blueberry bushes are common in the burned areas, but the fruit does not mature until the middle of August. Tag alder grows abundantly in the low areas and about the shores of the waterways. Labrador tea is the most profuse of the lower bushes. Fifty-five species of flora were identified during the summer by H. S. Armstrong.

Water Powers

The only practicable source of hydro-electric power within the area lies west of the outlet of North Spirit lake. The lake spills over a short 3-foot fall at the extreme west end, the water falling a further 13 feet over a 10-chain rapids half a mile to the west. Three miles farther west there is a waterfall having a straight 8-foot drop, and a short distance west there is another 7-foot fall over a 10-chain rapids. Thus within a distance of 4 to 5 miles there is a total drop of some 30 feet. Between this point and Rat House bay of Sandy lake there is a further drop in the river, estimated at 120 feet. If the plans of Berens River Mines to build a dam on the Flanagan river south of Rat House bay are completed, additional storage dams will be required north of the outlet of Whiteloon lake and between Margot and North Spirit lakes. In this way the level of North Spirit lake will not be altered.

In the year 1936–1937 the maximum natural difference in the water level of North Spirit lake was 6 feet 3 inches. Low water was recorded about the middle of April and high water on May 15, before the ice had broken. The only important flow of water into North Spirit lake comes from the Flanagan (Disbrowe) river, which drains Margot lake. Early in August, when the water level of North Spirit lake was only 1½ feet higher than the April low, there was a flow of water 4 feet deep and 75 feet wide over the 8-foot falls four miles west of the lake. Sufficient power might be developed here for a small-scale mining operation.

Drainage

Although North Spirit lake is beyond the southern limit of the Hudson Bay lowlands, it lies in part of the great peneplaned area that extends for hundreds of miles north of the height-of-land to the waters of Hudson bay. The average elevation of the area is estimated to be 1,150 feet above sea-level, and the elevation of North Spirit lake about 1,080 feet. Owing to seasonal changes in water level the character of the shore contours of North Spirit lake varies somewhat, and late in the summer the low water level exposes many reefs in different parts of the lake.

The area is one of the headwater tributary systems of the Severn river, which flows northeast into Hudson bay. The extreme southern part is drained by MacDowell lake, the waters of which are discharged into the Severn river by an

Eight-foot falls on the Flanagan (Spirit) river, 4 miles west of the outlet of North Spirit lake.

eastern route. The Flanagan river, which empties into Sandy lake, drains the remainder of the area. It rises southwest of Margot lake, draining a large section of the country to the south and west and discharging its waters into the south side of Margot lake. It drains north from Margot lake to North Spirit lake, from the west end of which it flows northwest into Tallrice lake, and then swings north into Whiteloon lake. From this lake it cascades over a series of rapids and falls, and continues through North Wind lake and into Rat House bay of Sandy lake.

Topography

Although the region is one of gentle relief, the low, rolling character of the land surface is obscured for the most part by a dense forest growth. Only in the open burns and on the broader lakes is the relief evident. Low hills and ridges in general do not rise more than 100 feet above the mean elevation, and they are characterized by an accordance of summits. The eastern part of the area and the section northwest of Tallrice lake show the greatest relief. The highest hills occur at the east end of North Spirit lake, in the vicinity of Nemakwis lake and in the region about Atikamik lake; but even here the maximum relief does not exceed 175 feet. Bed-rock relief, which is much sharper than that of the general topography, is modified by the occupation of the deeper valleys with lakes and glacial debris.

In general, the area is one of low rock ridges interspersed with muskeg and spruce swamp, the most extensive muskeg area lying between South bay and Hewitt lake, but for the most part muskegs occur in the narrow depressions between low ridges.

The present topographical features are the combined effect of pre-glacial erosion and glaciation. The regional trend of bedding and foliation planes in the sedimentary-volcanic belt is northwest-southeast, whereas the direction of ice movement was from northeast to southwest, crossing the structure at right angles. The shore contours of many of the lakes are definitely related to geological structures, particularly those that might induce lines of weakness in the rocks. The low, steep cliffs of foliated rocks that occur on the shores of some of the lakes owe their topographic expression to the rock structure; whereas the smooth flat outcrops that rise gently from the water about the shores are the product of glacial smoothing. Thus the shores of portions of North Spirit, Little Hewitt, Wapisipi, Makataiamik, and Atikamik lakes are controlled by lines of weakness due to shearing and foliation within the rocks. The elbow shape of Hewitt lake is the result of a local change in the strike of foliation, with which each arm of the lake is parallel. The shore contours of the eastern part of Margot lake, Nipa lake, and the northern section of MacDowell lake coincide with concordant granite-sedimentary contacts.

The fine stream patterns of the small creeks that drain the muskeg sections of the area are consequent on the glacial mantle over which they meander, and have no relation to rock structure. The larger streams, such as the Flanagan river, have built stratified clay deposits immediately adjacent to their banks and any relation to geological structure is obscured.

The topographic prominences of "W" island, "X" island, and Bijou point owe their existence to the massive stock of diorite that outcrops in the South bay section. The present configuration of the islands and point are due in part to the major directions of jointing within the stock (see Fig. 2 on page 63).

The lake depressions and stream courses that lie in the relatively structureless granite encircling the sedimentary-volcanic belt tend, on the other hand, to coincide with the direction of glacial movement, producing a northeast-southwest elongation to many of the waterways. The lake basins owe their origin to glacial excavation.

It is concluded that the topographic expression within the sedimentary-volcanic belt resulting from glaciation is subordinate to that dependent on structure, although the structure may have locally controlled the direction of ice movement to some extent. This implies the existence of a pre-glacial topography that has been modified, but not eradicated, by glacial action.

GENERAL GEOLOGY

All the consolidated rocks of the North Spirit Lake area, with the possible exception of a few post-granite diabase dikes, are early pre-Cambrian (Archean) in age. The formations consist of closely folded volcanics and sedimentary strata distinguished respectively by prominent iron formation and conglomerate formation. Accompanying and following the deformation of these rocks there were injected extensive granite bodies of batholithic dimensions, so that the North Spirit lake volcanic and sedimentary rocks now occur as a deeply intrenched linear belt in the extensive granite and granite gneiss that underlies the greater part of Northwestern Ontario.

The name "Keewatin type" has been given to the volcanic and iron formations, and "Timiskaming type" to the conglomerate and other sedimentary formations. This is not meant to imply any correlation with other formations called Keewatin and Timiskaming, but merely that in lithological character and structural relations, the formations herein described resemble those called respectively Keewatin and Timiskaming in other parts of the province. The Keewatin and Timiskaming types are not separated by a marked unconformity.

Table of Geological Formations

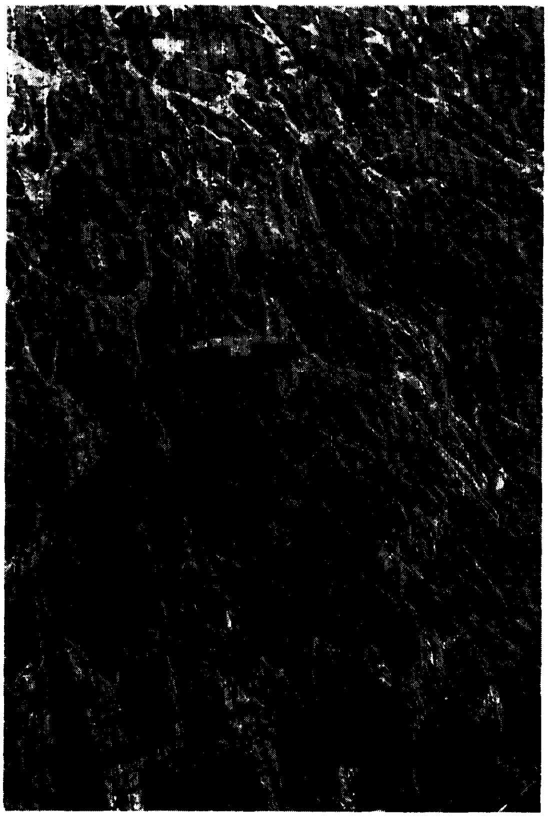
QUATERNARY	
RECENT:	Stratified river clay; peat.
PLEISTOCENE:	Boulder clay, sand, and gravel (till); boulder moraines.
	Great unconformity
PRE-CAMBRIAN	
POST-TIMISKAMING(?) INTRUSIVES:	Diabase dikes. *Intrusive contact* Rhyolite porphyry dikes; felsite dikes; feldspar porphyry dikes. Pegmatite dikes. Massive pink to grey granite and monzonite, locally syenitic and porphyritic; granodiorite gneiss. Diorite; andesite porphyry.
	Intrusive contact
TIMISKAMING TYPE:	Sedimentary Formation: Interbedded greywacké, slate, and arkose, locally altered to amphibolite, phyllite, mica schist, and sericite schist; slaty iron formation; quartzite; chert; conglomerate; crystalline limestone, hornfels; garnetiferous and andalusite schists and gneisses; minor volcanics. Chert pebble conglomerate; grey granite pebble and cobble conglomerate.
KEEWATIN TYPE:	Iron formation. Volcanic Formation: Massive to schistose greenstone; chlorite schist; pillow lava; amygdaloidal lava, flow breccia, and amphibolite, representing former basaltic to andesitic effusives; trachyte and meso-type effusives; rhyolite and rhyolite flow breccia; minor sediments and iron formation.

Keewatin Type

Volcanic Formation

There are three principal areas of volcanic rocks in the region, in addition to some minor flows intercalated with the sedimentary members. The lithologic types are chiefly represented by fine-grained, dark-green, massive to schistose rocks termed greenstones. They are extensively altered to chlorite schists and contain narrow zones of rusty-weathering carbonates. In the vicinity of granite contacts they have been amphibolitized. The steep folding of the volcanic rocks was accompanied by considerable drag-folding, and the flows are so sheared that original structures, for the most part, have been obliterated. Some pillow structures and amygdaloidal horizons in these rocks were, however, observed in a few places.

Eastern Belt.—The most extensive area of volcanic rocks borders the sediments on the north and east. At the east end of North Spirit lake the volcanics have been exposed over a width of some 4 miles, but the true thickness of the formation here has been greatly exaggerated by folding. Extending south the belt narrows and becomes discontinuous, and is generally less than half a mile in width. The original width of the belt is not known, as it is bordered along its east side by intrusive granite. The flows comprising this belt represent the oldest rocks in the area.

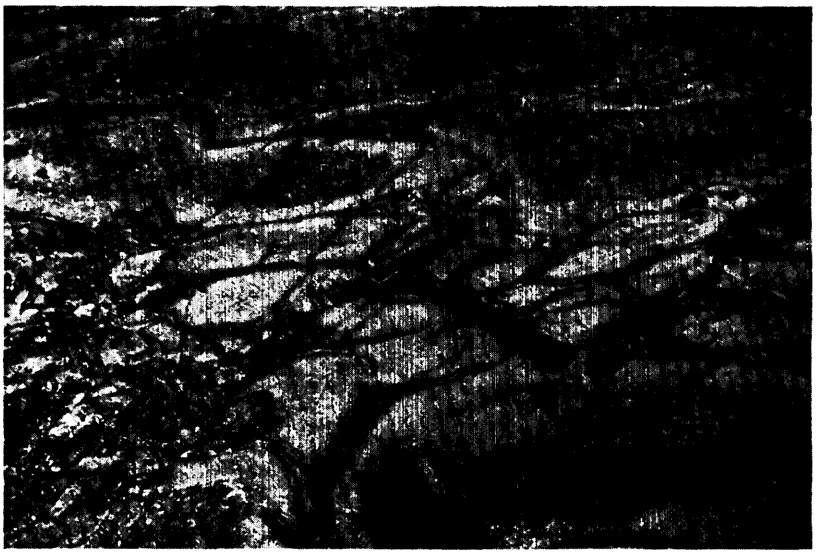


Pillow lava in which pillows are sheathed in felsite from solutions derived from the intrusion of an adjacent dike. Note the glacial striae crossing the picture from right to left.

Most of the islands lying to the north and northeast of Prospair point in North Spirit lake are underlain by pillow lava. The bun-shaped pillows are somewhat elongated, the long dimension of the pillow ranging from 2 to 4 feet, whereas the distance from bottom to top of the pillow does not, in general, exceed 12 inches. Associated with the pillows are narrow bands of stretched amygdaloids, some 4 inches wide. On one of the small islands off Prospair point the pillow lavas are cut by a rhyolite porphyry dike, from which solutions have sheathed the adjacent pillows with light-coloured, fine-grained felsite borders. Microscopic examination of material from the central part of the dike, which is at least 30 feet wide, shows it to consist of sparse phenocrysts of altered albite and clear "bird's eyes" of quartz set in an aphanitic matrix. A sample from the contact of the dike compared with the material sheathing the pillows shows that they are identical, consisting of a very fine grained mosaic of quartz and feldspar.

In the central part of the flows, as seen on some of the islands, pillows are not developed and the rock is coarser-grained, resembling a fine-grained gabbro or dolerite. The pillowed horizons are altered to soft chlorite schists.

South of Makataiamik lake the volcanics have suffered much less deformation than in the vicinity of North Spirit lake and, at their western extremity, occur intercalated with conglomerate beds. Across the east of the conglomerate, pillows were observed in one flow over a width of 400 feet. At the west end of the flow, near the conglomerate contact, the pillows are small and well-defined, the dimensions being about 7 by 10 inches; to the east, they become less distinct

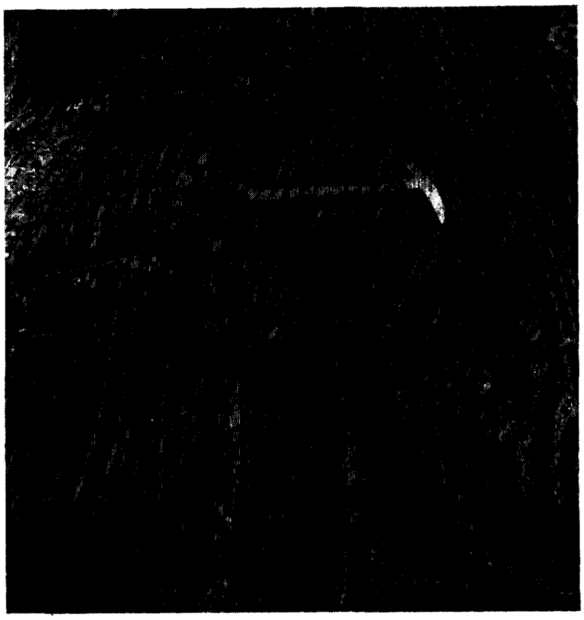


Weathered amygdaloidal pillow lava south of Tahoe lake.

and larger, about 2 by 1 feet. The top of the flow faces west. Farther east, near the contact of the volcanics with granite, the former are altered to amphibolite and amphibolite schists.

Central Belt.—A second belt of volcanic rocks extends south of the diorite stock in North Spirit lake, outcrops in the vicinity of the northeast arm of Hewitt lake, and attains its best development south of Tahoe lake. North of Hewitt lake the rocks comprising this belt consist mostly of chlorite schists, some flow breccias, and mesotype effusives. Near Hewitt lake the volcanics have been so severely deformed and metamorphosed that original structures are entirely obliterated, and the origin of the rocks is obscure. South of Tahoe lake there are extensive outcrops of volcanics showing well-preserved structures. Most of the rocks here are made up of amygdaloidal pillow lavas, in which the larger pillows are characterized by a concentration of amygdules in a zone near the periphery, whereas the amygdules in the smaller pillows occupy the centre. Intercalated with the flows of pillow lava are narrow andesitic flow breccias characterized by rounded to angular fragments.

Thin sections of the rock comprising the pillow lava show that it is made up essentially of chlorite and calcite with some epidote and residuals of plagioclase feldspar. This rock is interpreted as being a former basalt. Associated with the basic flows are some narrow rhyolite flows, which are characteristically brecciated, and some trachytes showing poorly developed pillow structure. The rhyolite flows, commonly less than 50 feet in thickness, are characterized by abundant subangular rhyolite fragments up to 18 inches in diameter set in a sheared rhyolitic matrix, which contains some chlorite and epidote.



Iron formation outcropping on an island northeast of Prospair point; pseudo cross-bedding is produced by slipping along bedding-planes during folding. The light layers are silica; the dark ones, magnetite. The small spots are raindrops.

Western Belt.—The third volcanic belt, which is the smallest in extent, outcrops in the vicinity of Little Hewitt lake and extends discontinuously southeast adjacent to the western granite boundary of the area. Owing to the extensive amphibolitization of both sediments and volcanics south of Hewitt creek, it is difficult to distinguish between them. The volcanics at Little Hewitt lake consist of chlorite and biotite schists associated with small amounts of trachyte and rhyolite. Some of the chlorite schists on the north shore of the lake show a poorly developed pillow structure.

Sedimentary Iron Formation

A number of belts and lenticular-shaped bodies of magnetic iron formation occur within and adjacent to the volcanic rocks in many parts of the area. Characteristically the iron formation occupies a position between the volcanics and the clastic sediments. It is younger in age than most of the volcanic formations but is older than the conglomerate and sedimentary formations and is distinct from the slaty iron formation or ferruginous slates that comprise minor members of the sediments.

The most extensive belt of iron formation occurs in the vicinity of South bay, passes through North Spirit lake east of Prospair point, south through Wapisipi lake, and outcrops discontinuously to the south adjacent to the volcanics along the eastern margin of the sedimentary belt. Between North Spirit lake and Wapisipi lake it attains a width of more than 2,600 feet, but the true thickness is

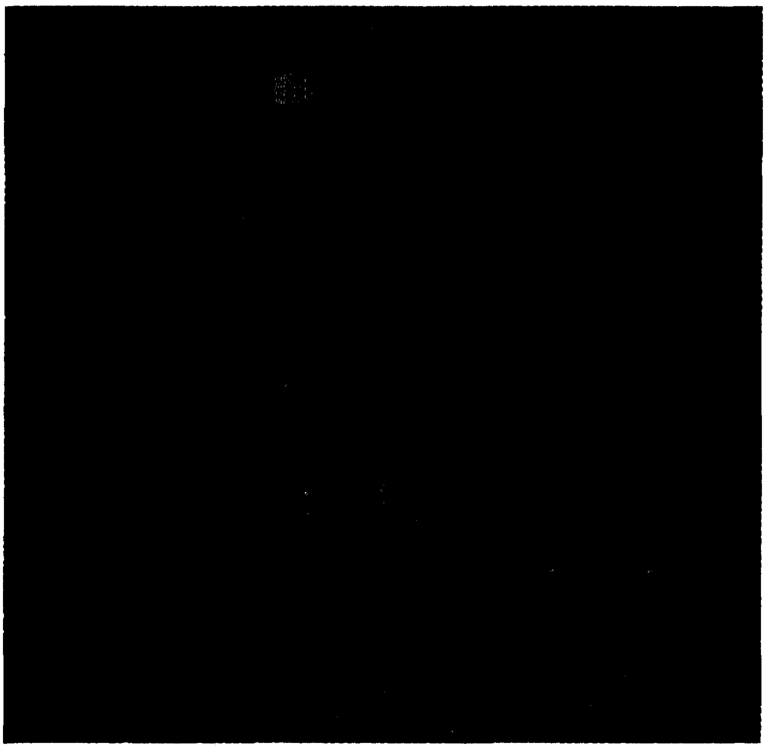
Hand specimen showing drag fold in iron formation. The horizontal surface is on a plane with the page; the fold axis is vertical. The coin is a one-cent piece.

considerably less as much drag-folding has taken place. This body is so strongly magnetic that compass readings are unreliable within a radius of some 5 miles from Prospair point.

The iron formation consists essentially of interlayered chert and magnetite, the layers ranging in thickness from less than an eighth of an inch to 3 inches and averaging about a third of an inch. The chert varies from light to dark in colour and is characterized by very fine, parallel bedding lines. Locally, both magnetite and chert layers contain slaty material.

The beds have been subjected to much drag-folding, both internally and together with other formations, so that they tend to occur as S-shaped and reverse S-shaped lenses. The linear discontinuity of the iron formation beds may be due to either deposition in limited sedimentary basins or separation into lenses by drag-folding. Probably both these factors play a part in producing the present character of the beds. Near Hewitt lake there are extensive outcrops of interbedded dark and light chert, similar to that which occurs in the iron formation, but containing little or no iron.

At the northeast end of North Spirit lake there are outcrops of beds, about 200 feet in width, of highly magnetic iron formation, which consist of alternate layers of magnetite and chert up to 2 inches in thickness. The estimated magnetite content of these beds approximates 40 per cent.



Conglomerate on one of the north-central islands of North Spirit lake. The longer axes of the pebbles plunge 40 to 60 degrees from the horizontal in an easterly direction (towards the bottom of the photograph).

Iron formation similar to that described as occurring in the vicinity of Prospair point is found within or adjacent to volcanic rocks in many other parts of the area. Microscopic examination of the chert layers show them to consist of mosaics of very fine grained quartz; whereas polished sections of the magnetite layers show from 30 to 90 per cent. magnetite distributed in non-opaque material.

Timiskaming Type

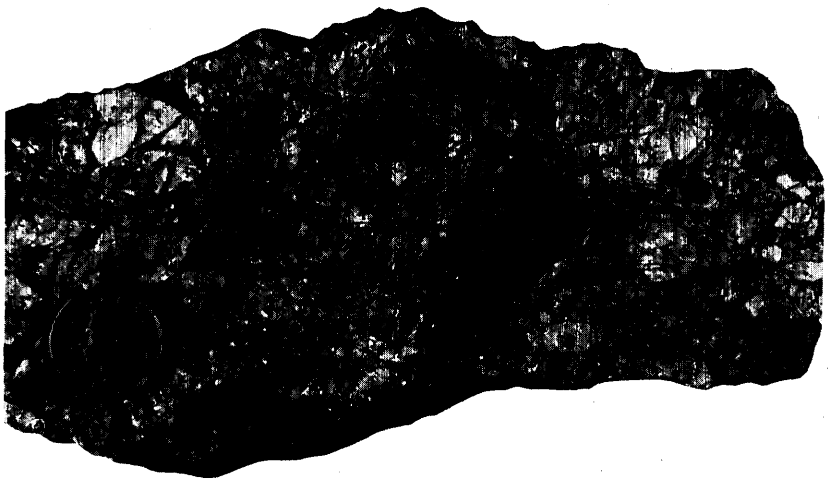
Conglomerate Formation

Extensive beds of conglomerate, variable in character but persistent in length, occur along the northeast margin of the sedimentary rocks adjacent to the volcanic and iron formations. The conglomerate formation attains its greatest thickness in the north-central islands of North Spirit lake, in the vicinity of Prospair point, and south of Makataiamik lake. At the last locality the formation is approximately 7,000 feet wide. It consists of pebble and cobble horizons from 4 to 200 feet thick in an arkosic or quartzitic matrix. No individual beds of conglomerate having a true width of more than 200 to 300 feet were observed. The average width of the pebble beds is about 30 feet. Since the

Stretched chert pebble from conglomerate formation on Prospair point. The pebble is 5½ inches long.

folding is not complicated south of Makataiamik lake, the true thickness of the formation at this point is probably close to 7,000 feet.

North-Central Islands of North Spirit Lake.—The conglomerates that outcrop in this locality consist, for the most part, of sparse pebbles of chert and grey granite in a sericite schist matrix. Where the conglomerates are less deformed the matrix proves to be a brown, sandy arkose.



Hand specimen showing the horizontal surface of a closely packed chert pebble conglomerate from Prospair point. The coin is a one-cent piece.

The beds have been foliated, the direction of shearing being east and west, and the pebbles are moderately elongated, the average plunge of the longest axes being 40° E. The mean axes are parallel to the planes of foliation, and the short axes normal to the direction of shear. The arkosic matrix contains rounded grains of quartz up to a quarter of an inch in diameter, and under the microscope these are shown to be drawn out into fractured quartz lenses surrounded by sericite.

Prospair Point.—In the vicinity of Prospair point the conglomerate beds have been severely deformed and drag-folded together with rusty-weathering greywacké and ferruginous slate. The beds consist essentially of well-sorted and well-sized, closely packed chert pebbles. The ratio of stretching is estimated as being from 3 to 1 to 6 to 1. There are, in addition, greenstone pebbles that have been almost obliterated by stretching, as well as pebbles and cobbles of grey quartz monzonite, which are comparatively undeformed. Under the microscope the quartz monzonite pebbles are seen to consist of equal amounts of oligoclase and potash feldspar, about 30 per cent. quartz, and almost no ferromagnesian constituents.

In this locality the longest axes of the pebbles are oriented either vertically or with steep plunges to the southeast or northwest. The pebbles are characteristically stretched into shapes of carrots and beets. Those composed of chert are identical in character to the material comprising the chert layers in the iron formation and are thought to have been derived from its erosion.

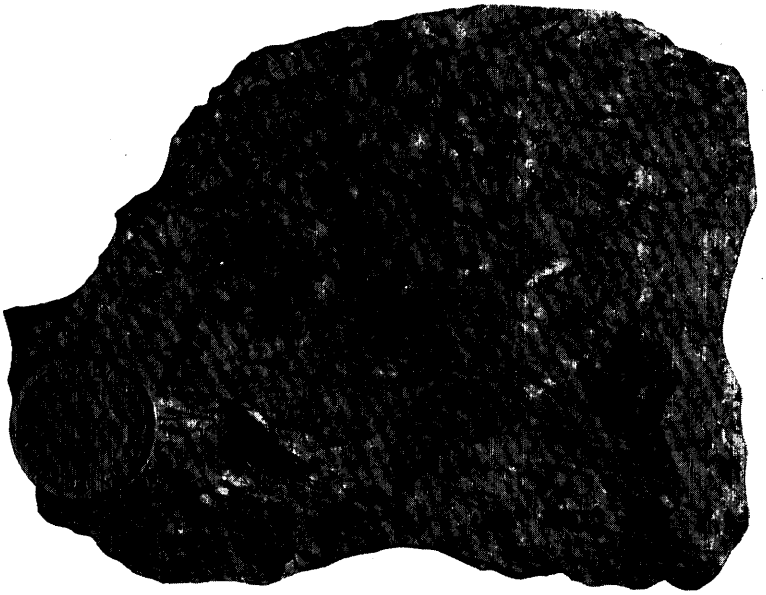
Side view of the specimen shown in the bottom photograph on page 57, oriented with respect to its position in the field and showing the vertical elongation of the pebbles.

South of Makataiamik Lake.—The conglomerate formation attains a remarkable development in this locality where, as previously mentioned, there is a section up to 7,000 feet or more in width consisting of pebble and cobble horizons from 4 to 100 feet wide, averaging 20 to 30 feet in width and spaced 20 to 30 feet apart. Most of the horizons consist of massive, well-rounded quartz and chert pebbles up to 3 inches in diameter, 3- to 10-inch granite cobbles, and a few granite boulders up to 30 inches. The pebbles are enclosed in a well-bedded quartzite matrix, which varies from material so fine-grained that it is chert-like to coarse, angular quartzite, the particles of which are as much as half an inch in diameter. The bedded sediments between the pebble horizons consist of graded quartzite similar to that which constitutes the matrix of the conglomerates.

Near the east margin of the conglomerate formation narrow basic flows occur interbedded with the pebble horizons, and the proportion of greenstone and iron formation pebbles in the conglomerate beds is notably greater. At the east limit of the conglomerate formation, adjacent to the volcanics, the beds consist entirely of greenstone pebbles lithologically similar to the adjacent pillow lava. The conglomerate formation is younger than both the iron formation and the eastern belt of volcanics. South of Makataiamik lake the volcanics have suffered less deformation than elsewhere, and the beds have not been subjected to drag-folding.

Sedimentary Formation

The major part of the area is underlain by a series of steeply folded, drag-folded, foliated and otherwise metamorphosed fine-grained sediments made up, for the most part, of impure greywacké and slate. In general, the rocks are well bedded, but this feature has been obscured in many parts of the area by the deformation that accompanied folding. In addition to slate and greywacké there are smaller amounts of arkose, quartzite, and crystalline limestone, as well as metamorphic equivalents of these and mixtures of these rock types.



Hand specimen of garnetiferous phyllite from the west end of North Spirit lake. The coin is a one-cent piece.

Arenaceous Sediments.—Except for the quartzite that makes up the matrix of the southern part of the conglomerate formation, only a few of the greywacké beds that are relatively free from ferromagnesian and argillaceous impurities might be termed quartzites.

The arkose, which grades into greywacké on the one hand and quartzite on the other, has already been described as making up the matrix of the northern part of the conglomerate formation. In the north-central islands of North Spirit lake the conglomerate formation passes towards the south into an arkose facies. The feldspar grains have been smeared out during folding and are largely converted to sericite, so that these rocks are now essentially sericite schists.

The dominant sandy sedimentary type that underlies a large section of the area extending south of North Spirit lake to Hewitt lake is greywacké. The rock occurs in beds from an eighth of an inch to 2 feet thick, but averages less than 6 inches. The beds consist essentially of quartz with minor amounts of feldspar and biotite, the latter oriented parallel to the planes of foliation. There is generally some argillaceous material present.

The effect of folding on the quartzites, arkoses, and greywackés is seen by the cataclastic deformation of the larger grains of quartz, which are drawn out into broken lenticles, and by the conversion of the feldspars to sericite. Where deformation has been more severe there has been a general recrystallization and reorganization of the rock constituents, and near granite contacts the arenaceous sediments have, in some instances, been amphibolitized.

Argillaceous Sediments.—On the south shore of North Spirit lake and in the bottom of South bay there are considerable areas underlain by drag-folded sericite slates, in which the slaty cleavage is generally divergent from the direction of bedding. Since the slates have proved most susceptible to metamorphism they are represented in most other parts of the area by phyllites and mica schists.

Interbedded greywacké and argillaceous material typical of the fine-grained bedded sediments of the North Spirit Lake area.

The narrow sedimentary belt extending northwest of North Spirit lake and through Tallrice lake is underlain principally by phyllites. They have the appearance of very fine grained micaceous rocks, which resemble slaty schists and, in the vicinity of intrusive granites, contain small garnets that give the rock a spotted appearance.

In the vicinity of Margot lake and in the area between Margot and North Spirit lakes the slates and phyllites have been altered to fine-grained mica schists and coarse-grained garnetiferous biotite gneisses by intrusive granites. Under the microscope these rocks are shown to be composed principally of biotite and quartz. The argillaceous sediments at granite contacts near Margot lake and Atikamik lake are characterized in some localities by large crystals of andalusite, cordierite, sillimanite, and chiastolite in a finer-grained matrix. In some cases bedding is still preserved.

Crystalline Limestone.—Since crystalline limestone of sedimentary origin is not common in the Archean rocks of northwestern Ontario, its presence here is a matter of interest. In the region about Hewitt lake there is a marked change in the character of the sedimentary rocks, the shores about the northwest arm and south end of the lake being underlain by crystalline limestone interbedded with impure calcareous material. On the northeast arm of the lake limestone occurs thinly interbedded with layers of amphibolite. Other dark, fine-grained interbedded material is seen under the microscope to consist of hornblende and epidote with smaller amounts of secondary andesine, clino-pyroxene, zoisite, and titanite. Some dense, finely laminated, chert-like rocks associated with the limestone are interpreted as hornfels.

Stucture of the North Spirit Lake Series

The regional trend of the sedimentary-volcanic belt is northwest-southeast, and this is the prevalent direction of foliation as well as bedding within the sedimentary members. In the central part of North Spirit lake the direction of bedding swings sharply from an easterly to a southeasterly strike, and it is at this point that there is a marked divergence between the direction of foliation and bedding. The dip of the planes of bedding and schistosity is close to vertical, although there is a general tendency towards steep southerly dips throughout the region. Along the strike there is an easterly plunge to the structure, which varies in amount from place to place and is marked in the vicinity of Prospair point by vertical fold axes.

The structure in the northern and eastern part of the area is that of the north limb of a steeply southeastward-plunging syncline. Two determinations made from bottom accommodation of the pillows in the eastern belt of volcanics indicate that the tops of the flows face southwest; thus most of the sedimentary iron formation in this belt, which lies to the southwest of the volcanics, is presumed to be younger.

The conglomerate formation contains pebbles of both the volcanic and iron formation that lie to the east of it and is doubtless younger. In common with many other ancient pre-Cambrian sediments the conglomerate contains pebbles of an older granite or quartz monzonite, which has not been found in place. The chert pebbles, which occur abundantly in the conglomerate, are thought to have been derived from the chert layers in the iron formation. The greywacké on Prospair point contains an appreciable content of iron as seen by the presence of rusty-weathering carbonates, and the slate at the same locality is of a ferruginous variety. The iron in both instances may have been derived from the iron formation.

The matrix of the conglomerate north of Opwagan lake is essentially an arkose, while to the south it is made up principally of quartzite. At two localities a regular imbrication of the pebbles in southeastward-striking beds of conglomerate was observed, in which the pebbles shingled over each other towards the south. It is thought the source of the sediments lies to the north of North Spirit lake.

The contact of the conglomerate with the volcanics south of Makataiamik lake is characterized by a zone in which basic flows occur intercalated with pebble horizons, the strike of the flows coinciding with that of the conglomerate beds. Since there is no complicated folding in this locality, it is evident there is no angular unconformity between the volcanics and conglomerate; thus the passage of the Keewatin-type into the Timiskaming-type rocks represents a gradual change from vulcanism to sedimentation. Since no iron formation was found to occur between the volcanics and sediments at this locality, it is presumed to have been deposited in local basins. Furthermore, the close association of volcanic flows with sedimentary iron formation, as well as the intercalation of flows with conglomerate, suggests that the flows may have had a subaqueous origin in shallow bodies of water.

A study of the graded beds within the sediments that pass through North Spirit lake showed the tops of the beds facing south-southwest in 11 out of 13 instances, the two exceptions being reversed arms of drag folds. This was supported by two additional determinations made from cross-bedding. Unfortunately no suitable beds for similar determinations were found in other parts of the area.

Thus far the geological series shows an orderly succession from northeast to southwest across the eastern belt of volcanics, iron formation, conglomerate formation, and part of the sediments; but whether the ubiquitous greenstones and associated iron formations that comprise the central and western volcanic belts are repetitions of the eastern belt produced by folding, or whether they are the result of later periods of volcanic activity, is not known. A single determination of bottom accommodation of the pillows in the central belt would indicate that the tops of the flows face east, but on the other hand there is no repetition of the conglomerate formation in other parts of the area.

One of the structural features of the area is the change in regional pitch of the fold axis along the sedimentary-volcanic belt. From the west end of North Spirit lake to Prospair point the southeasterly plunge of the structure steepens from 30 degrees until, at the latter locality, it is vertical and even reversed. Continuing south towards Atikamik lake the plunge gradually flattens out again to about 30 degrees or less. Determinations of pitch were made from the direction of elongation of the stretched pebbles in the conglomerates, inclination of stretched pillows, orientation of tabular minerals, and plunge of the axes of minor drag folds.

Even though there is a local divergence between the directions of bedding and schistosity, the general coincidence of these features throughout the area is thought to be due to slipping along bedding planes during folding.

Post-Timiskaming(?) Intrusives

There are two distinct types of granitic rocks in the North Spirit Lake area, one apparently intrusive into the other, but both probably belonging to the same general period of granitic invasion. The existence of a still older granite is evident from the large number of quartz monzonite cobbles in the conglomerate formation, although this older granite has not yet been identified in place.

Granodiorite Gneiss

The older granitic type is best developed near the west end of North Spirit lake and in the vicinity of Margot lake, where it encircles the sediments. The rock is a grey, gneissic quartz monzonite or granodiorite in which the amount of oligoclase equals or exceeds the amount of potash feldspar. The dominant ferromagnesian mineral is biotite. The rock is fresh-appearing under the microscope, although there has been some albitization of the potash feldspars. The principal feature of this granitic type is that it is found only bordering the sediments and, characteristically, the gneissic structure is concordant with the bedding or foliation within the sediments; in some instances it occurs as *lit par lit* injections within the sediments. In contrast with the younger granite this type has not produced any appreciable contact metamorphic effect on the sediments, nor does it appear to have any related dikes or pegmatites.

Diorite

One of the largest intrusive bodies occurring within the sedimentary-volcanic belt is the diorite stock that outcrops in the South bay section. It was in this body, which is approximately 1½ miles in diameter, that the original gold-bearing arsenopyrite discovery was made. The stock is intrusive into a series of folded, interbedded sediments and volcanics, in which it has produced a narrow aureole of amphibolites and mica schists by contact metamorphism. The diorite weathers

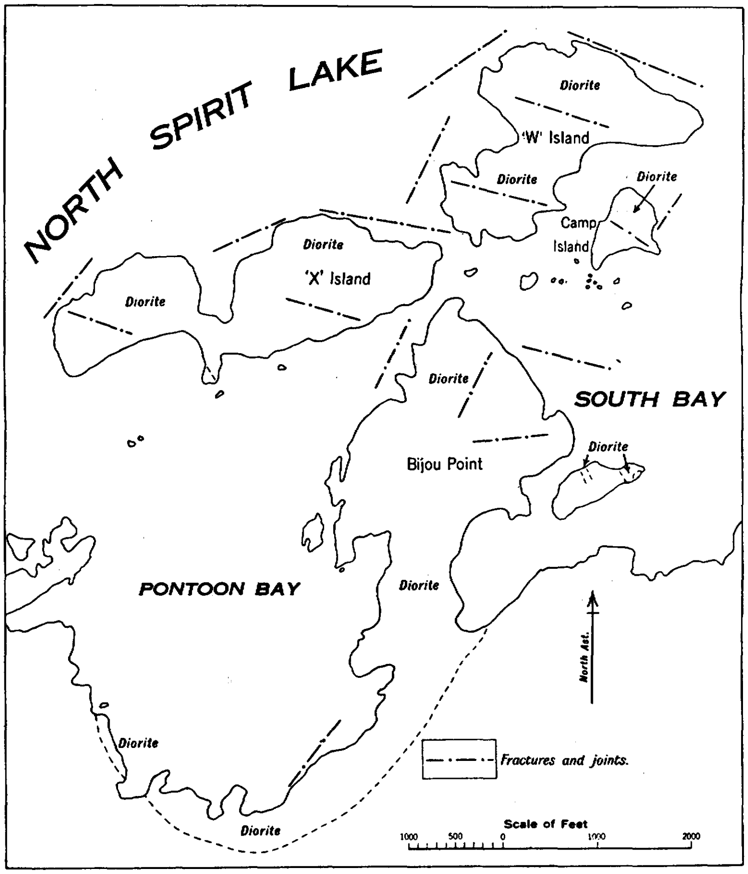


Fig. 2—Diagram showing the principal directions of fracturing and jointing in the diorite stock, south-central part of North Spirit lake.

from buff to grey in colour, is medium-grained and well-jointed, and although it is generally massive it has a local indistinct gneissic structure. It is composed essentially of altered sodic andesine and small amounts of potash feldspar and biotite, most of which has gone over to epidote. Some parts of the stock contain up to 15 per cent. quartz, most of which is secondary.

The stock is intersected by a northwest-southeast master set of joints in a nearly vertical plane and by two minor sets, one striking northeast-southwest with steep dips and the other striking northwest-southeast with flat, southwesterly dips. Narrow shear zones have been localized along some of the joints; neither jointing nor shearing, however, have produced any persistent fractures within the stock. The jointing to some extent controls the shapes of "W" and "X" islands and Bijou point.

Since the diorite is not found in contact with any other intrusives, its age with respect to the granitic rocks is not known. On the basis of comparative deformation it is thought to be older than the massive younger granite and probably older than the granodiorite gneiss. Less than a mile south of the stock two or three small bodies of similar diorite and diorite porphyry occur, and another body of unknown extent was observed between Hewitt and Atikamik lakes.

Granite

The great areas of granite that surround the sedimentary-volcanic belt are, in general, pink, coarse-grained, and massive. This granite tends to cut the older rocks; but where the granite parallels the sediments it may have a narrow gneissic facies. The granite consists of a number of types, characterized by syenitic, porphyritic, and pegmatitic facies, some of which may be of different ages. It has produced extensive contact metamorphism on both the sediments and volcanics and is accompanied by the injection of numerous pegmatite and porphyry dikes.

North of Nemakwis lake the granite is grey, high in ferromagnesian minerals, and low in quartz, whereas southeast of Makataiamik lake it is very coarse grained and porphyritic, with phenocrysts of pink feldspar up to 2 inches in length. For the most part the granite occurs as normal pink and grey types in which the potash feldspar dominates over oligoclase. Biotite is the dominant primary ferromagnesian mineral, although hornblende is present in some granites. In all cases the biotite and hornblende have been extensively altered to epidote, and the plagioclase feldspars in particular have been appreciably saussuritized with the development of sericite, zoisite, albite, and calcite.

Granite Pegmatite Dikes

Within the margins of the massive pink granite and in the adjacent sediments and volcanics, there are numerous pegmatite dikes up to 200 feet in width. They are most abundant north of North Spirit lake, near the tongue of granite that extends east of Margot lake, and in the southern part of the area north of MacDowell lake.

The pegmatites are characteristically pink, flesh-coloured, or grey. The pink pegmatites occur as dikes or, more commonly, as pink pegmatitic facies near granite contacts.

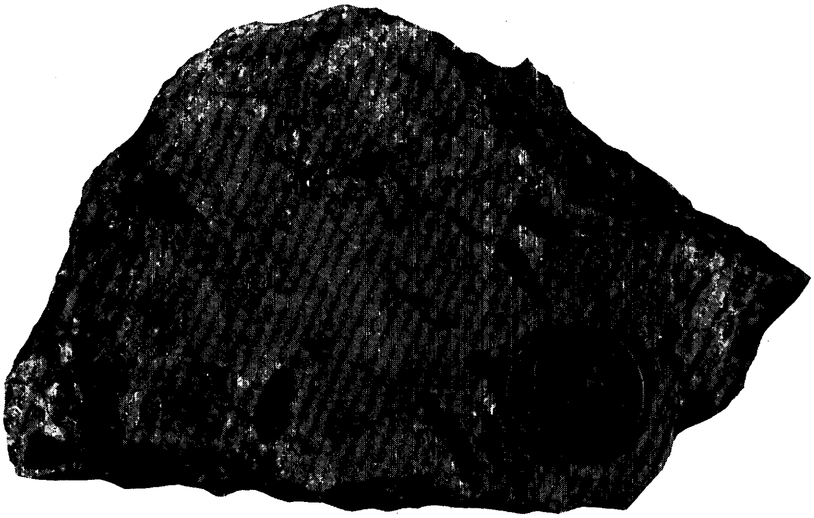
The flesh-coloured pegmatites, such as those that occur at the west end of Atikamik lake, are characterized by graphic intergrowths of microcline, oligoclase, and quartz, as well as muscovite, which occurs in pseudo-hexagonal plates up to 3 inches in diameter. The pink and flesh-coloured pegmatites have not produced a strong metamorphic effect on the intruded rocks.

The grey pegmatites are abundant in the vicinity of Margot lake and are composed of microcline, albite, and quartz; they contain, in addition, biotite, muscovite, pyroxene, tourmaline, and garnet and have produced tourmaline and garnet in the adjacent mica schists. The tourmaline crystals in the dikes are found enclosing microcline and quartz and are thought to have been formed by replacement. Cross-sections of crystals examined under the microscope show a zoned structure. The contact-metamorphic effect of this type of pegmatite is marked.

Rhyolite Porphyry, Felsite, Feldspar Porphyry

About the periphery of the tongue of granite that extends towards Prospair point from the east end of North Spirit lake there are a number of small acidic dikes intrusive into the volcanics, iron formation, and sediments. The centres of the wider dikes, in which the rock is medium-grained, are characterized by sparsely distributed phenocrysts of quartz and residuals of feldspar phenocrysts. These have been termed rhyolite porphyry dikes, and the narrower dikes, which are finer-grained samples of these, have been called felsites. Narrow zones of rusty-weathering carbonates are visible adjacent to joint planes in the dikes, and thin sections show a considerable amount of secondary calcite.

About the shores of Wapisipi lake there is a number of feldspar porphyry dikes in which phenocrysts of oligoclase and andesine occur embedded in an



Hand specimen of grey pegmatite showing black tourmaline crystals developed by replacement. The coin is a one-cent piece.

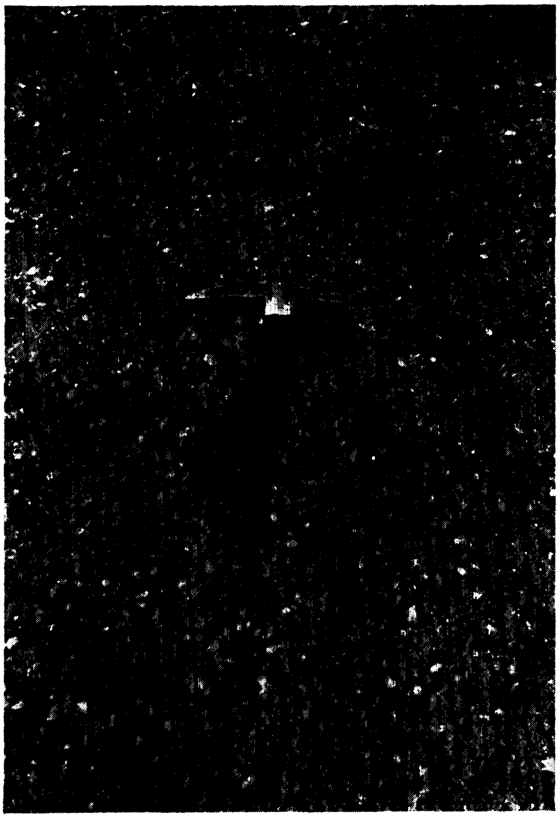
aphanitic matrix. In the Hewitt lake section there is also a number of feldspar porphyry dikes that have suffered some shearing. The feldspar phenocrysts are andesine, and the rock might be more properly called an andesite porphyry.

Diabase Dikes

The youngest consolidated rocks in the area comprise a few diabase dikes, which cut the granite and sediments near Margot lake and at the west end of North Spirit lake. The dikes have a maximum width of 150 feet; the central parts resemble a fresh, medium-grained gabbro, whereas the chilled edge is basaltic. Under the microscope they are seen to be composed essentially of laths of labradorite with interstitial pyroxene and a small amount of quartz forming a subophitic texture.

Deformation and Metamorphism

There are two distinct types of metamorphism in the sedimentary and volcanic rocks. The first consists of the changes brought about by deformation as a result of folding movements; and the second is the result of contact metamorphism of the sediments and volcanics, produced by the intrusion of granite bodies. The deformation of the rocks was probably accompanied by the intrusion of the peripheral granodiorite gneiss but was prior to the time of intrusion of the massive pink and grey granites as shown by the contact metamorphism of the previously deformed rock formations.



Andalusite gneiss developed from contact metamorphism of argillaceous sediments west of Atikamik lake. The white spots are porphyroblasts of chiastolite up to 1½ inches in length.

Deformation

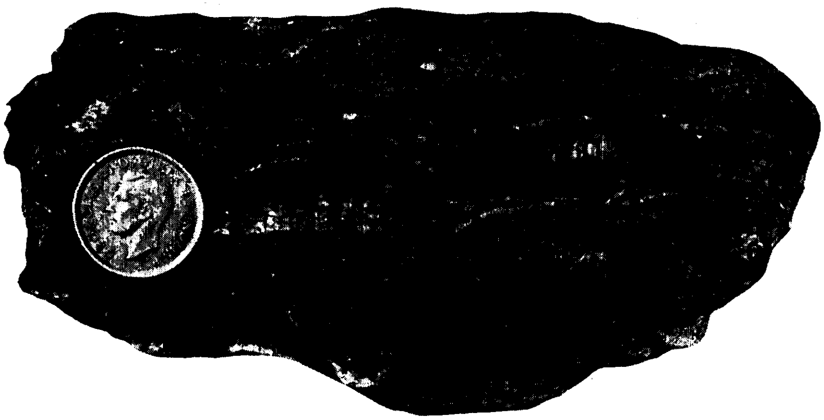
Strata that were once horizontal have been so folded that the bedding planes are now vertical. Accompanying the major folding movements was considerable drag-folding within the different formations. The severity of the folding produced long S-shaped forms to parts of many formations and resulted in a discontinuity of others.

Deformation has locally obliterated primary flow structures in the volcanics as well as bedding in the sediments. The most important effect of folding movements on the rock types has been the reorganization and recrystallization of the component minerals accompanied by cataclastic deformation of the coarser, clastic sediments. The argillaceous sediments have been converted to slates and, where more severely deformed, phyllites have been formed. The most notable effect in the conglomerate beds has been the stretching of the pebbles, and the longer axes of the stretched pebbles may lie at any angle to the bedding. The general effect of folding on the volcanic rocks has been the production of chlorite schists.

Local zones of shearing and faulting occur in the vicinity of volcanic-sedimentary contacts, and where the shearing has been intense the greenstones have been altered to talc schists. Some of the volcanic-sedimentary boundaries may represent the trace of thrust faults. Much of the local thickening of the formations is attributed to crinkling of the rocks into small isoclinal folds.

Contact Metamorphism

Contact metamorphism, particularly that produced by the transgressive granites, has produced a variety of metamorphic rock types, the most common

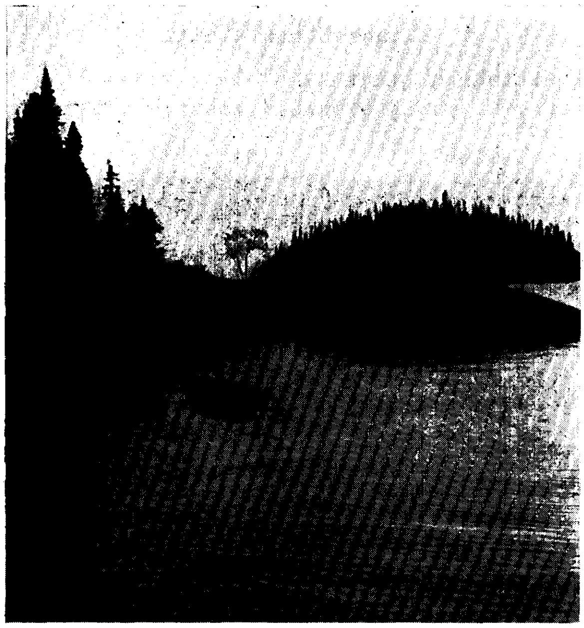


Porphyroblastic cordierite and sillimanite schist characterized by remarkably large porphyroblasts of sillimanite. The coin is a one-cent piece.

being an amphibolite facies in the sedimentary and volcanic formations adjacent to granite contacts. The development of massive amphibolites and amphibolite schists has taken place with the preservation of primary structures such as bedding; in fact, selective amphibolitization of susceptible alternate beds has, in some instances, produced a more distinct bedding than was formerly evident. The amphibolites, which are best developed in the southwestern and southeastern parts of the area, are made up of metamorphic amphiboles with lesser amounts of quartz and feldspar, biotite and calcite. Laths of amphibole up to half an inch in length were observed in some places. All of the sedimentary rock types, in addition to the basic volcanics, appear to have suffered amphibolitization in some localities.

Another result of contact metamorphism, which has been effective for the most part on the argillaceous members of the sediments, is the development of fine-grained mica schists and medium-grained biotite gneisses, such as those that are found in the Margot lake section. In addition to biotite the mica schists and gneisses may contain porphyroblasts of garnet. In the Margot lake section there are also a number of mica schist inclusions in the granite; these are generally garnetiferous and oriented with flat, southerly dips, although the strike is in conformity with the regional structure. Some of these inclusions are hundreds of feet in length.

Accompanying the metamorphic changes, particularly in the neighbourhood of pegmatitic intrusions, andalusite is developed by the reorganization of mineral constituents. When metamorphism reaches a stage where there is a total reorganization, the bedding is commonly obliterated. West of Atikamik lake a brown-weathering andalusite-biotite gneiss has been produced by contact metamorphism. The rock is characterized by large and profuse porphyroblasts of chiastolite up to 1½ inches in length.



Glacially grooved and smoothed rocks on one of the north-central islands of North Spirit lake.

Chert-like hornfelses have been produced by contact metamorphism of lime-alumina rocks associated with the limestone at Hewitt lake. The greywackés and other sediments high in quartz have been least affected by contact metamorphism.

Pleistocene

Ice-sheets of continental proportions passed over the area in Pleistocene time, the direction of movement of the last glacial advance being from northeast to southwest. The principal effect of glaciation has been the planing off of weathered rock surfaces, rounding of the hilltops, and modification of relief by the filling-in of the deeper depressions with till. The glacial mantle consists almost entirely of boulder clay with some sand and gravel lenses. The material is relatively fresh and unweathered. No glacial lake clays were seen within the area, nor was more than one age of till observed. The abundance of rock exposures suggests that this mantle is ordinarily thin, but in the higher parts of the area between Hewitt lake and MacDowell lake there are a number of east-west-trending stony morainic ridges and fewer bed rock outcrops.

No suitable exposures for taking determinations on the strike of the glacial striae were found in the southern part of the area, but in the vicinity of North Spirit lake 110 observations fell within the limits of S. 34° W. to S. 50° W. Although the trend of striae is northeast-southwest the stoss slopes of a few north-south-trending asymmetric ridges, such as occur on "W" island, invariably face the east rather than the northeast. Projection of the striae would indicate movement from a Labradorean centre.

No positive evidence was found in support of a Patrician (pre-Labradorean) centre of ice accumulation supposed to have been located some 75 miles east of North Spirit lake. Since there is only one set of striae and one layer of till within the area, it is presumed that any evidence of former glaciation has been removed by the last ice movement.[1]

The unconsolidated material that lies above the bed rock beneath the lake in South bay is well sorted and stratified. The following section taken from diamond-drill cores in that part of the lake is the composite of a number of borings:

Surface to 40 feet	Water.
40 to 80 feet	Clay.
80 to 110 feet	Sand and gravel.
110 feet	Bed rock.

An examination of the material showed the sand and clay to be well sorted, although there is a transition zone between them; similarly the sand passes into gravel at the base. The clay shows a poorly defined stratification.

ECONOMIC GEOLOGY

Gold

Owing to the remoteness of the area the only mineral of economic significance discovered up to the present time is gold. The principal gold discoveries were made in the east margin of the diorite stock that outcrops in the South bay section of North Spirit lake, and to the east of the stock on Prospair point. In this locality mineralized occurrences fall into two groups:—

1. The first type occurs in narrow, irregular joints in the eastern part of the diorite stock that have been filled with massive and disseminated arsenopyrite associated with tourmaline-quartz stringers and minor amounts of pyrite, chalcopyrite, and pyrrhotite. The coarse, massive arsenopyrite type of mineralization yields the highest values in gold, some extraordinarily high assays being obtained. Development work has, to date, not defined any zone of mineralization in the diorite sufficiently persistent in length and width to contain an economic ore body.

2. The second type occurs in conglomerate beds on the east shore of South bay and on Prospair point, where the conglomerates are drag-folded together with rusty-weathering greywacké and ferruginous slate. In this locality the greywacké and sericite matrix between closely packed chert pebbles in the conglomerate contains disseminated pyrite and small amounts of pyrrhotite, chalcopyrite, and arsenopyrite. Most of the samples taken for assay from this type of occurrence yielded less than 0.03 ounces in gold per ton, although values up to 0.15 ounces have been obtained.

Gold has also been discovered associated with sulphide mineralization in a silicified shear zone in drag-folded sediments on the northeast arm of Hewitt lake. At the 8-foot falls, 4 miles west of the outlet of North Spirit lake, gold has been

[1] J. B. Tyrrell, "The Patrician Glacier South of Hudson Bay," Internat. Geol. Cong., 12th Sess., Canada, 1913, pp. 523-534.

found associated with pyrite in quartz stringers that fill factures in drag-folded phyllite. A recent discovery of gold-bearing arsenopyrite associated with quartz in a slaty schist was made near Pakeagama lake, about 12 miles west of North Spirit lake.

Quartz veins are numerous throughout the area, but for the most part these are barren. Narrow shear zones and carbonate zones, some containing sulphide mineralization, are not uncommon and occur in many parts of the area, particularly in the vicinity of contacts between sediments and volcanics.

In general, both from lithological and structural considerations, the area is favourable for the occurrence of gold deposits of economic importance. No systematic prospecting was carried on during the summer of 1937, and most prospecting activities to date have been confined to sections near some of the larger lakes, so that a large portion of the area is still virgin prospecting territory. All the gold discoveries made to date, with two or three minor exceptions, have been found associated with arsenopyrite. The presence of this mineral appears to be the best indicator for gold in the region, but the prospector is advised not to overlook other sulphides in his search.

Lime

On the south shore and northwest arm of Hewitt lake a number of beds of crystalline limestone occur infolded with other sediments. Portions of some of the beds are more than 99 per cent. calcite and, therefore, of sufficient purity to provide lime for metallurgical purposes in any local mining operations.

Iron

The iron formation in the vicinity of Prospair point and at the northeast end of North Spirit lake contain the highest iron content of the different beds of iron formation examined throughout the area. In these localities parts of some of the beds contain up to 50 per cent. magnetite, much of which is amenable to concentration by magnetic methods. There is a large tonnage of low-grade iron ore which, owing to the remoteness of the region, has no economic significance at the present time.

DESCRIPTION OF PROPERTIES

Spirit Lake Gold Mines, Limited

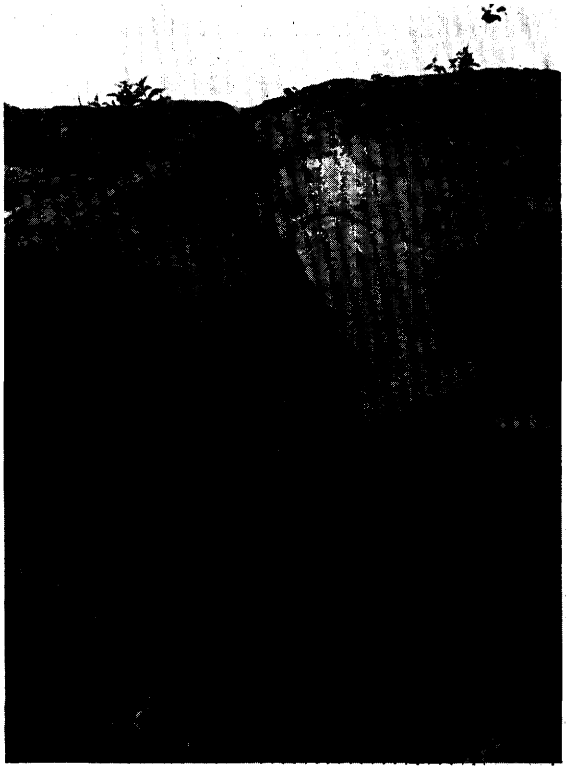
History

Spirit Lake Gold Mines, Limited, was incorporated in 1936 to develop the original claims staked in April of that year by prospectors financed by the Derby Gold Syndicate, under the leadership of A. F. Hewitt. The property consists of 96 claims in the South bay section of the lake, the greater part of which covers water locations. During the summer of 1936 a programme of trenching and test-pitting was carried out by representatives of Interlac Gold, Limited, under Mr. Hewitt. In September, after the appointment of V. E. C. Odlum as resident manager, a programme of diamond-drilling was commenced and continued until May, 1937. During the winter a geophysical survey was made of part of the water locations in South bay. Permanent camp buildings, capable of housing 40 men, have been constructed. The company has been inactive since June, 1937.

Mineralization

The principal geological feature of the property is an irregularly shaped stock of medium-grained diorite, which intrudes a folded series of impure slates and greywackés together with greenstones. The stock is probably not more than 1½ miles in diameter, but its shape is not known, as the periphery of all but a small portion lies beneath the lake. The geophysical survey was undertaken to locate the eastern contact of the stock.

The three principal loci of mineralization on the property are: (1) the Camp Island and "W" Island sections near the northeastern margin of the diorite stock; (2) "A" section, which lies at a volcanic-sedimentary contact with a small



Fracture in massive diorite on Camp island filled with solid arsenopyrite with an average width of 8 inches.

andesite porphyry body 5,000 feet south of Camp island; and (3) "J" and "T" sections, which occur in conglomerate beds on the east shore of South bay, 10,000 to 11,000 feet east of Camp island.

Camp Island and "W" Island Sections

Mineral occurrences in this vicinity are characterized by gold-bearing arsenopyrite filling short, narrow, irregular fractures (joints) in the diorite. On Camp island there is an irregular fracture zone about 50 feet wide, striking northeast, which has been traced for some 500 feet beneath the lake. This zone consists of 2- to 3-inch, irregularly dipping tourmaline-quartz stringers associated with fine-grained massive arsenopyrite in strongly fractured diorite. The stringers, however, are not closely spaced, and the diorite between them carries no mineralization. Two hundred and fifty feet north of this zone there is a parallel fracture, averaging 8 inches in width and traced for 60 feet, which is filled with solid arsenopyrite. A specimen of the mineralized material yielded 0.25 ounces in gold per ton.

On "W" island, over a width of 275 feet, there occur at least three narrow mineralized zones having a rough northwest-southeast trend, normal to the mineralized fractures on Camp island. The trends of the mineralized zones coincide with the directions of jointing in the stock. The zones outcrop near the shore of the island and strike into the water; they have been traced into the island for some 200 feet, but appear to have no continuity. Diamond-drill holes indicate that, although irregular, these fractures extend at least some 750 feet southeast of the island.

The mineralized zones rake to the southeast at an angle of about 30 degrees. The fractures, which vary from 2 to 12 inches in width, occur in otherwise massive diorite and are irregular in both strike and dip. Each of the zones is characterized by massive arsenopyrite, which fills the fracture and occurs as a disseminated replacement in the wall rock for 6 inches to 1 foot on either side. Narrow tourmaline-quartz stringers, which vary from half an inch to 3 inches in width, also carry arsenopyrite and are associated with the massive sulphides in the fractures. In addition the zones contain small amounts of pyrite, chalcopyrite, magnetite, and epidote. The diorite in the vicinity of the fractures has been metasomatically altered, whereas the walls of the fractures have been hydrothermally altered to dark-green chlorite and have been partially bleached. The following chemical analyses are given of these two altered products of the diorite in order to indicate the intensity of chemical changes produced by mineralizing solutions.

	Altered diorite	Wall rock
	per cent.	per cent.
SiO_2	57.28	54.87
Al_2O_3	15.48	18.08
Fe_2O_3	5.69	1.82
FeO	2.58	4.86
MgO	2.78	2.69
CaO	3.68	4.41
Na_2O	2.38	1.88
K_2O	4.76	6.64
H_2O	1.66	1.41
TiO_2	0.64	0.79
P_2O_5	0.35	0.39
CO_2	2.09	2.21
FeS_2	0.88	trace
Total	100.25	100.05
Specific gravity	2.798	2.87

Analyses by Provincial Assay Office; W. F. Green, analyst.

The metasomatically altered diorite, in thin sections, differed from the fresh diorite in that there was a considerable amount of secondary biotite and muscovite (up to 20 per cent.), as well as albitization of potash feldspars and introduction of allanite and tourmaline. These changes show an appreciable increase in potash and soda. The more intense hydrothermal alteration resulted in a further increase in potash but decrease in soda; ferrous iron increased with a corresponding decrease in ferric iron.

Development work has been concentrated on the Camp island and "W" island sections, but up to the present time no zones of commercial lengths or widths have been defined. A 202-pound specimen of massive, mineralized material from the "W" Island location sent to the Mines Branch, Department of Mines and Natural Resources, Ottawa, for laboratory testing purposes, yielded 2.35 ounces in gold per ton. The specimen was found to contain 21.83 per cent. arsenic or the equivalent of 47.5 per cent. arsenopyrite. Assays of the disseminated mineralization in the wall rock yield negligible values in gold. Studies indicated that the gold is present largely with the arsenopyrite, coating crystals and grains and within fractures in them. There does not appear to be any

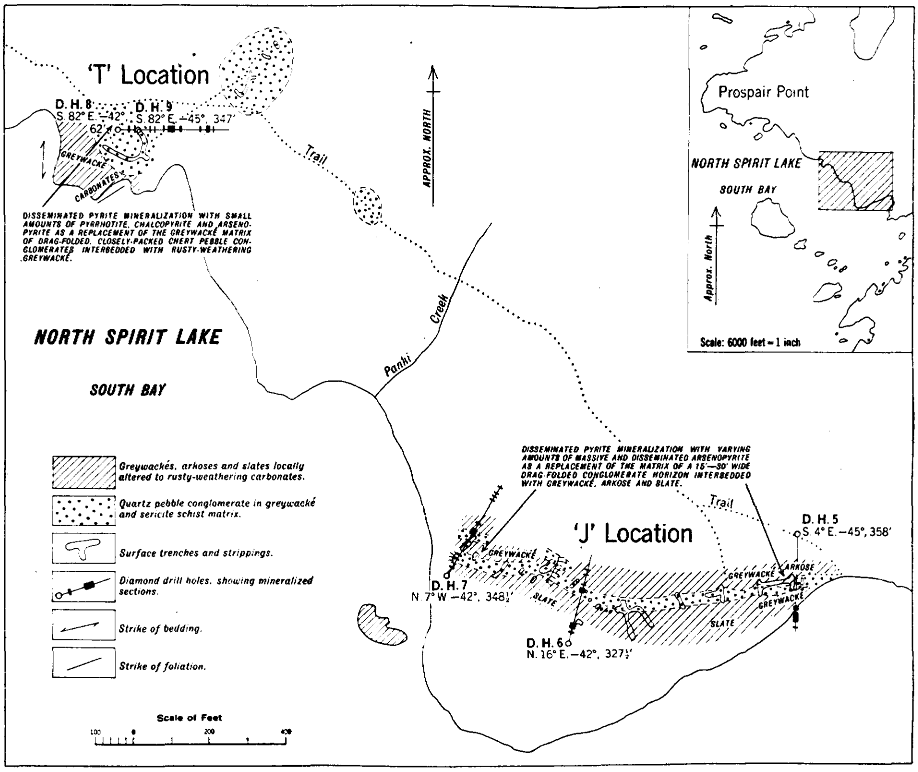


Fig. 5—Plan showing geology, prospect workings, and diamond-drill holes, "J" and "T" sections, Spirit Lake Gold Mines.

relation of gold content to the tourmaline-quartz stringers. A mineralographic examination of three polished specimens from "W" island location, which assayed 0.83, 0.87, and 2.38 ounces in gold per ton showed visible gold only in the first one. In this case the gold occurred as very fine micro-seams between arsenopyrite crystal boundaries.

"A" Location

Approximately 1 mile south of Camp island, mineralization was found at the contact of a small andesite porphyry body across an outcrop of greenstone and greywacké. The discovery consists of a 4- to 6-inch massive arsenopyrite vein filling a fracture in the porphyry adjacent to the volcanic-sedimentary contact. Narrow parallel quartz stringers carrying arsenopyrite occur here over a width of 25 feet. A small zone of pyrite mineralization was found 100 feet south in quartz stringers in bedded greywacké.

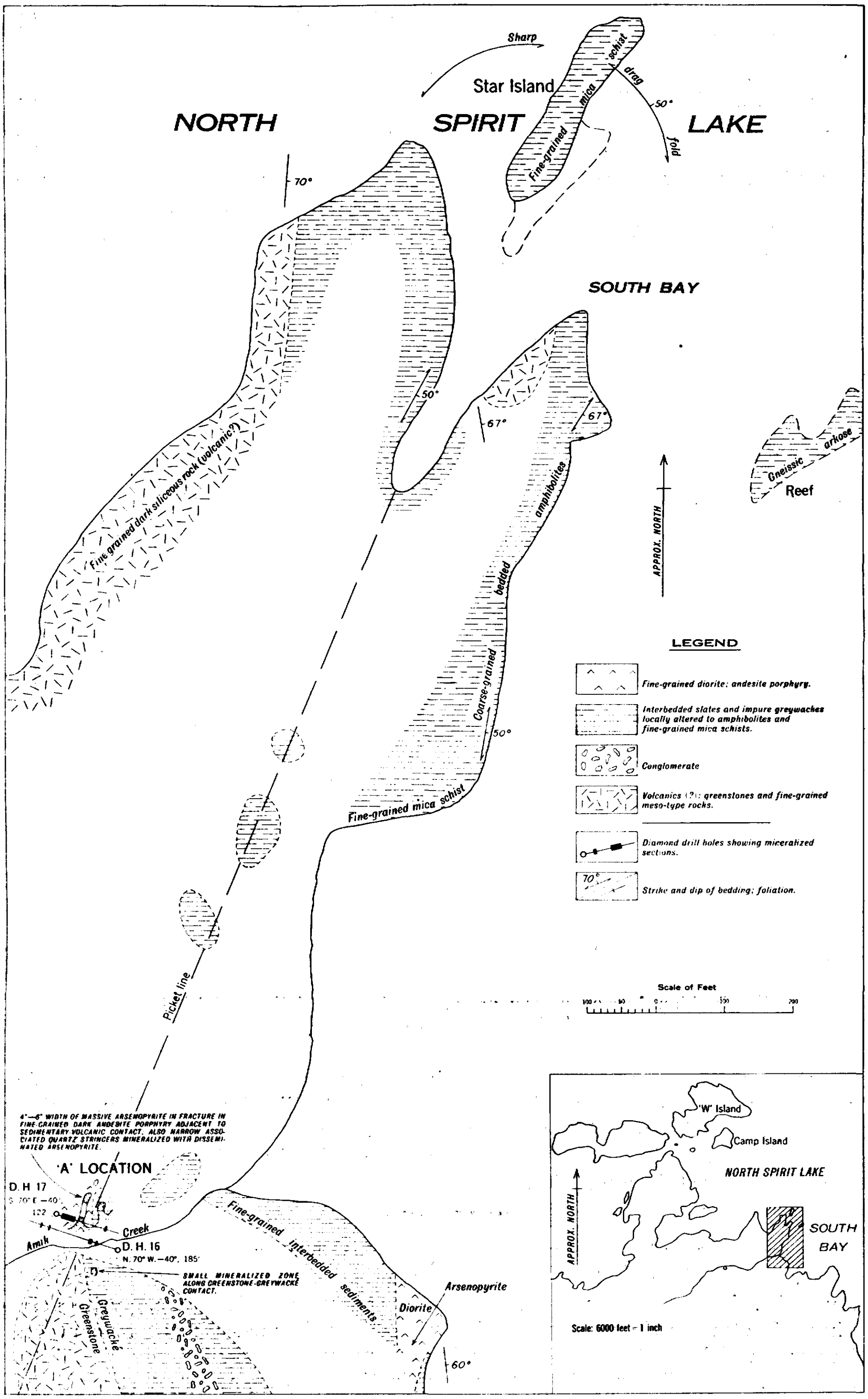


Fig. 6—Geological sketch map showing prospect workings and diamond-drill holes, "A" location, Spirit Lake Gold Mines.

A 28-pound specimen of mineralized material from "A" location was reported by the Mines Branch, Ottawa, as carrying 0.11 ounces in gold per ton and 72 per cent. arsenopyrite. A comparison of this analysis with the one from "W" location suggests that there is no constant relation in the ratio of gold to arsenopyrite. Mineralographic examination of a polished specimen carrying 0.12 ounces in gold per ton did not show any gold. Although some encouraging assays were obtained, development work failed to show any persistent length to the fractures at this location.

"J" and "T" Locations

"J" location, which lies 2 miles east of Camp island, on the east shore of South bay, is situated in a mineralized chert pebble conglomerate bed interbedded with rusty-weathering greywacké, arkosic quartzite, and slate. The mineralization consists of pyrite, varying amounts of arsenopyrite, and minor amounts of pyrrhotite and chalcopyrite, which occur as a replacement of the matrix between the pebbles of the conglomerate. The conglomerate bed ranges in width from 15 to 25 feet and was traced in a northwesterly direction for some 500 feet. Most of the assays, according to company reports, yielded less than 0.04 ounces in gold per ton.

"T" location, which lies approximately 1,000 feet north of "J," occurs in a thick conglomerate formation drag-folded with sediments that have been altered to rusty-weathering carbonates. Irregular pyrite mineralization occurs as a replacement of the slaty and sericitic matrix of the conglomerate. Low values in gold have been reported.

Development

Mineralized zones on the property have been probed by more than 30 diamond-drill holes ranging from 120 to 630 feet in length, with a total length of more than 8,000 feet. Except for 2 holes at "A," one at "T," and 3 at "J" locations, drilling has been confined to the Camp and "W" island sections. The results of drill-holes in irregular fractures such as these have been inconclusive.

The development was planned to search beneath the lake by diamond-drill for the eastern diorite-sediments contact in order to search for fractures more persistent that those that occur within the diorite itself. In February, 1937, a geophysical survey was undertaken to locate the eastern contact of the diorite beneath the lake. The survey, which was conducted by Hans Lundberg, Limited, covered an area of 230 acres extending east and southeast of Camp island. The results are shown in Fig. 3 (see insert facing page 70).

Fig. 6 shows the supposed contact drawn on the basis of the geophysical results whereas the actual contact, determined from a detailed examination of rock outcrops, is seen to lie more than 2,000 feet to the west.

Prospectors Airways Company, Limited

Representatives of the Prospectors Airways Company, Limited, staked a block of 15 claims adjoining the "J" and "T" sections of Spirit Lake Gold Mines on the northeast. A detailed geological map of the claims was made under the direction of J. E. Hawley and three zones of mineralization were examined, two of which were in conglomerate and the third in rusty-weathering greywacké.

The property is underlain by a vertically plunging drag-folded series of conglomerates interbedded with slates, slaty iron formation, and rusty-weathering greywacké. Surface stripping was carried out at 3 locations on Prospair point, and shallow test pits were sunk in small mineralized zones at locations Nos. 1

and 2. The mineralization at locations Nos. 1 and 3 consists of sparse, disseminated pyrite with small amounts of chalcopyrite, pyrrhotite, and arsenopyrite in the sericite matrix between closely packed chert pebbles in the conglomerate. Twenty-one samples from location No. 1 are reported to have yielded

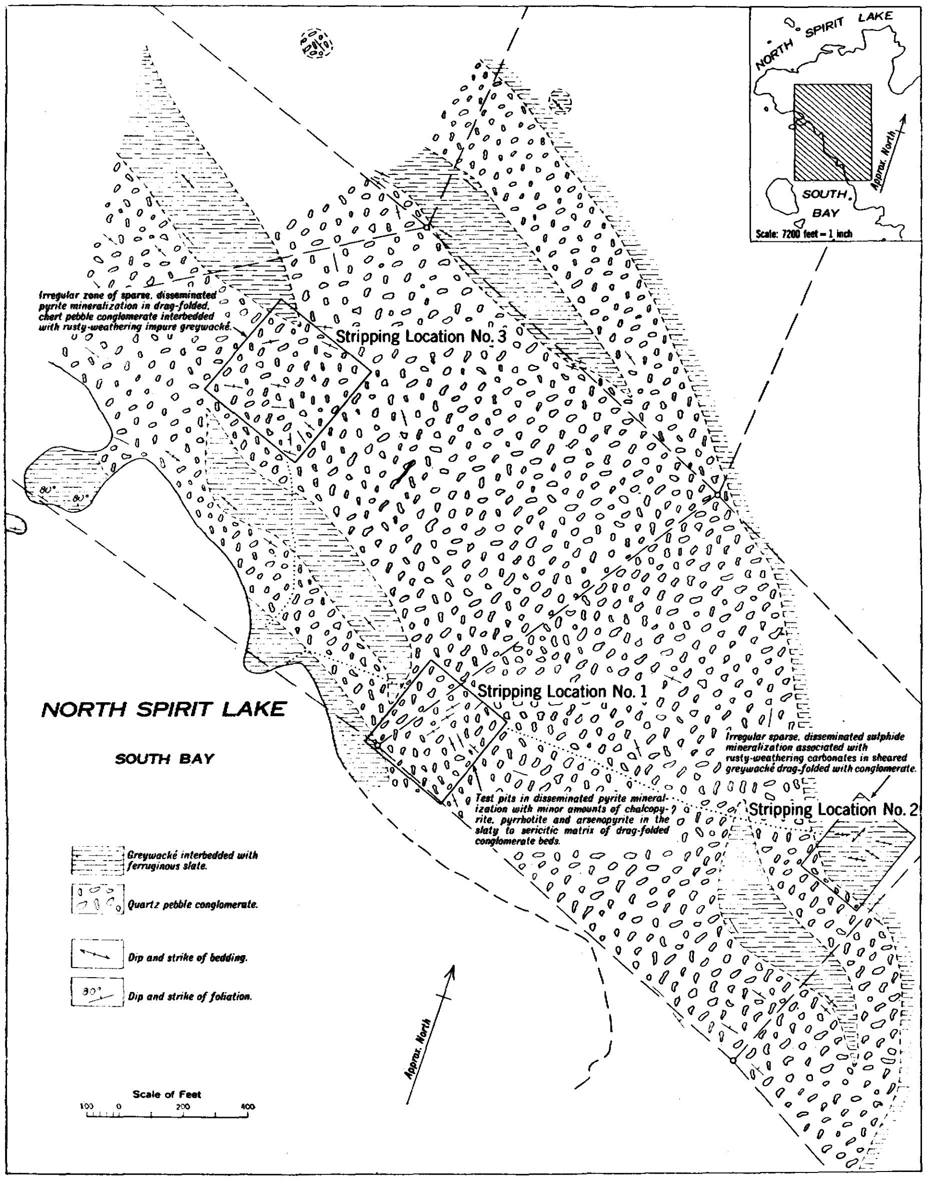


Fig. 7—Plan showing geology and surface-stripping locations on part of the Prospectors Airways claims, North Spirit lake.

less than 0.03 ounces in gold per ton. At location No. 2 sparse disseminated sulphide mineralization is associated with rusty-weathering carbonated sediments. Eleven specimens from this location are reported by the company to have yielded less than 0.03 ounces in gold per ton. Gold is reported to have been panned from the oxidized surface of a band of cherty iron formation at this location.

Interlac Gold, Limited

Interlac Gold, Limited, hold a group of claims adjoining the "J" and "T" sections of Spirit Lake Gold Mines on the southeast. Gold has been discovered on the prominent point at the southeast end of South bay in an occurrence consisting of a small mineralized zone in a complex east-plunging drag fold of siliceous material interbedded with slate and greywacké. Mineralization consists of massive and disseminated arsenopyrite with small amounts of pyrite and chalcopyrite associated with actinolite. Two shallow test pits have opened up the discovery for an east-west length of 20 feet and a width of 15 feet. A grab sample is reported to have assayed 0.3 ounces in gold per ton, and a chip sample across 7 feet taken by the writer returned 0.07 ounces.

Keefe Group

A group of claims on the southwest side of South bay adjoining those of Spirit Lake Gold Mines on the south was staked on behalf of William Keefe of Sioux Lookout. A geophysical survey of part of the property was made in the summer of 1937 by Hans Lundberg, Limited. No mineralized occurrences have been reported.

Mining Corporation of Canada, Limited

Prospectors for the Mining Corporation of Canada, Limited, staked a group of 12 claims in 1936 on the northeast shore of the northeast arm of Hewitt lake, as the result of obtaining gold in pannings from an exposure of rusty schist. The occurrence consists of a siliceous shear zone in drag-folded garnetiferous sediments near a contact with greenstone. Trenching failed to disclose any persistence to the zone, which outcrops as a low rusty cliff, about 20 feet wide, at the lake shore, striking slightly south of east. Mineralization consists of disseminated pyrite with minor amounts of arsenopyrite and pyrrhotite in fine-grained, chert-like, siliceous material. Three grab samples are reported by the company to have given 0.29 ounces, 0.81 ounces, and 0.14 ounces per ton. Subsequent check sampling failed to yield more than 0.10 ounces per ton in 17 samples. A grab sample taken by the writer returned 0.07 ounces per ton.

Wynne Claims

In the summer of 1937, two groups of claims were staked by C. Wynne, representing J. D. Kennedy, manager of San Antonio Gold Mines, in the vicinity of Pakeagama lake, which lies 12 miles west of North Spirit lake and 2 miles west of Tallrice lake. This was the result of Wynne having been taken during the summer to a showing of gold-bearing arsenopyrite by James Linklater, an Indian.

There are two zones of mineralization. The first, on which 3 claims were staked, lies 25 chains to the north of Pakeagama lake. Grab samples yielding 0.21 ounces, 0.14 ounces, 0.15 ounces, and 0.07 ounces per ton are reported by Wynne to have been obtained from this zone. The second zone, on which two claims were staked, lies on the southwest shore of the lake. At this locality 3 mineralized veins up to 200 feet in length have been reported, the mineralization consisting of pyrite and arsenopyrite in irregular quartz stringers filling a shear zone in schistose, slaty sediments.

Other Properties

A number of groups of claims in addition to those mentioned have been staked, for the most part in the South bay section of the area, but these are not known to contain mineralized occurrences.

Recent Developments in the Favourable Lake Area

By J. D. Bateman

Introduction

The Favourable Lake area lies between latitudes 52° 45′ and 53° 00′ N. and longitudes 93° 30′ and 94° 00′ W., in the Patricia portion of Kenora district in northwestern Ontario. The lake is located approximately 210 miles north-northwest of Hudson or Sioux Lookout on the transcontinental line of the Canadian National Railways and 135 miles east of Berens River Post on Lake Winnipeg.

The earliest reliable reference to the volcanic and sedimentary rocks at Favourable lake dates back to a reconnaissance exploration of the country between Lake Winnipeg and Hudson bay (via the Berens and Severn rivers) in 1886, by A. P. Low,[1] who stated:—

> The Huronian [now called Keewatin] rocks were first observed in Favourable lake, where they consist of chloritic and altered hornblende rocks, with talc and hydro-mica schists.

It was not until 1925, however, when G. V. Douglas[2] reported on a reconnaissance trip of the water routes between Red lake and Favourable lake, that the mineral-bearing potentialities of the area were considered.

Subsequent prospecting activities in the fall of 1927 led to the discovery of native gold and, later, of gold-silver-lead-zinc occurrences in the vicinity of Favourable lake. The area was examined by M. E. Hurst[3] in 1928, and developments up to 1929 are recorded in his report. Surface trenching and diamond-drilling on a number of claims at that time failed to disclose any ore bodies of commercial importance, and, with minor exceptions, prospecting activities in the area ceased. With a lowering of the cost of airplane transportation and the increased price for gold, interest in the area was revived in 1936, with the formation of Berens River Mines, Limited, to develop the former property of the Favourable Lake Mining and Exploration Company. In September, 1937, the writer spent 10 days in the area, during which time the property of Berens River Mines was examined in addition to two other small prospects.

Acknowledgments

The writer is indebted to H. De Witt Smith, of the Newmont Mining Corporation, and to M. D. Banghart, general manager, and B. R. Frisbee, engineer, at Berens River Mines, for their friendly co-operation, which has made this report possible. In particular, the writer would like to express his thanks to P. C. Benedict, geologist of the Newmont Mining Corporation, whose stimulating discussions and keen observations were of the greatest help to the writer.

Berens River Mines, Limited

HISTORY AND DEVELOPMENT

Berens River Mines, Limited, which is one of the most northerly underground mining operations in Ontario, is of particular interest owing to the fact that a complete mining plant and all supplies have been moved to the property by means of airplanes. The unusual metallic assemblage, gold-silver-lead-zinc, makes it unique among present mining developments in the province. The

[1] Geol. Surv. Can., Vol. II, pt. F, 1887, p. 17; reprint, Ont. Bur. Mines, Vol. XXI, 1912, pt. 2, p. 105.
[2] Ont. Dept. Mines, Vol. XXXV, 1926, pt. 4, pp. 1-21.
[3] Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 2, pp. 49-84.

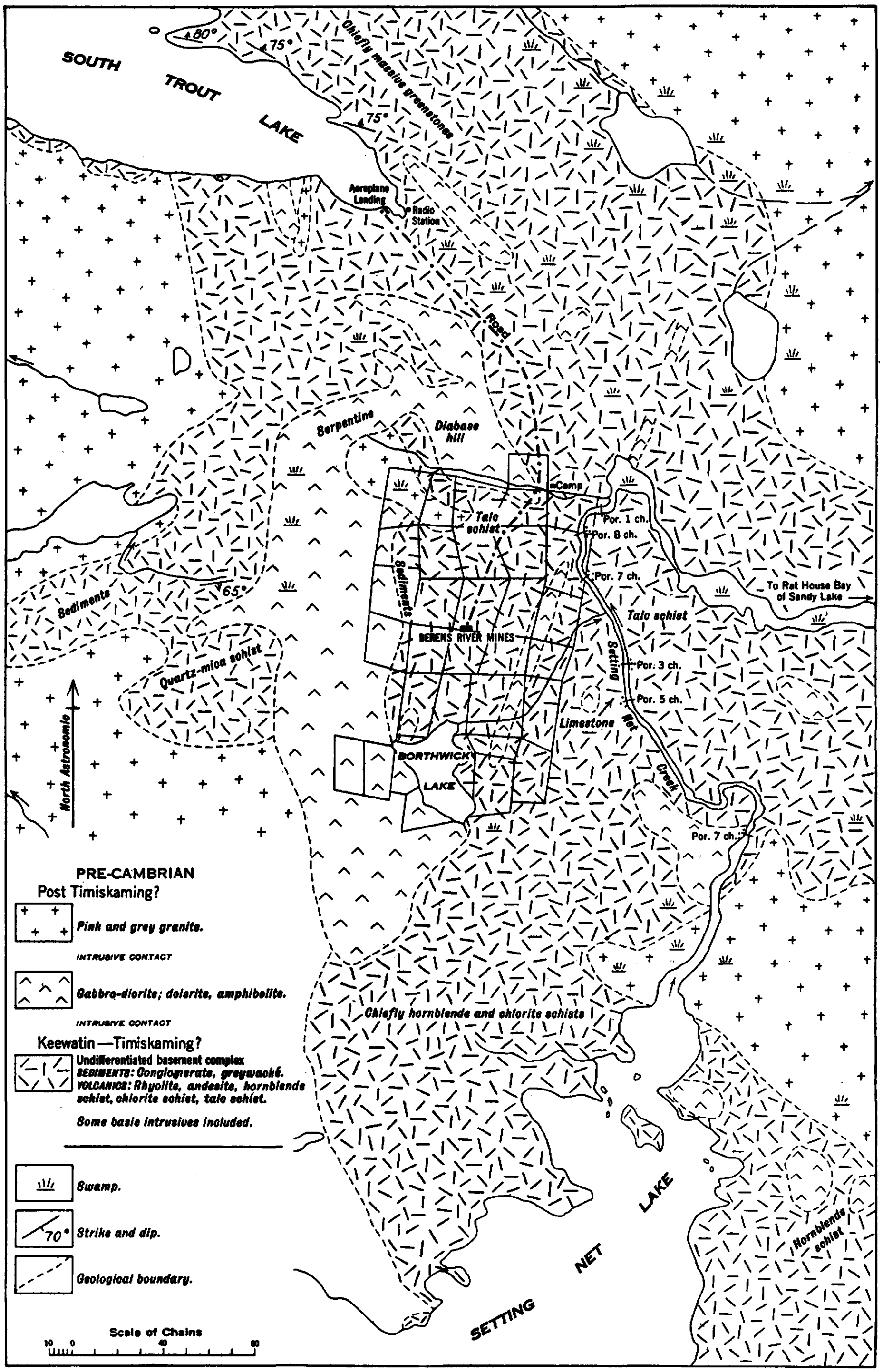


Fig. 1—Geological sketch map showing the location of the property of Berens River Mines, Limited, with respect to the Favourable lake volcanic-sedimentary belt. (Geology after M. E. Hurst, 1929.)

property lies within the Favourable lake volcanic-sedimentary belt, some 6 miles east of Favourable lake and 2½ miles southeast of South Trout lake.

The original discovery was made by K. C. Murray, of Winnipeg, who, in 1927, staked the 9 claims (Pa. 112–120) that constitute the nucleus of the present property. At that time F. M. Connell, J. H. C. Waite, and associates, organized the Favourable Lake Mining and Exploration Company to develop the discovery, and 21 additional claims (Pa. 2,164–2,184) were added to the property. The discovery consisted of four mineralized zones, trending east-west, from 600 to 800 feet apart. Zones Nos. 1 and 3 were diamond-drilled, the work being completed in July, 1929, at which time operations were discontinued. Approximately $100,000 was expended on the property in 1928 and 1929.

In July, 1936, the property was taken over by the Newmont Mining Corporation, and a subsidiary, Berens River Mines, Limited, was formed to carry on development.

In 1937, three additional claims, Pa. 3,267–3,269, were located by the present company, and six claims, Pa. 2,513, 2,514, 2,519, 2,520, 2,540, and 2,548, were acquired by stockholders and donated to the company. The property thus consists of 39 claims containing approximately 1,556 acres.

Transportation

Equipment, supplies, and men are transported from Winnipeg to Berens River Post on boats operated on Lake Winnipeg by the Selkirk Navigation Company. The fare from Winnipeg to Berens River is $7.00 and the rate for freight is $7.00 per ton.

Supplies are flown from Berens River, 145 miles east to South Trout lake, in planes operated by Wings, Limited.

The following prices quoted for air transportation are part of a contract in existence during the summer of 1937 between the mine and Wings, Limited, and may vary somewhat depending on the loads carried and the number of special trips required.

	Freight	Passengers	
	per ton	one way	round trip
Berens River to South Trout lake	$145	$25	....
Lac du Bonnet to South Trout lake	250	45	$81
Winnipeg to South Trout lake	300	50	90

A comparison of these figures with those quoted by Hurst[1] demonstrates the remarkable decrease in freight and passenger rates since 1928. Passenger rates at that time were $145 for the 188-mile trip from Goldpines to Favourable lake, and freight rates $1,000 per ton.

A bush road has been constructed from the landing base at South Trout lake to the property 2½ miles southeast.

Construction of a mill and power plant will require some 2,000 tons of equipment and supplies. In order to transport this material, the company is building a winter road from Berens River Post to the mine property. The road will cover about 100 miles of land and 80 miles of waterways, and it is estimated that freight could be transported by tractors for about 25 cents per ton per mile.

Communication

Wings, Limited, maintain a radio station at South Trout lake, in order to contact the company stations at Berens River Post and Lac du Bonnet. In

[1]M. E. Hurst, op. cit., p. 51.

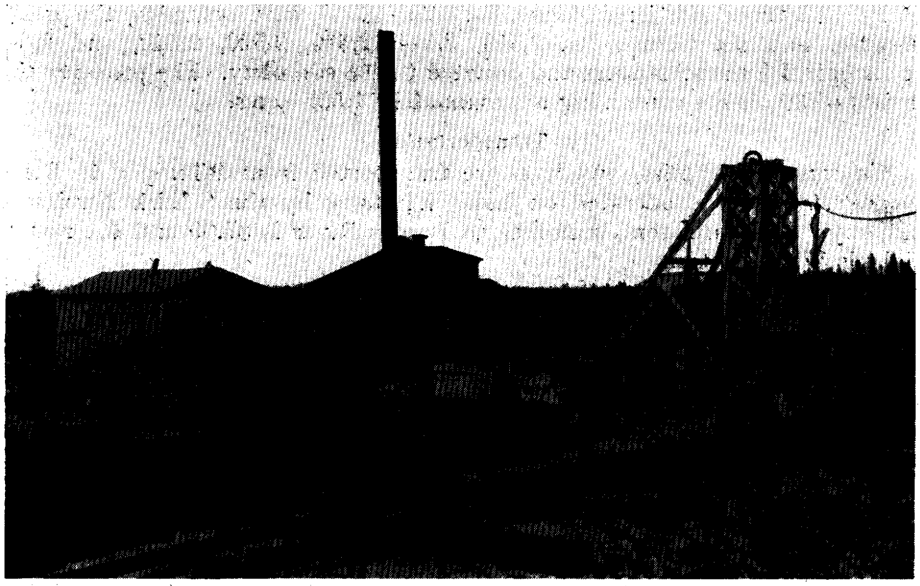
addition a small 5-watt transmitter is operated at the property for communication with the landing base.

Equipment

The property is equipped with a complete mining plant and camp accommodation for 70 men. At present the plant is operated by steam generated from wood-burning boilers. The company has constructed a saw-mill with a capacity of 5,000 feet of lumber per day.

Power

The company is developing its own hydro-electric power on the Flanagan (Duck) river, 8 miles east of the property. A dam site has been surveyed on the upper falls between North Wind lake and Rat House bay of Sandy lake; and an



Mining plant at the Berens River mine.

8½-mile power line survey has been made from that point to the property. The dam site is located above a 48-foot fall in the river near the outlet of North Wind lake, the projected power plant lying 800 feet to the west. At this locality there is a potential 4,000 horse-power, of which 1,600 horse-power will be required initially for development. One and a half miles farther north on the river there is another fall of 25 feet, which could supply an additional 2,000 horse-power. In order to ensure a sufficient flow of water at all seasons, two diversion dams will be required, one at the outlet of Margot lake in the North Spirit Lake area, and the other 3 miles north of Whiteloon lake at Johnston rapids. In this way the level of North Spirit lake will not be altered.

The cost of placing two 800-horsepower turbines in operation, which would deliver an estimated 1,350 horse-power to the mine, is figured at $268,000; power could be produced at a cost of about $15 per horsepower year. This would be sufficient for a mining and milling operation of 200 to 250 tons per day.

Development

In 1928 and 1929, former operators probed the Nos. 1 and 3 zones with 35 diamond-drill holes having a total length of 5,389 feet. From January to August, 1936, 23 holes totalling 8,794 feet were drilled. With the exception of 3 assessment core-holes, this work was confined to the No. 1 zone.

Further drilling has been done by the present company on the No. 1 zone both from surface and underground.

The sinking of a 3-compartment shaft was started on January 20, 1937, and completed to a depth of 400 feet by May 4. By September 15, 2,600 feet of lateral work and 100 feet of raising had been completed on the 250- and 375-foot levels. On September 15, lateral work was temporarily discontinued; the shaft was completed to 515 feet by October 6. Lateral work on the 500-foot level consisted of a 202-foot crosscut south of the shaft, 820 feet of drifting, and 195 feet of additional short crosscuts, which were completed by January 15, 1938. During this period 700 feet of additional lateral work was accomplished, principally on the 375-foot level. On January 23, underground exploration was discontinued and the mine allowed to fill with water.

GEOLOGY

General

The property of Berens River Mines lies in the granite-bordered Favourable lake volcanic-sedimentary belt (Keewatin-Timiskaming?), to the east of a large mass of altered pre-granite gabbro. A small body of monzonite lies half a mile north of the mine, and a larger-sized body of pink granite outcrops 2 miles to the southeast. Half a mile east of the shaft there is a long north-south-striking dolerite dike cut by an east-west-striking andesite dike 2 feet in width. A narrow east-west-striking felsite dike, parallel to the No. 2 zone, is the nearest known intrusive to the shaft.

The following table gives the formations that outcrop on the property:—

Table of Formations

LATER INTRUSIVES:	Felsite and andesite dikes, porphyry, monzonite.
	Intrusive contact
PRE-GRANITE INTRUSIVES:	Gabbro-diorite, dolerite. Diabase, locally altered to amphibolite.
	Intrusive contact and intense folding
SEDIMENTS:	Chert, iron formation, slate. Greywacké and undifferentiated metasediments. Conglomerate.
VOLCANICS:	Rhyolite, andesite, chlorite schist, and greenstone.

Most of the property is underlain by a series of closely folded sediments and volcanics, which represent the oldest formations in the area. The trend of these formations is roughly north and south, and the planes of foliation, where evident, are vertical.

The Nos. 1, 2, 3, and 4 zones occur as east-west fractures in what is believed to be a series of north-south-striking, almost vertical, siliceous or rhyolitic flows. A hundred feet to the west of the No. 1 zone is a north-south-striking conglomerate bed containing pebbles of the volcanics. This would suggest that the conglomerate is the basal member of the sediments lying to the west, and that the tops of the formations face west at this locality. A diamond-drill hole at the

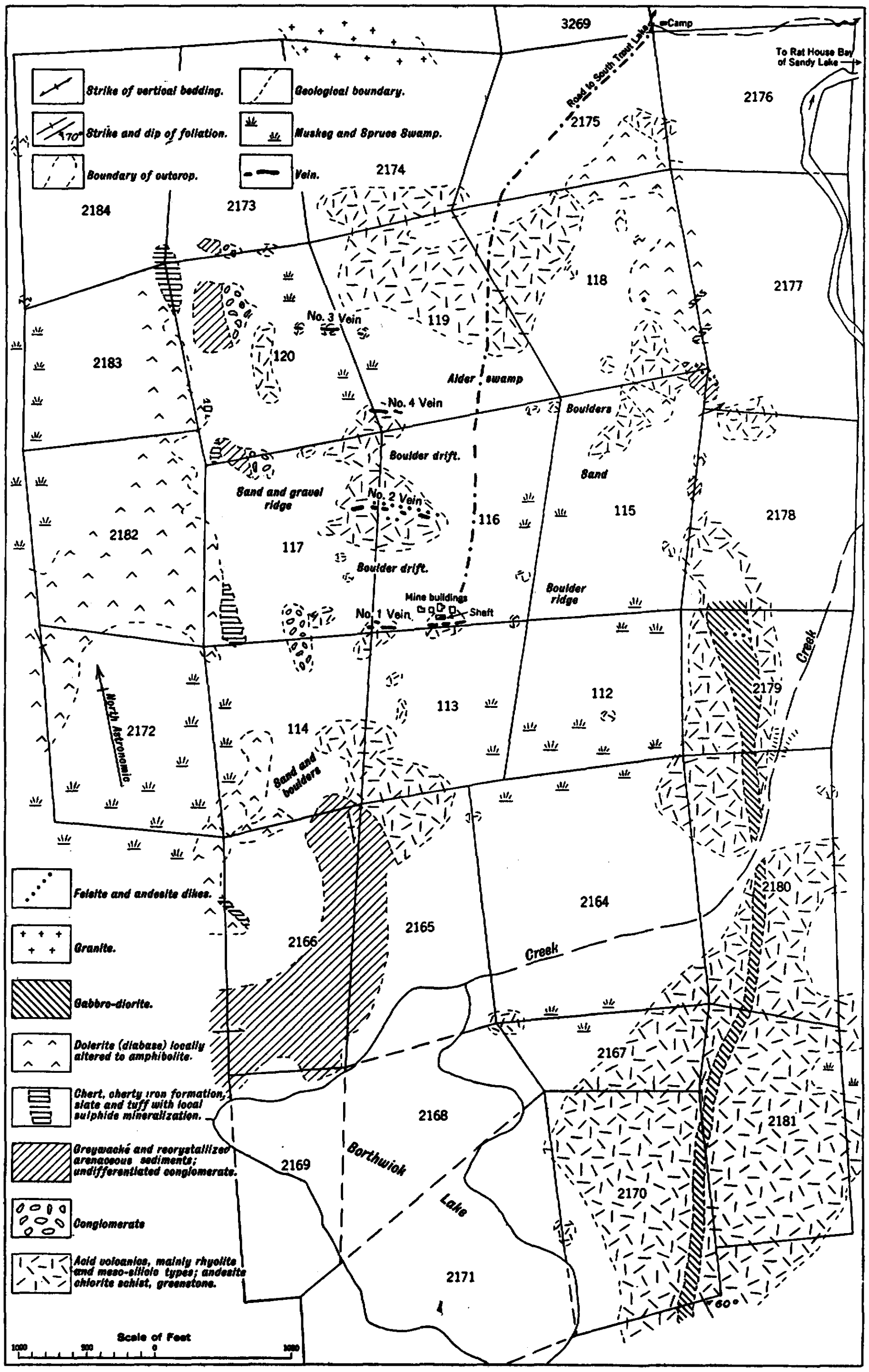
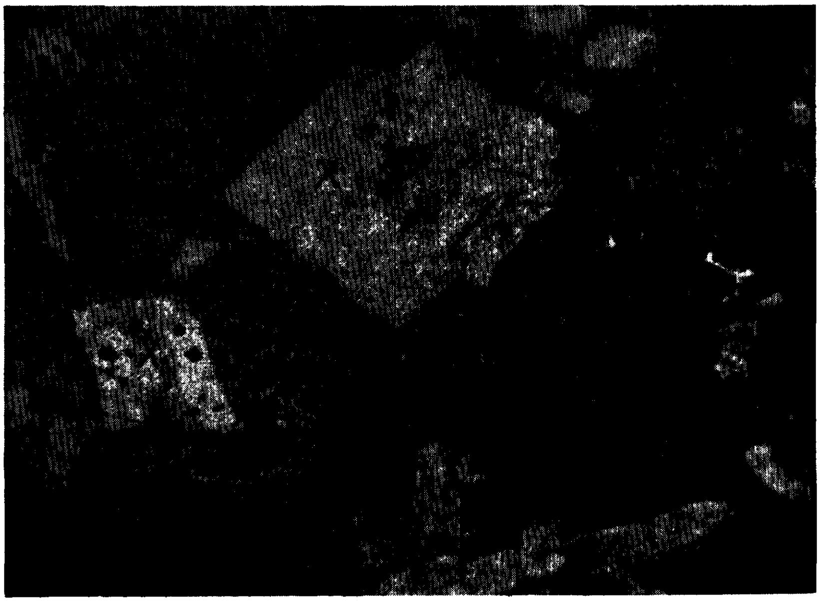


Fig. 2—Geological sketch map of the property of Berens River Mines, Limited.

west end of No. 1 zone indicates that the volcanics-conglomerate contact dips about 50° E., suggesting that the beds have been overturned.

Petrology of the Country Rocks

The rhyolite flows in the vicinity of the shaft have been altered so much that nearly all primary structures and textures have been obliterated. An underground examination of the rock types shows that they are mostly very fine grained, massive, and buff-coloured; local areas show a granular texture, and in many places the rocks have a brecciated appearance. There are less extensive exposures of a dark-coloured, siliceous rock, which contains megascopically visible garnet.



Photomicrograph of a thin section of light-coloured country rock from the Berens River mine. The angular white areas (X) represent probable feldspar phenocrysts, now entirely replaced by a very fine grained mosaic of quartz grains; the groundmass is sericite; the black areas and specks are pyrite. (X 20.)

These rocks, when viewed under the microscope, show intense metasomatic alteration. They are composed essentially of quartz with minor amounts of sericite, chlorite, and carbonate, and variable amounts of biotite, garnet, and pyrite. The quartz, which constitutes 80 per cent. of the light-coloured varieties and 50 to 60 per cent. of the dark-coloured rock types, occurs in four ways: (1) as the microcrystalline groundmass of the rock; (2) as clusters of small grains; (3) as mosaics of quartz grains, which have replaced former angular fragments or feldspar phenocrysts; and (4) as veinlets. Sericite comprises about 15 per cent. of the sections as fine, micaceous shreds. The light-coloured rock type contains less than 1 per cent. biotite; but the dark-coloured type contains up to 15 per cent. biotite, which is the cause of its dark colour; this type also contains some garnet. All the rocks contain a small amount of pyrite (see photomicrograph above).

Much of the quartz and all of the remaining constituents of these rocks are secondary, having been produced by thermal metasomatism.

If these rocks are correctly interpreted as former siliceous flows, it appears that they have undergone more or less silicification and pyritization, but secondary biotite and garnet have developed in some flows and not in others, owing either to chemical or physical differences in the original rocks, no vestige of which now remains. The widespread silicification and development of so much secondary biotite as well as garnet and pyrite in the wall rock suggests that a rather intense high-temperature metasomatism preceded the introduction of the ore minerals.

There is no apparent relationship of either the pattern of the fracture system occupied by the veins or the character of the mineralization in the ore bodies to the different rock types, both passing from one to the other without change. Any former schistosity in these rocks has been obliterated by subsequent silicification.

Structure of the Veins

The regional trend of the folded sedimentary and volcanic rocks, as well as the pre-granite basic intrusives, is north and south; but the trend of the younger andesite and felsite dikes, as well as the veins, is east and west, transverse to the regional trend. These transverse fractures are later than the basic intrusives and may be connected with the intrusion of the massive granitic rocks that outcrop to the north and south of the mine. The fractures bear no relation to the regional folding, as this occurred prior to the basic intrusions. The localization of the alteration of the country rock and of the ore minerals was caused by these fractures, whose formation must have accompanied or preceded the intrusion of an igneous body, which may be the granite already mentioned.

The No. 1 zone, which has been opened up by underground operations, varies in strike from east-west to S. 70° E., with an average dip of 60° S. The veins occur as short, narrow, silicified zones, which range from tabular to lenticular in form and are either parallel or *en échelon* in arrangement. The ore shoots in the veins are between 60 and 350 feet long and range from 3 to 25 feet in width.

A structural feature, which was not recognized until the veins had been opened up by underground development, is their displacement by a number of post-ore faults. These are narrow northwestward-striking reverse or thrust faults, which have an average dip of less than 50° N.E. This explains the fact that, although the veins dip 60° S., the ore bodies are almost vertically above each other on different levels. From surface to the 500-foot level, four major faults have been delineated, and diamond-drilling has indicated another reverse fault of this type between the 500- and 650-foot horizons. There are, in addition, a number of minor faults of various strikes and dips, which displace the veins several inches or a few feet at the most; but the horizontal displacement of each of the major faults varies from 30 to 80 feet. The fault zones are very narrow and free from gouge or breccia, and can only be discerned with difficulty. Since the ground is "tight," dilution due to faulting should not be appreciable, although the displacements will complicate stoping operations to some extent.

The major fault problems of the ore body have been capably solved by P. C. Benedict, to whom the writer is indebted for information. Mr. Benedict states in part:[1]—

> Their strike [the faults] is nearly parallel with the veins, their dip almost at right angles to them. Consequently the faults are much more obvious and their importance much more determinable in a raise than in a drift. . . . In a surprisingly large number of instances the displacement appears to be about the same as the distance between adjacent veins, so that it will occasionally be possible to start a stope on one vein and carry right through the fault and on up to the next level on a different vein.

[1]Personal communication.

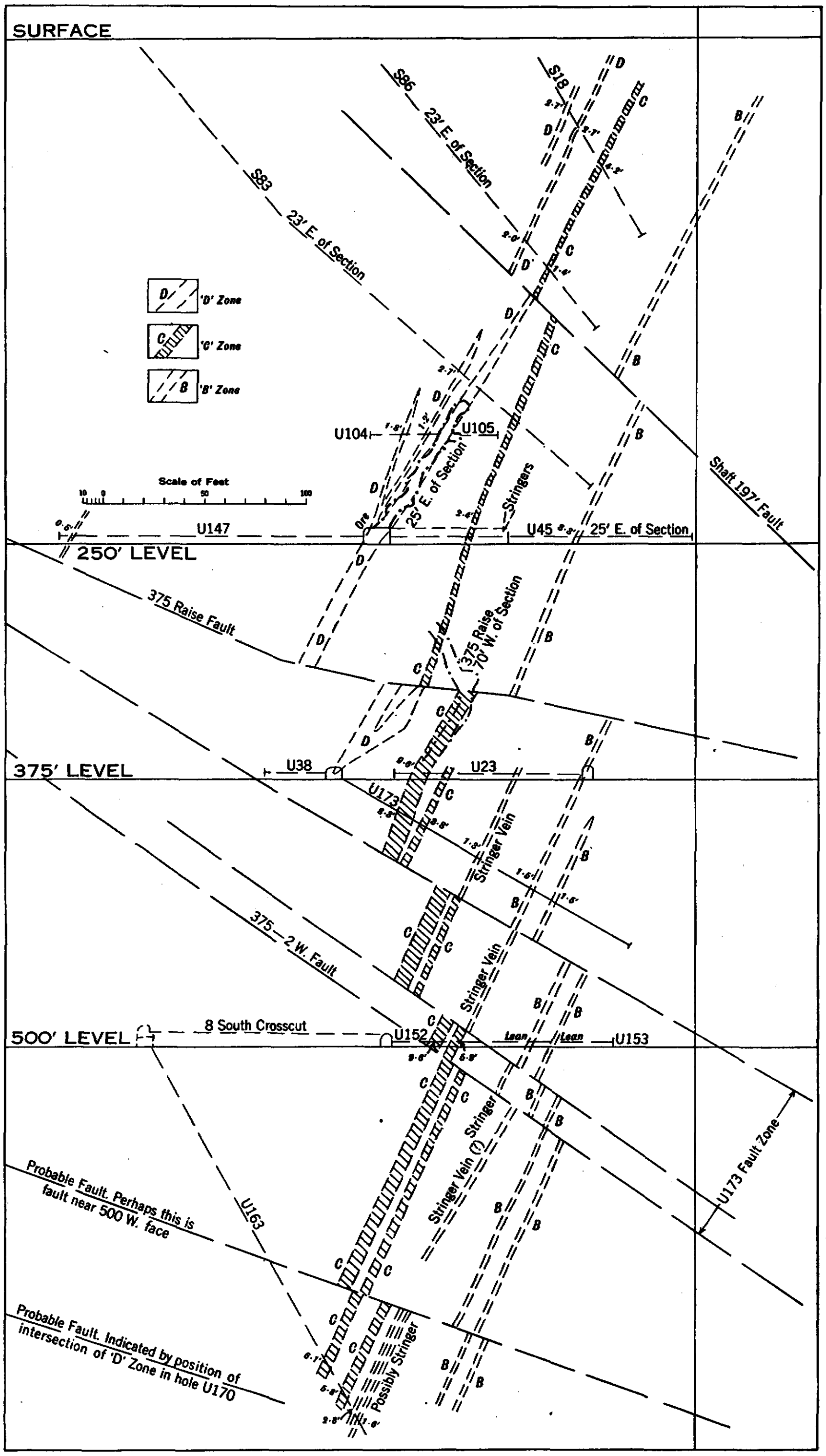


Fig. 4—Vertical section 250 feet east of the shaft, Berens River mine, showing displacement of veins by reverse faults. (After P. C. Benedict.)

The recognition of these faults explains the difficulty experienced by former operators in attempting to correlate core sections from surface diamond-drill holes.

The displacement on the faults tends to throw the ore to the east with depth, and since the ore extends as far east on the 500- as on the 250-foot level, the ore bodies may have a slight westerly rake.

Mineralization of the Veins

The ore shoots are fracture fillings and replacements in a strongly silicified zone, which contains sparsely distributed, unreplaced residuals of country rock. The silicified zone consists of quartz-actinolite veins formed by replacement of the wall rock, the localization of the zone being due to the original fractures along which rose the solutions that caused the extensive alteration of the country rock.

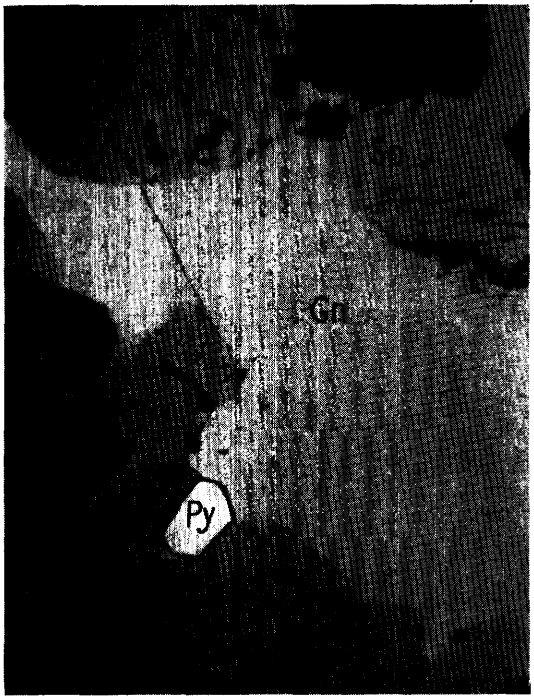
Photomicrograph of a polished section of ore from the Berens River mine, showing the relation of galena (Gn) to pyrite; the light-grey area at the right is sphalerite (Sp); the lower grey portion is quartz. (× 100.)

At a later date the quartz-actinolite veins were fractured and the ore-bearing constituents were introduced as partial replacements of the quartz-actinolite and, in part, as open-space fillings. The ore shoots are thus veins within veins.

Thin sections of the quartz-actinolite material shows a quartz content of at least two generations, which varies from less than 20 per cent. to more than 90 per cent, but is generally the dominant gangue mineral; the actinolite content varies from 5 to 30 per cent. and the carbonate from 5 to 40 per cent. There are, in addition, small amounts of pyrite, garnet, and secondary iron-bearing chlorite. The quartz of the first generation is fine-grained and sugary in contrast to the later quartz, which occurs as open-space fillings and is euhedral and glassy. The later generation of quartz was accompanied by carbonate, primary chlorite, and a complex assemblage of sulphides, as well as gold and silver. A still later generation of quartz is found in narrow, undisplaced quartz stringers, which cut across the faults.

The ubiquitous pyrite belongs to two generations; the first accompanied the metasomatic replacement of the silicified zone and country rock and is invariably isotropic in character. The second generation is associated with the ore minerals along with the first generation and is slightly, but distinctly anisotropic under reflected polarized light. The relative proportions of these two ages of pyrite cannot be determined.

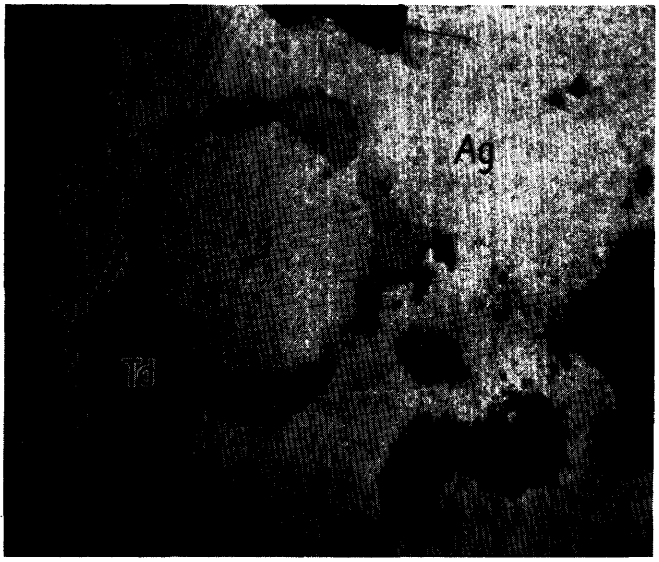
The metallic minerals in the ore body, which are present in a ratio of about 3 to 7 with the gangue, are, in order of relative abundance: pyrite (much of which belongs to an early generation), sphalerite, galena (which may belong to more



Photomicrograph of a polished section of ore from the Berens River mine, showing the relation of galena (Gn) to sphalerite (Sp); the dark-grey areas are quartz. Note the euhedral crystal of pyrite. (× 46.)

than one generation), pyrrhotite, chalcopyrite, tetrahedrite, native silver, ruby silver, and gold. Pyrite, sphalerite, and galena are widely distributed in the veins and constitute more than 95 per cent. of the metallic minerals, the galena being subordinate. Pyrrhotite, chalcopyrite, and tetrahedrite are present in local occurrences. Arsenopyrite is sparse. Ruby silver is confined to the planes of narrow fractures and is perhaps supergene. A few occurrences of native silver are reported, but most of the silver in the ore is contained in galena; etching reactions suggest that the native silver may be supergene. No visible gold has been observed or reported.

Microscopic examination of polished sections of the ore revealed the following relationships: (1) The pyrite is euhedral, may be enclosed by other sulphides or gangue, and in some instances is partially replaced by galena (see photomicrograph on page 88). (2) Galena and sphalerite are intimately associated with each other, one enclosing the other, but with a general tendency for the sphalerite to embay the galena (see photomicrograph on page 89). (3) Most of the tetrahedrite observed was associated with native silver, in which it forms atolls (see photomicrograph below). (4) Intimate intergrowths of chalcopyrite in sphalerite were observed (see photomicrograph on page 91), the chalcopyrite apparently oriented along cleavage planes in the sphalerite; such a texture has been interpreted as either due to unmixing or to replacement,[1] but the intimate relationship of these two minerals observed in sections from other parts of the veins suggests that they are contemporaneous and that the texture is due to unmixing of a solid solution. (5) Chalcopyrite and pyrrhotite are commonly in close association, but the pyrrhotite may also occur as islands in sphalerite.



Photomicrograph of a polished section of ore from the Berens River mine, showing the atoll-like structure of tetrahedrite (Td) in native silver (Ag); the black areas are gangue. (× 100.)

The time of formation of all the sulphide minerals, with the possible exception of pyrite, appears to be approximately contemporaneous. The gold is apparently associated with the sulphides.

Field and mineralographic studies indicate the following succession of mineralization:—

1. Metasomatic replacement localized along a fracture zone, which resulted in almost complete silicification of the zone, partial silicification of the adjacent country rock, and development of secondary biotite, garnet, and pyrite in the country rock, as well as actinolite, garnet, and pyrite in the silicified zone.
2. Fracturing of the silicified zone.
3. Introduction of pyrite, arsenopyrite, pyrrhotite, galena, sphalerite, chalcopyrite, tetrahedrite, and gold(?), accompanied by quartz, carbonate, and primary chlorite as open-space fillings, and partial replacement of the fractured silicified zone.

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[1]E. S. Bastin, L. C. Graton, Waldemar Lindgren, W. H. Newhouse, G. M. Schwartz, and M. N. Short, "Criteria of Age Relations of Minerals, with Especial Reference to Polished Sections of Ores," Econ. Geol., Vol. XXVI, 1931, pp. 561-610.

4. Displacement of the veins by low-angle reverse faults.
5. Post-fault quartz stringers intersecting both faults and veins.
6. Formation of ruby silver and possibly native silver as supergene(?) minerals.

Character of the Ore Shoots

The ore zones appear to have definite walls, the lowering of values in both the hanging wall and footwall being abrupt and the area on either side of the commercial parts of the veins being commonly filled with non-commercial quartz stringers. Pyrite is abundantly disseminated in both the commercial and non-commercial parts of the veins as well as in the wall rock, but bears no relationship to the gold content. The non-commercial parts of the veins contain unreplaced country rock residuals.

Photomicrograph of a polished section of ore from the Berens River mine, showing chalcopyrite (white) oriented along probable cleavage planes of sphalerite (grey); this texture is interpreted as being due to unmixing of a solid solution and, therefore, indicating contemporaneous deposition. (X 100.)

In many instances the hanging-wall side of the veins locally contain a higher sulphide content accompanied by increased quantities of gold and silver, whereas the footwall side may be principally quartz-actinolite vein material. Sphalerite, with the exception of pyrite, is the most abundant metallic mineral in the ore shoots and, locally, galena is quantitatively important. The presence of sphalerite and galena commonly indicate ore tenor, but there is no relationship between the proportions of these sulphides and the precious metal content. Native gold was not observed in polished sections of the ore. The microscopic examination conducted by the Mines Branch, Department of Mines and Resources, did not reveal any gold. The explanation is offered that, since the gold is comparatively free-milling, "it might lie in narrow stringers or streaks and might be relatively coarse."[1]

Development work on the 250-foot level revealed 1,040 feet of ore in 7 shoots, averaging 7.4 feet in width. On the 375-foot level, 772 linear feet of ore, averaging

[1]Personal communication.

5.6 feet in width, have been developed. The 500-foot level, which is not yet fully developed, contains an indicated 3,711 square feet of ore in four shoots, compared with 4,317 square feet in five shoots on the 375-foot level. Diamond-drilling, spaced to cover a length of 220 feet along the strike, has indicated economic mineralization to a depth of 650 feet.

The management's estimate of probable ore is as follows:—

	Width	Length	Area	Tons	Grade	
					Gold	Silver
	feet	feet	sq. ft.		ounces	ounces
Shallow drilling	10.1	840	8,484	115,000	0.27	13.6
250-foot level	7.4	1,040	7,704	112,000	.30	14.6
375-foot level	5.6	772	4,317	49,000	.36	22.3
500-foot level	8.3	450	3,711	42,000	.35	19.8
Totals and averages	7.8	775	6,064	318,000	0.31	16.4

Metallurgical tests on the ore have indicated that 96 per cent. of the gold and 75 per cent. of the silver can be recovered by cyanidation after grinding to 75 per cent. minus 200 mesh.

Wentricia Mines, Limited

Wentricia Mines, Limited, holds two groups of claims in the Favourable Lake area. The first group consists of 6 claims, Pa. 2,459–2,464, adjoining the property of Berens River Mines on the northeast; and the second, a group of 12 claims, Pa. 2,465–2,476, lies to the west of the Berens River property and includes the old Zionne showing.

The Zionne showing, described by M. E. Hurst,[1] consists of a narrow, cherty slate zone of sulphide mineralization in an amphibolitized basic intrusive. The zone was probed by a 60-foot diamond-drill hole in July, 1937, K. C. Murray being in charge of the work. A second 60-foot hole was placed to pick up a new gold discovery a short distance east, which consists of a narrow short quartz lens containing pyrite, pyrrhotite, and chalcopyrite, associated with actinolite in an altered basic intrusive. The writer was able to pan colours from surface material at this location. A third diamond-drill hole, 90 feet in length, was located in a silicified zone near the west boundary of the claims of Berens River Mines. The three holes gave inconclusive or negative results.

Other Claims

At the time of the writer's visit, four men were carrying out a programme of assessment work on a group of 18 claims known as the Graves, Macdonald, and Sternberg group, Pa. 3,471–3,488, K. C. Murray being in charge of the work. No mineral occurrences of economic importance were reported.

[1]Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 2, pp. 81, 82.

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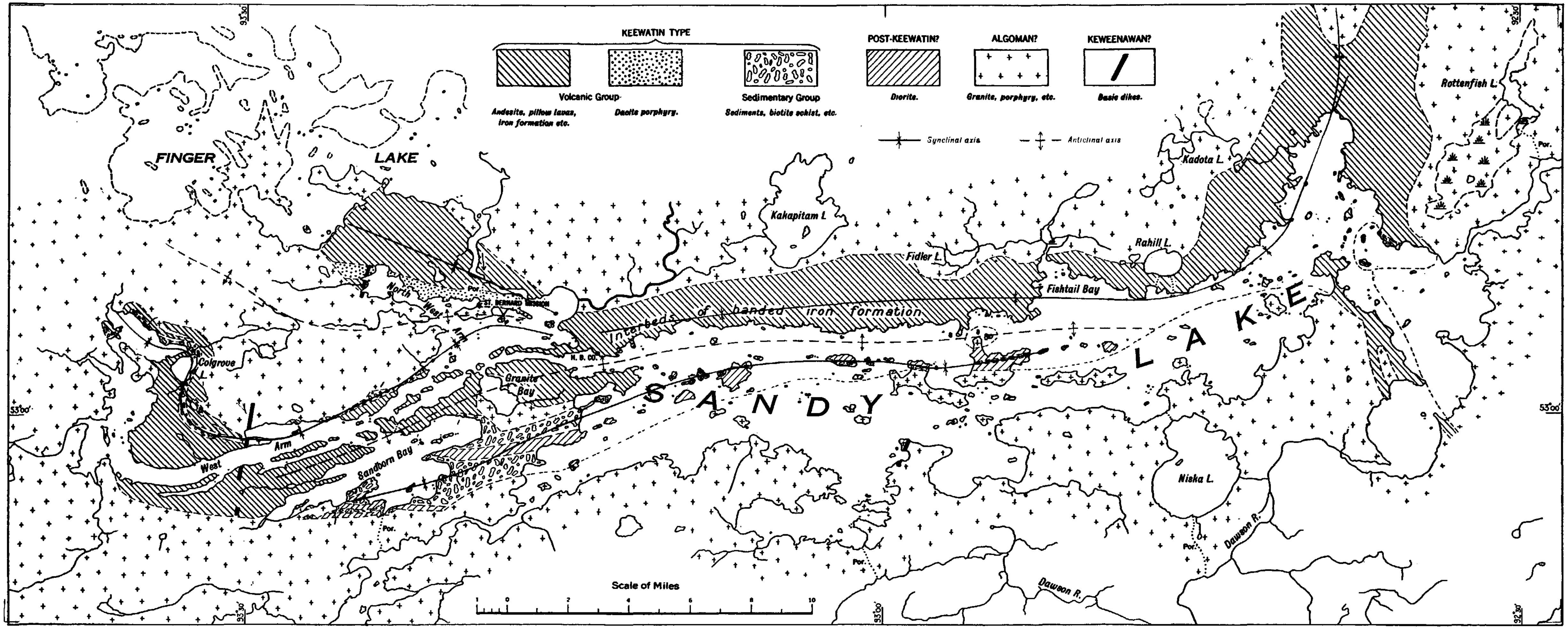


FIG. 3—INTERPRETATION OF THE GEOLOGICAL STRUCTURE ON SANDY LAKE.

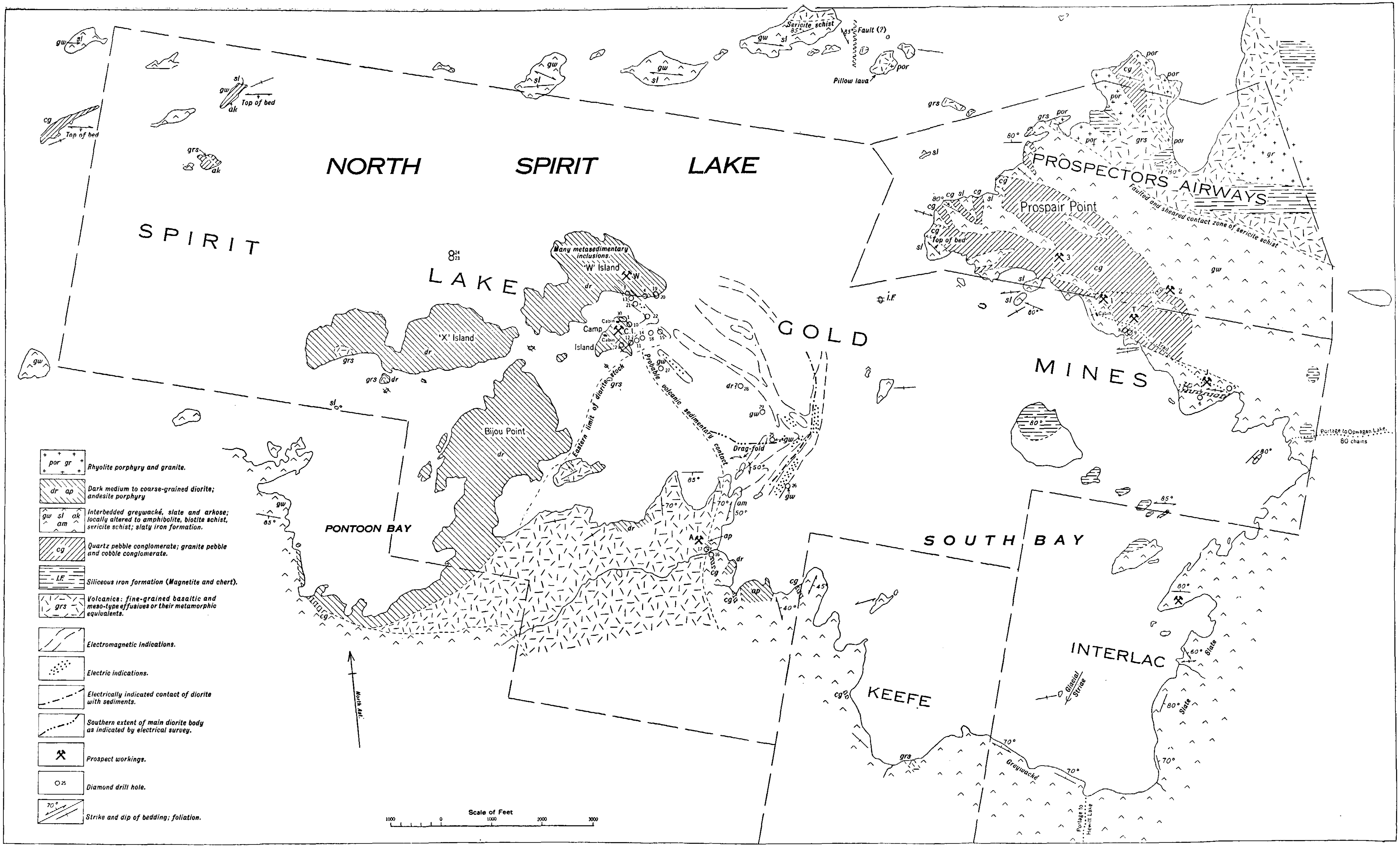


FIG. 3—GEOLOGICAL SKETCH MAP SHOWING PROSPECT WORKINGS, DIAMOND-DRILL HOLES, RESULTS OF GEOPHYSICAL SURVEY, AND PRINCIPAL CLAIM LOCATIONS, SOUTH BAY SECTION, NORTH SPIRIT LAKE.

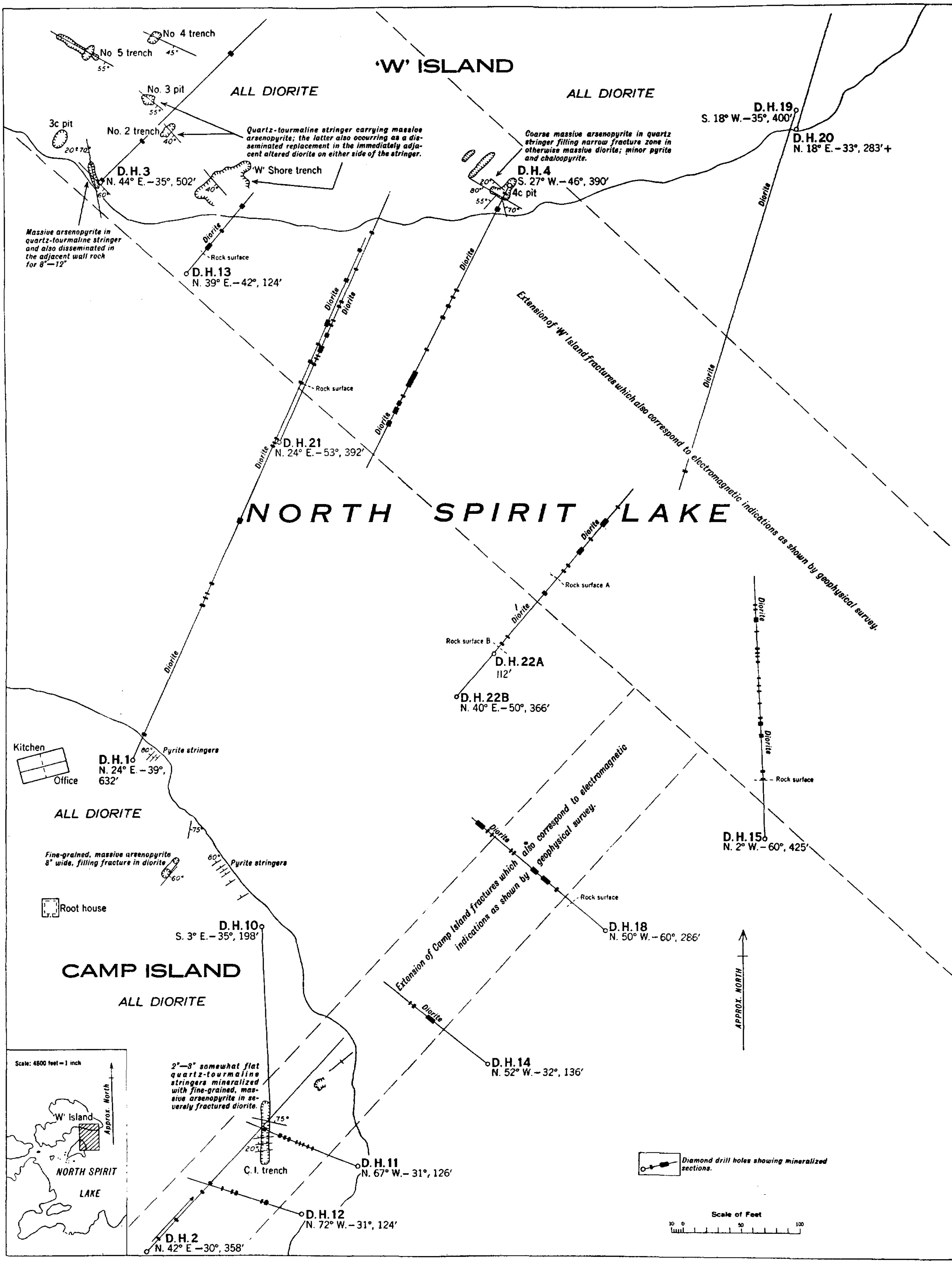


FIG. 4—PLAN SHOWING GEOLOGY, PROSPECT WORKINGS, AND RESULTS OF DIAMOND-DRILL HOLES, CAMP ISLAND AND "W" ISLAND SECTIONS, SPIRIT LAKE GOLD MINES.

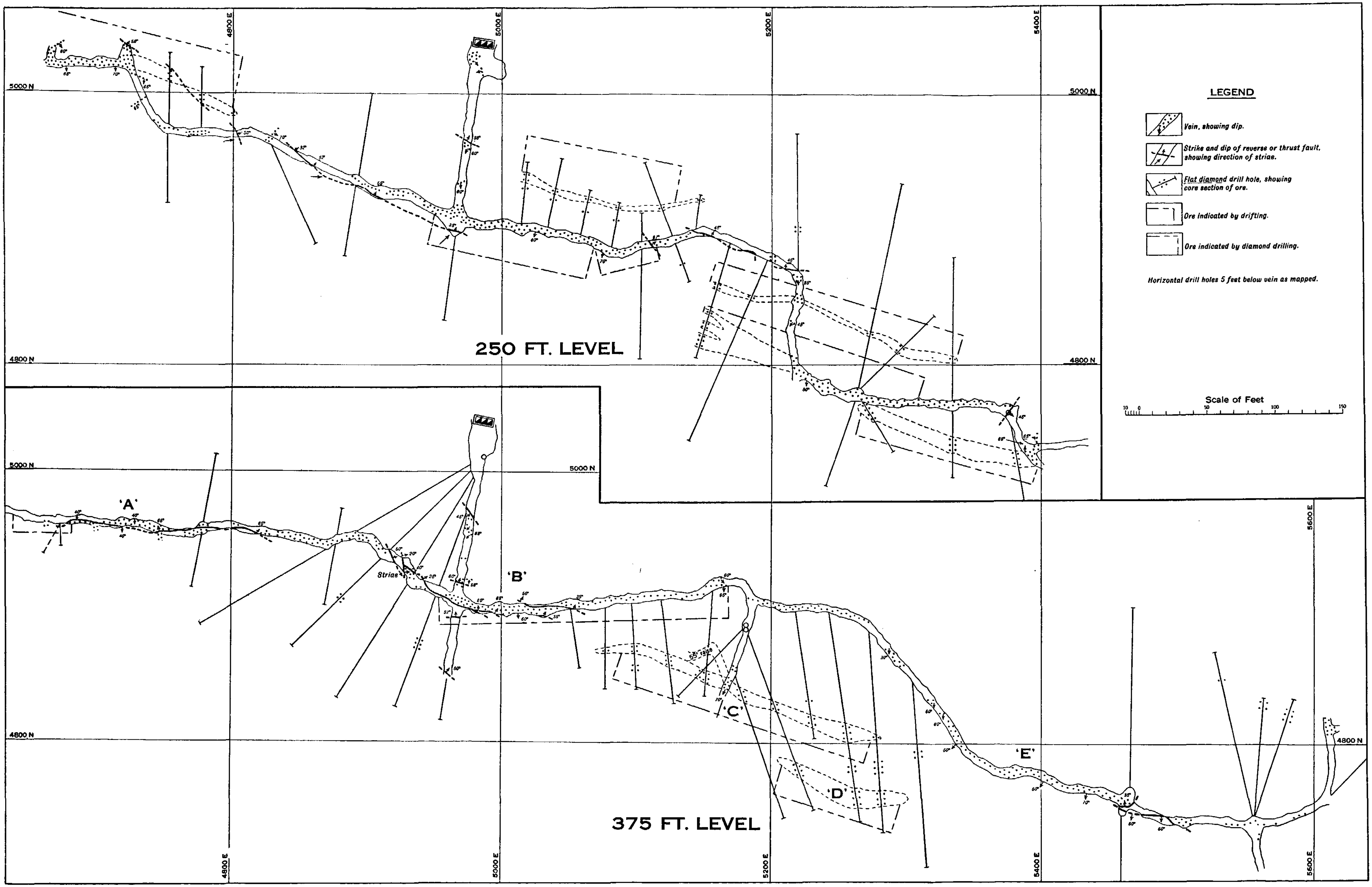


FIG. 3—PLAN SHOWING DIAMOND-DRILL HOLES AND UNDERGROUND DEVELOPMENT UP TO OCTOBER 1, 1937, ON THE 250- AND 375-FOOT LEVELS, BERENS RIVER MINE.

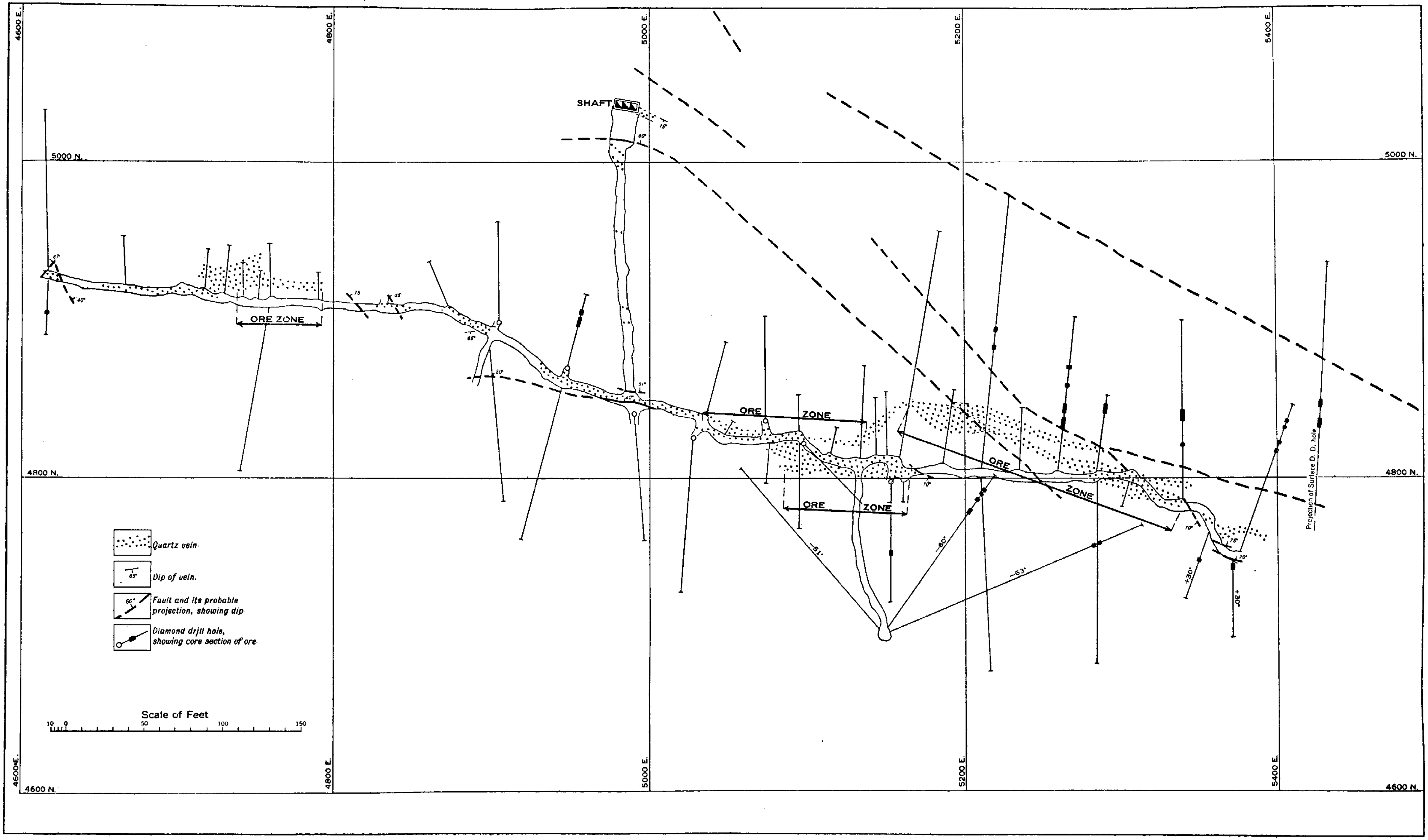
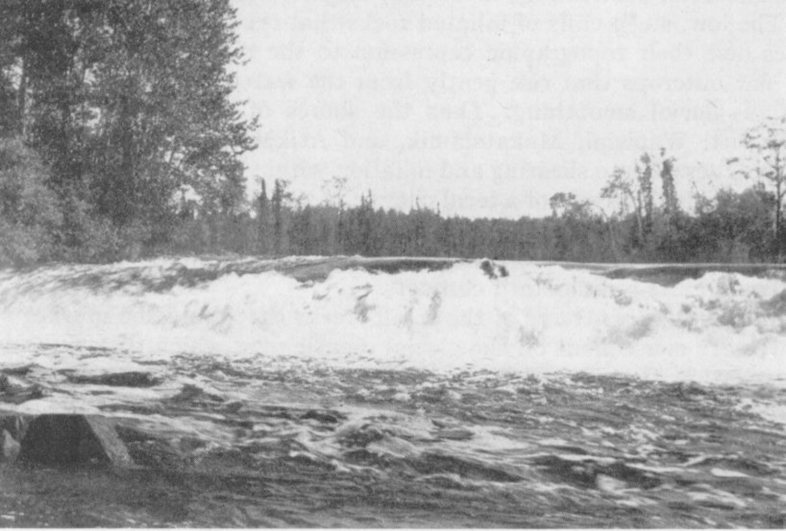
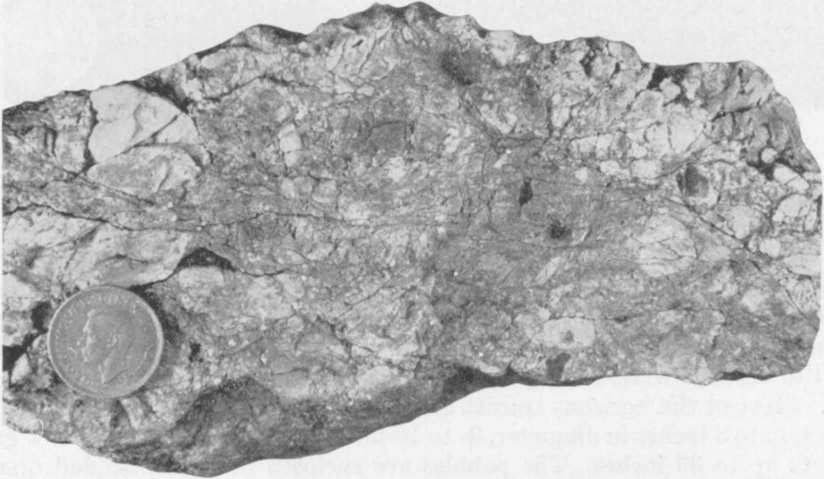
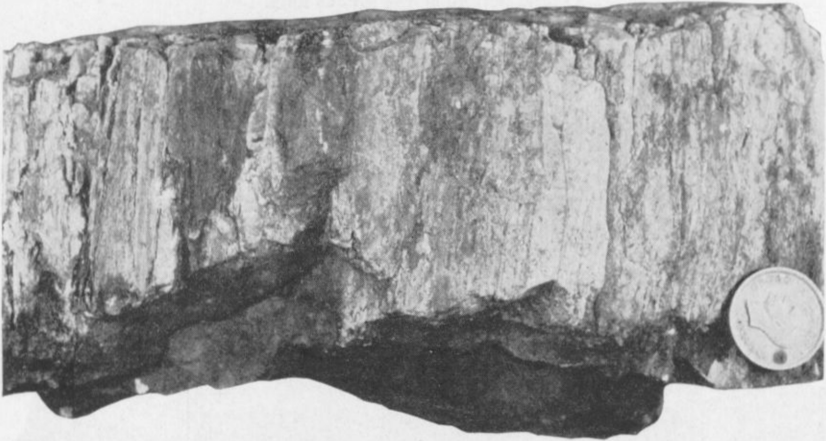
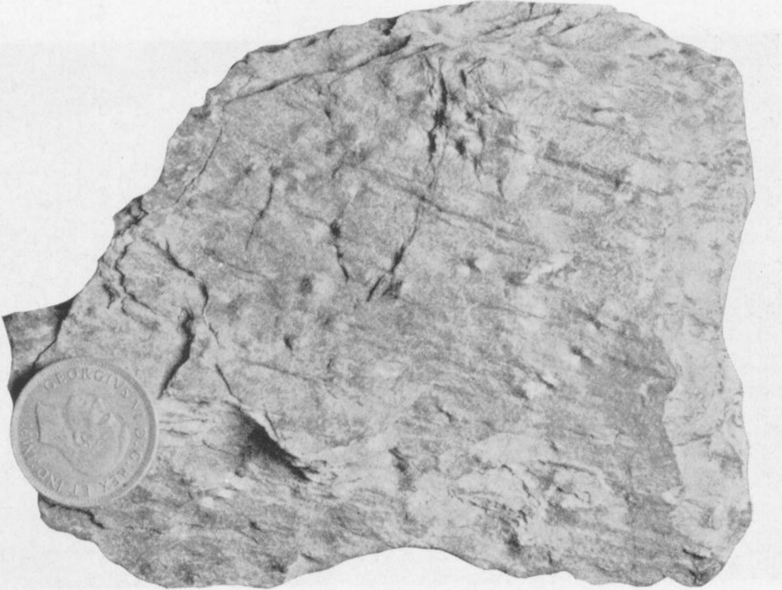


FIG. 5—PLAN SHOWING DIAMOND-DRILL HOLES AND DEVELOPMENT UP TO MARCH 31, 1938, ON THE 500-FOOT LEVEL, BERENS RIVER MINE.





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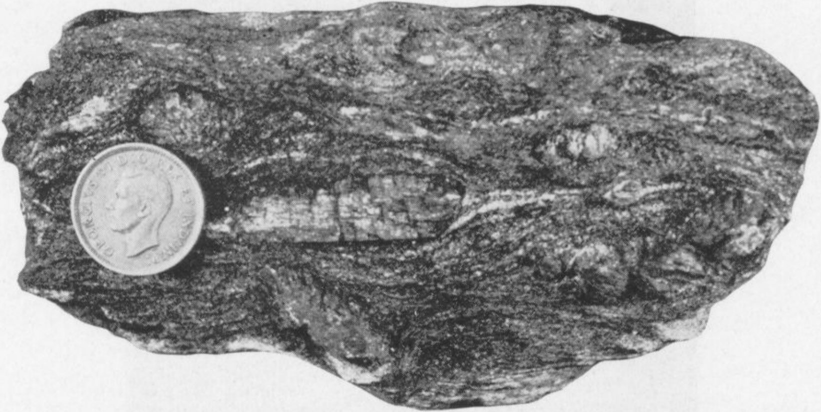

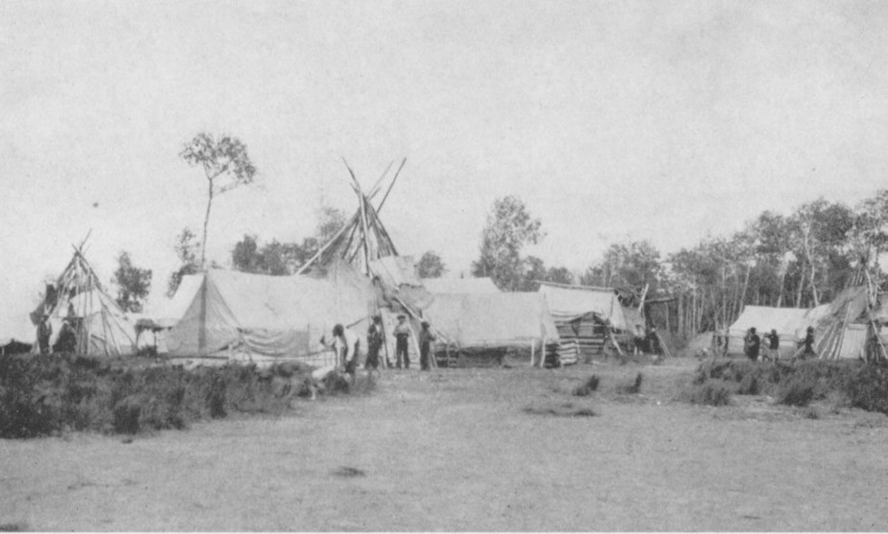

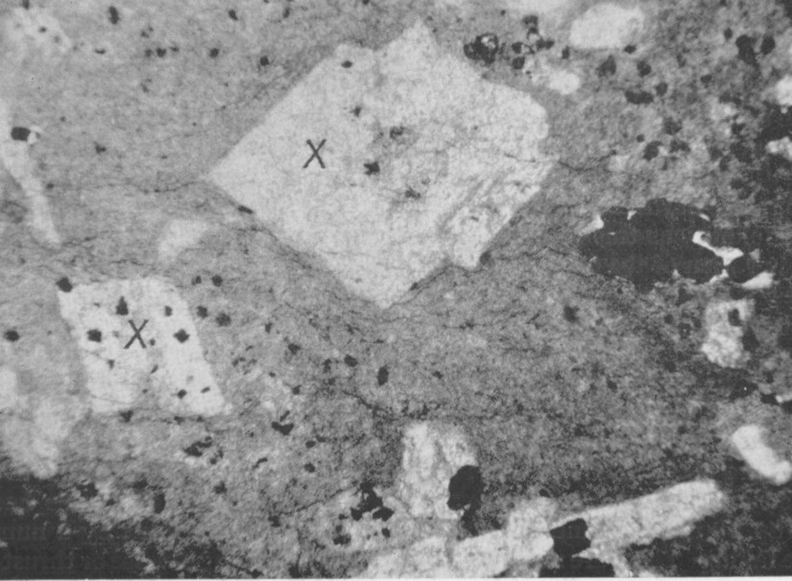
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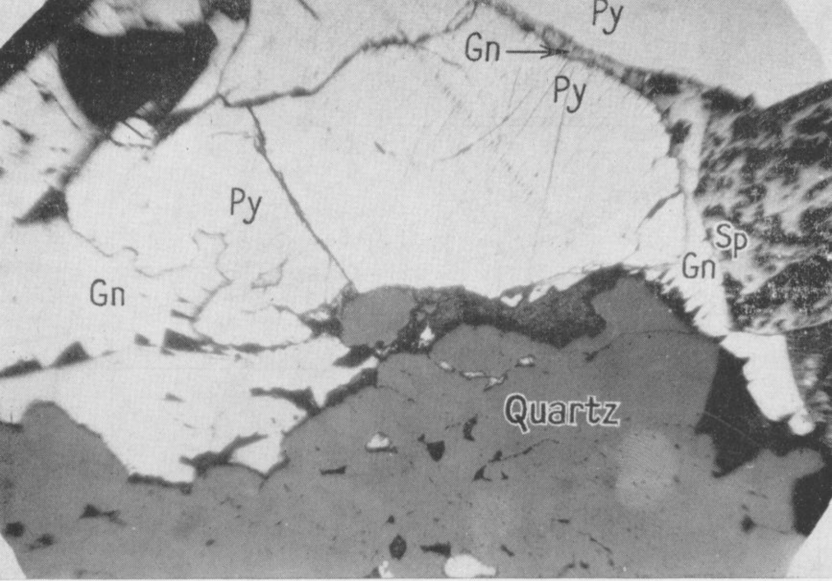
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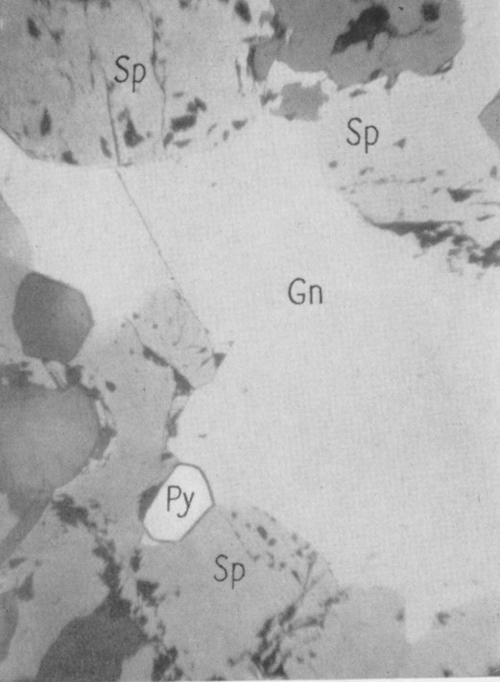
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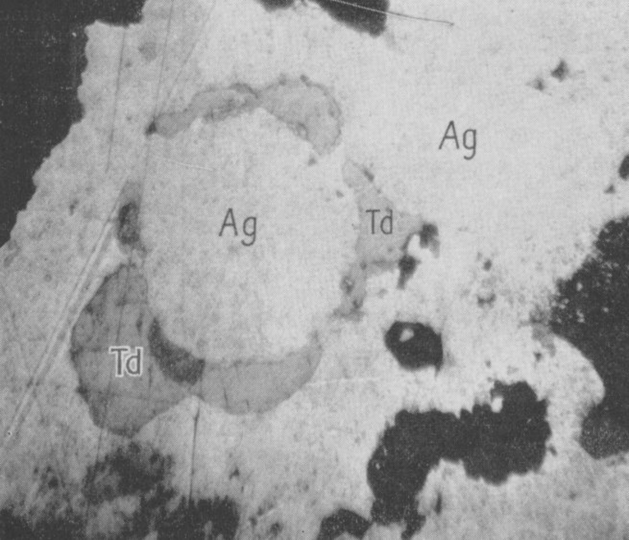
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