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# Geology of the Lumby Lake Area

By

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## COLOURED GEOLOGICAL MAP

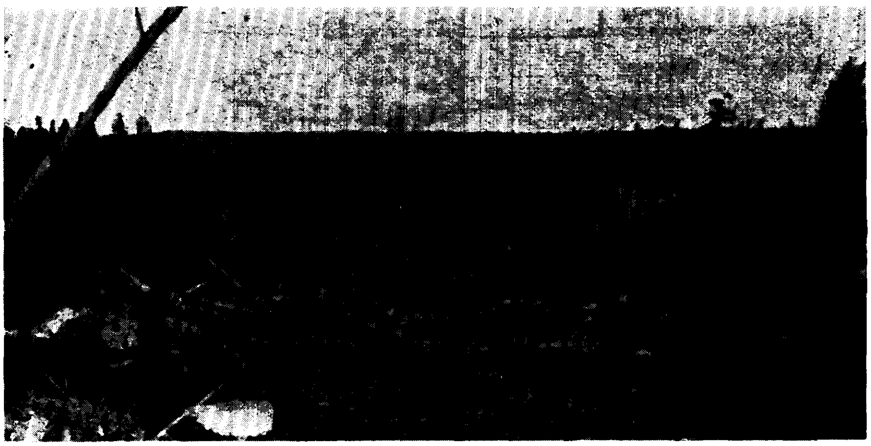
# Geology of the Lumby Lake Area

BY

Ralph S. Woolverton

## INTRODUCTION

During the 1951 and 1952 field seasons, the author was employed by the Ontario Department of Mines to carry out a geological survey on the greenstone belt in the vicinity of Lumby Lake, in the southeast corner of the District of Kenora. During the 1951 season the area between Redpaint and Bar lakes was surveyed, and in 1952 mapping was extended southwestward to Finlayson Lake and eastward to the boundary of the District of Thunder Bay.



View northward over Gargoyle Lake from the winter road to Pipestem Lake.

### Field Work

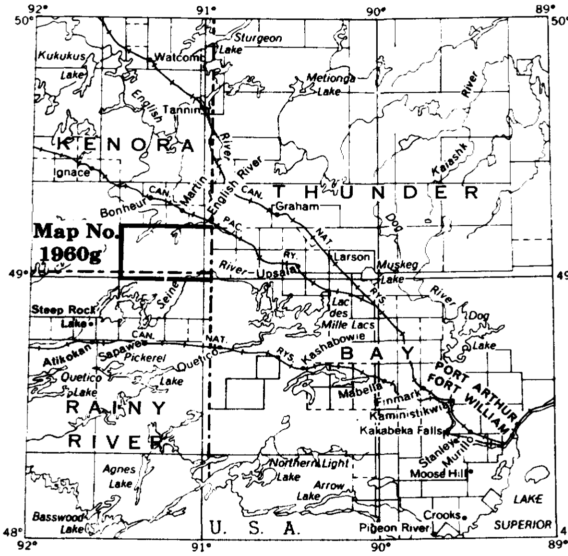
Mapping was done in the field on a scale of ¼ mile to an inch, using as base maps the Forest Resources Inventory maps of the Ontario Department of Lands and Forests. Mapping was carried out by canoe along the shorelines of the lakes, and by traversing overland between known points, usually locations on lakes, recognizeable on air photographs. Traverses were about ¼ mile apart and were laid out to cross the strike of the schistosity, formations, and contacts at high angles. Air photographs on the same scale as the base maps were used to spot tie-in points of traverses but were found to be useless for mapping outcrop because of the heavy obscuring bush. Overland traversing was found to be very difficult because of the dense undergrowth and the slash in recently cut-over areas.

## Acknowledgments

During the 1951 season, the author was ably assisted by R. A. Knutson, R. L. Pretty, S. Korchuk, and the late Charles Billington. In 1952, A. J. Laurin, J. A. Outram, and G. E. Bouchier provided able assistance. The kind hospitality and assistance of Noranda Mines Limited, the Great Lakes Paper Company, and J. A. Mathieu Limited, is acknowledged.

The assistance of the members of the staff of the Provincial Air Service and the Ontario Department of Lands and Forests at Ignace, who serviced the party in the field, is also acknowledged.

Petrographic research on various rock types was conducted during the 1951-52 session at McGill University under a scholarship from the Research Council of Ontario. Dr. J. E. Gill directed the author's research at McGill University, and his assistance is gratefully acknowledged.




Key map showing the location of the Lumby Lake area. Scale, 1 inch to 50 miles.

## Previous Work

As far as is known, the first geologists to vist the area were Robert Bell and A. R. C. Selwyn of the Geological Survey of Canada, who together, in the course of a reconnaissance survey from Thunder Bay to Red River in 1871, crossed the eastern part of the greenstone belt from south to north by way of Brush Creek.

W. R. C. Smith of the Geological Survey of Canada crossed the greenstone belt by the Brush Creek route in 1890, making a micrometer and compass survey. The following year, William Lawson mapped the chain of lakes southwest of English River station, on the Canadian Pacific railway, and Smith made his way, with difficulty, across the greenstone belt from English River via the Scotch lakes and Norway Lake. In 1892, Smith and W. W. Leach continued explorations in the Scotch lakes–Norway Lake area, remapped the topography around Pyramid Lake, crossed to the Seine River via Brush Creek, and worked northwards in a vain attempt to find a route to the Scotch River system. From Steeprock Lake, these early investigations were extended as far north as Redpaint Lake. In 1896, William McInnes of the Geological Survey of Canada crossed the greenstone belt via the Scotch-Irish-Welsh-Norway lakes–Bar Creek route found by Smith in 1891. The results of the investigations by McInnes and Smith were compiled by McInnes, after Smith's death, and appear on the Seine River Sheet (Map No. 6, of the Geological Survey of Canada, issued in 1897). This map outlines the greenstone belt very much as it is known today.

Although the area received considerable attention from prospectors in the late 1890's, it was not visited again by geologists, as far as is known, until 1937, when L. F. Kindle traversed the area during a reconnaissance survey for the Geological Survey of Canada. The report on this field work was written by T. L. Tanton in 1938.

K. C. Rose of the Industrial Development Department of the Canadian Pacific Railway Company surveyed the area between Norway and Hematite lakes in 1951, and A. E. Rissanen completed the survey as far as Upsala in 1952.

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## Location

The area mapped is that part of the greenstone belt and adjacent granitic rocks lying between the north end of Finlayson Lake on the southwest and the boundary of Thunder Bay District on the east. This area lies about midway between the Canadian National Railways' Port Arthur–Winnipeg line, and the Canadian Pacific Railway's main line. Lumby Lake is about 20 miles due south of the town of Bonheur on the C.P.R. The part of the greenstone belt examined lies mainly within the District of Kenora.

## Access

The area is accessible by pontoon- or ski-equipped aircraft from bases at Dryden, Ignace, and Fort Frances. Commercial aircraft operate from Dryden and Fort Frances, and the Provincial Air Service of the Ontario Department of Lands and Forests has an aircraft based at Ignace, a divisional point on the C.P.R. about 30 miles northwest of Lumby Lake.

Motor roads from Martin, on the C.P.R. and the Trans-Canada Highway, to Upper Scotch Lake and to within a ¼ mile of Norway Lake have been built by Great Lakes Paper Company. Truck roads lead from Sweden Lake to other camps west of Norway Lake, and many winter roads and haul roads have been built in this area.

From Sapawe on the Port Arthur–Winnipeg line of the C.N.R., J. A. Mathieu Lumber Company has built a motor road, which provides access to the company's camps in the eastern part of the area. Use of these private roads is subject to regulations laid down by the companies. Another truck road, now largely overgrown, leads from English River station on the C.P.R. to an abandoned lumber camp midway between Pyramid and Prism lakes. Many haul roads and winter roads have been built in the Keewatin–Pipestem–van Nostrand lakes area during recent lumbering activity. In the western part of the area, wagon roads and trails cut during early mining and lumbering activity are now mostly overgrown. The old stage road, which led from Bonheur on the C.P.R. to the Sawbill and Hammond Reef gold mines on Marmion Lake and which follows the east shore of Redpaint Lake, is now very difficult to locate. A few new trails were cut during the renewed prospecting activity in 1951-52.

Various canoe routes provide access to the area. From English River on the C.P.R. or the Trans-Canada Highway, entry can be made by way of Scotch River and Lower Scotch Lake. Also from English River an ancient Indian canoe route leads to the eastern part of the area via Hawk and Squirrel lakes to Pyramid Lake, where the greenstone belt can be crossed via Brush Creek. Entry can also be made to the eastern part of the area by descending the Firesteel River from Upsala to the Seine River and then ascending Brush Creek to Oldman Lake. The early explorers, Bell and Selwyn, approached the area by descending the Seine River from Lac de Mille Lacs.

From Steeprock, entry could be made to Redpaint Lake through Marmion Lake and Sawbill Bay. A canoe route is shown on early maps, but some of the portages could not be found. A service road from Steeprock to the diversion cuts at Raft Lake provides motor transport to within a few miles of the southwestern part of the area.

The network of lakes and streams provides excellent canoe routes throughout the area; the portages are generally short and well cut out, and many of the portage trails in the eastern part of the area have been replaced by haul roads during recent lumbering operations.

It is of interest to note here that the motor roads from Sapawe to Keewatin Lake, and from Martin to Norway Lake could be linked by the building of 5–6 miles of road, thus providing a route from the Trans-Canada Highway to the Atikokan highway.

## Topography

This area, like so much of the Precambrian part of Ontario, has relatively low relief, with differences in elevation rarely exceeding 300 feet. Locally the country has rather a rugged nature due to a succession of ridges and valleys more or less parallel to the direction of schistosity, and to the presence of pronounced linear valleys across these features.

The highest points of the area preserve parts of a peneplane, rejuvenated by uplift and dissected during parts of one or more preglacial erosion cycles. Pleistocene glaciation modified and rejuvenated the landscape again, and, with the last retreat of the ice sheet, the present river erosion cycle was started. It is still in an extremely youthful stage.

The area includes parts of two main watersheds. Most of the greenstone area is drained southward into the Seine River system. North of the divide the drainage is northward into English River. Because the area lies on the divide, the run-off via the streams of the region is small, and in dry weather the streams are reduced to mere trickles. For this reason water-power resources of the area are negligible. Oldman Lake is used as a log-holding basin by J. A. Mathieu Lumber Company. A dam and sluice have been built at the outlet of the lake; pine logs are dumped on the lake ice in winter and after spring break-up are floated via Brush Creek and the Seine River to the mill at Sapawe.

The main lines of drainage were established by preglacial streams and show considerable subsequent adjustment to the bedrock structure. The present pattern of lakes and streams is in part consequent in the old drainage lines and in part upon the glacial debris spread over the landscape. The present drainage system is a good example of the influence of the structure of bedrock on consequent drainage, with modification by damming by glacial debris.

### Flora and Fauna

The forest of the area is mainly coniferous; the most abundant trees are spruce, balsam, jackpine, poplar, cedar, and birch. Good stands of white pine occur in areas of sandy ground moraine. Timbering, i.e. lumbering and tie-cutting, has been carried out in the past near Norway and Redpaint lakes; and pulpwood is now being cut near Riverview, Seahorse, and Norway lakes. White pine is being lumbered in the Oldman-Keewatin-Pipestem lakes area by J. A. Mathieu Lumber Company, and a small tie-cutting plant is operated south of Richardson Lake by the same company.

A dense, vigorous second-growth of alder, balsam, spruce, and jackpine over much of the area seriously hampers overland traversing and prospecting. Considerable slash in recently cut-over areas also hinders overland travel, but other parts of the area are accessible because of many roads and trails cut during lumbering operations.

Moose and deer are very scarce in the area. Black bears are numerous and threaten prospectors' and surveyors' provisions left unprotected. In most of the lakes the only plentiful fish is pike and yellow pickerel, but a few small lake trout were taken from Redpaint Lake, and large lake trout are reported to be common in the clear waters of Norway Lake.

## GENERAL GEOLOGY

The greenstone belt in the Lumby Lake area is one of many such belts of similar early Precambrian rocks that occur in the country between Lake Superior and Lake Winnipeg. Though smaller than many of these, averaging only 3–4 miles in width, it is made up of the typical assemblage of early Precambrian (Keewatin-type) basic and intermediate lavas and pyroclastic rocks with some sediments, in most places highly altered, schistose, and steeply folded.

At several places in northwestern Ontario, evidence of two periods of granitic intrusion in the granite complex has been found. On the assumption that these two ages are the same, wherever found, the term Laurentian has come to be used to designate the older age, and the term Algoman to designate the younger. Laurentian granite has been recognized only where early Precambrian sediments overlie it unconformably, as at Steeprock Lake. The Laurentian granite shows a variety of lithologically different phases, as does also the Algoman granite, which is recognized as intruding early Precambrian sediments. Where relationships of the granite with Temiskaming-type strata cannot be investigated, the granite cannot definitely be assigned to the Laurentian or Algoman. In the Lumby Lake area certain areal correlations are assumed in the granites bordering the greenstone belt, and on this and other debatable evidence Laurentian and Algoman granites are tentatively distinguished. For this reason the terms Laurentian and Algoman are used in this report with considerable reservation, and with the realization that, within the area covered, conclusive evidence for two ages of granite is lacking.

TABLE OF FORMATIONS

| | |
|---|---|
| CENOZOIC | |
| RECENT: | Alluvial deposits in lakes and along rivers. |
| PLEISTOCENE: | Boulder clay; varved clay; glaciofluvial deposits of boulders, gravel, sand, and silt. |
| | *Great Unconformity* |
| PRECAMBRIAN | |
| ALGOMAN (?): | Hornblende and biotite granite and granite gneiss; syenite; aplite and lamprophyre.<br>Metadiorite (may be pre-Algoman, and in part Keewatin). |
| LAURENTIAN (?): | Altered hornblende and biotite granite and granite gneiss, mainly sodic; porphyritic granite, granite porphyry (quartz porphyry). |
| | *Intrusive Contact* |
| KEEWATIN-TYPE: | Argillite (mostly graphitic, and in part concretionary); fine-grained argillaceous greywacke; conglomerate; crystalline limestone; iron formation; and hornblende, garnet-mica, andalusite-biotite-garnet, graphite and other schists; cordierite-garnet-mica, and other hornfelses derived from the sediments.<br>Altered basic and intermediate volcanics; minor rhyolite; tuff, agglomerate, flow breccia; minor interbedded quartzite, and argillite; and hornblende, biotite, chlorite, sericite, and carbonate schists and hybrid rocks derived from these various types of rocks.<br>Includes some intrusive metadiorite, and serpentinite (may in part be post-Keewatin). |

## Keewatin-Type Volcanics

### FLOW ROCKS

Most of the volcanic rocks of the Lumby Lake greenstone belt are altered basic and intermediate lavas, mainly andesite and basalt, with minor dacite. These are the oldest rocks of the area. The term greenstone is used to designate the altered equivalents of basic and intermediate lavas. Most of the original minerals of the volcanics have been altered to a mass of chlorite, epidote, and carbonate; with such a high degree of alteration, it is difficult to classify them according to their original mineral composition. Thus the names given are based on the general field appearance, on the presumed original composition as suggested by residual minerals, or by the nature of the alteration products.

Though the Keewatin rocks have been reconstituted mineralogically by regional metamorphism, the original texture and structure have been preserved in many places and are best seen on clean, weathered surfaces. Only in relatively few places are such primary structures as pillows, amygdules, and flow top features preserved in such form as to be valuable for determining the tops and bottoms of flows. Pillow structures are often distorted by shearing, and the pillows may be drawn out to many times their original length, thereby losing the shape and packing characteristics that are the top-determining criteria.

Amygdaloidal structure is common and is especially noticeable in the pillowed parts of flows. Nowhere, however, was it well enough preserved or exposed to be useful for top determination. Ropy structure was observed in several places but was not very useful in delineating flow contacts, and only in one place could the direction of top of the flow be determined by such a contact.

Textures in the greenstones range from aphanitic to coarse-grained. Grain gradation in individual flows was seldom observed and nowhere is exposed well enough to serve as a means of indicating tops and bottoms. Most of the flows are fine-grained equigranular, but a few andesites are porphyritic.

The Keewatin-type lavas in the greenstone belt are basalts, andesites, and minor dacites. In general, it is in the field that classification can best be made, as these rocks in thin section are seen to be altered to a mat of chlorite, epidote, secondary feldspar, carbonate, kaolin, and other secondary minerals, with little or no indication of the primary minerals. In the field, the colour of the weathered surface was used to a large extent to differentiate between basalt and andesite, the former being dark-green to black on the weathered surface, whereas the latter is light-green or grey-green. Fresh surfaces were found to be similar in colour and texture.

Basalt, or its relative greenstone, is less common throughout the southern part of the area than andesite. North of the band of sediments basalt is more common, representing about 75 percent of the flow rocks. This areal distribution was found impossible to map because of intermediate types between the two.

Dacite is found only in the southwestern part of the area, along the northwest shore of Lumby Lake and Spoon Lake. It is a medium-grained porphyritic grey-green rock, weathering to a light-green surface on which feldspar crystals up to ¼-inch weather in relief. It is not so completely altered, possibly because of its more acid composition, as the basalt and andesite of the area. It occurs with, and in places appears to grade into, non-porphyritic andesite. Also, with the diminution of the porphyritic texture and the introduction of a few quartz phenocrysts, it seems to grade into a rhyolite porphyry towards the south. For this reason it is possible that at least some of the acid porphyritic rocks in the Lumby-Jefferson lakes area may be equivalent in age to the Keewatin-type greenstones. That the dacite is extrusive is supported by the presence of dacite fragments in agglomerate at Lumby Lake.

Under the microscope, the typical andesite shows a primary crystalline structure, and is composed of subhedral crystals and microlites of plagioclase in a groundmass of epidote, chlorite, quartz, and opaque minerals. The plagioclase, forming about 30 percent of the rock, is albite, indicating that the lava is spilitic. Furthermore, the presence of spilitic metadiorite and the high-soda southern granites suggest that albitization may be fairly widespread.

In several places a porphyritic andesite is exposed. North of Rea Lake, a formation about 100 feet thick striking N.80°W. can be traced for about 1½ miles. Other occurrences are found on the large peninsula in Bar Lake, on the trail between Rea and Spoon lakes, and ½ mile south of the west end of Lumby Lake.

This rock has been rather aptly termed "golf ball porphyry" by prospectors. It occurs rather frequently in the greenstone areas of northwestern Ontario and has been described by various geologists. Wright[1] has applied the name "leopard rock" to it because of its spotted appearance.

[1] D. G. H. Wright, *The Black River Area*, Ont. Dept. Mines, Vol. XXX, 1921, pt. 6, pp. 27–60.

This porphyritic lava is composed of a medium-green, fine-grained groundmass, probably originally andesitic in composition in which are set idiomorphic phenocrysts of feldspar up to 1½ inches in diameter, which are generally quite subordinate to the lava matrix and are in places well rounded in outline, suggesting either movement within the flow or corrosion by chemical reaction with the matrix. Locally the rock grades into a greenstone schist, which has lenses of lighter-coloured material, which are obviously sheared phenocrysts.

A thin section cut across a phenocryst was expected to reveal the type of feldspar by microscope study, but though the crystal outline was visible, the interior was found to be composed of a mass of anhedral grains of clinozoisite, which represents the alteration of the original calcic plagioclase.

### ACID ROCKS OF DOUBTFUL AGE

Some of the finer-grained acid rocks in the area mapped as a quartz porphyry-diorite complex may be extrusive rhyolites and associated dike rocks of the same age as the Keewatin-type greenstones. The largest area of these fine-grained acid rocks extends from the west end of Lumby Creek eastward to Richardson Lake and ranges in width from about 1 mile at Spoon Lake to 20-foot zones near Richardson Lake. Most of this area is considerably, and in places intensely, sheared, much of the quartz porphyry being altered to a quartz-sericite schist. In the vicinity of Richardson Lake the porphyritic nature is almost entirely absent, and the narrow zones are altered to fine-grained, white-weathering, quartz-epidote rocks with minor garnet. Narrow sill-like bodies of quartz porphyry occur north cf Gargoyle Lake, but evidence of an intrusive or extrusive nature is lacking.

That the larger area of quartz porphyry is extrusive is suggested locally by an apparent gradation from dacite into quartz porphyry. Also the presence of acid tuffs and quartzites seems to indicate that acid rocks such as those under question were erupted or exposed during Keewatin time. On the other hand, the gradation southwards in this area from rhyolite porphyry, through granite porphyry, and porphyritic granite into Laurentian (?) granite suggests that they are all related to a single period of intrusion.

The presence of metadiorite of pre- and post-Laurentian age is a further obscuring feature near the south contact.

The same situation exists on the south side of the Laurentian (?) granite in the Sapawe Lake area 15–20 miles to the south. Hawley[1] considers all the quartz porphyries (felsites and micropegmatites) to be of Laurentian age. Here also the relationships of the intrusions of diorite and gabbro are not clear, but Hawley recognizes a pre- and post-Laurentian set of intrusives.

### VOLCANIC FRAGMENTALS

Various types of volcanic fragmentals occur throughout the area, mainly as occasional thin beds separating lava flows. Acidic varieties appear to be most abundant, though the predominance over basic types may be more apparent than real, since metamorphism may have altered the basic tuffs to such an extent that they are no longer recognizeable.

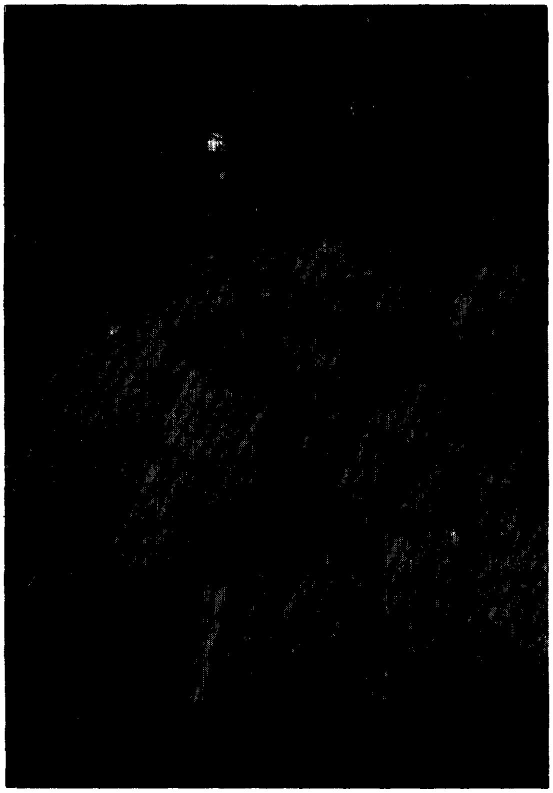
The texture ranges from very fine-grained tuffs to agglomerates with fragments up to 8 inches in diameter. In several places a gradation from agglomerate to tuff was used for top determination.

Except for a band of agglomerate-tuff that extends from Lumby Lake to north of Spoon Lake, a band of acid tuff extending from Rea Lake to Bar Lake,

[1]J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, p. 11.

and a band midway between Upper Scotch Lake and Leach Lake, the volcanic fragmental horizons are of limited length, and though many outcrops were observed, they could not be correlated between adjacent traverses.

Flow breccias were observed in a few places within the greenstone area. On a point in the south bay of Bar Lake, angular fragments of andesite and hornblende schist occur in an andesite matrix. There is no indication of any bedding, the



**Agglomerate on north shore of Lumby Lake.**

fragments are jumbled together, and the rock is not schisted. A somewhat similar rock is exposed at the south side of a small lake at the side of the road south of Hematite Lake but is considerably schisted.

Volcanic fragmentals appear to be more common in the western part of the area than in the east.

### GREENSTONE SCHISTS

Various types of schists have been derived by regional and contact metamorphism of the greenstones, and these grade either into the massive greenstones recognizeable as originally volcanics or into dioritic intrusions. Varying degrees of schistosity are recognizeable in nearly all the oldest rocks of the area and in the higher degrees it has obliterated the primary volcanic structures.

The most common types are chlorite schist, chlorite-carbonate schist, and actinolite schist, which are the result of low-grade regional metamorphism. Near the north contact, and in the tongue extending westward from Redpaint Lake, and east of Upper Scotch Lake, hornblende and hornblende-biotite schists predominate. In the shear zone near the south contact, and in the sheared and dragfolded zone on the east side of Redpaint Lake, and in minor shear zones in various places, sericite schist and sericite-carbonate schists have been developed.

In the area between Norway and Rea lakes and eastward north of Bar Lake, banded schists derived from Keewatin volcanics are common. The banding appears to be due to the metamorphic effect of the intrusion of Algoman granite on previously schisted greenstone, and has given rise to pseudo-bedding. If any one band, ⅛–¼ inches wide, is traced along strike it is found to be either discontinuous or to double back forming a parallel band, finally forming a very elongate closed figure.

## Early Precambrian Sediments

### MINOR SEDIMENTS

Interbedded at various places in the Keewatin volcanics are minor beds of quartzite, argillite, and iron formation. These beds are relatively narrow, although the complete width is seldom exposed, and some are represented by a single small outcrop. All of them stand vertically, or nearly so, and few are traceable between traverses. Some are too small to be shown on the map at the scale used. It is difficult in the field to distinguish between fine-grained sediments and volcanic tuffs, especially between their schistose derivatives.

These narrow bands of sediments occur both north and south of the main band of sediments but are more numerous to the north. They are especially common in the areas west of Norway Lake and north of Cryderman Lake. Even here, correlation of zones between adjacent traverses was not possible. Magnetic attractions of various intensities are associated with some of these narrow bands, and since many such attractions are found in areas of no outcrop, it is concluded that many unmapped zones occur.

### MAIN SEDIMENTARY BAND

A band of sediments, 300–3,500 feet wide, extends from east of Brush Creek to the west end of Seahorse Lake. It strikes N.80°W., and its various members dip vertically or nearly vertically. Its position is marked over most of its length by a series of lakes whose basins have been eroded out of the softer components of the belt. In the vicinity of Norway Lake, it is intruded by Algoman (?) granite; at the east end of Hematite Lake, a granite intrusive, the so-called van Nostrand stock, intrudes the sediments and forms a 3-mile gap in the belt. To the southeast, the band of sediment approaches to within 1 mile of the Laurentian (?) granite, but the mutual age relationships are not known.

This main band of sediments is composed of cherty iron formation with local carbonate rock and conglomerate, overlain by fine-grained argillaceous greywacke with important lenses of graphitic and concretionary argillite, and local conglomerate. Regional and contact metamorphism has produced a variety of schists and hornfelses. West of Garnet Bay minor amounts of Keewatin-type volcanics are interbedded with metamorphosed sediments.

The sediments appear to lie along, or near, the trace of the axial plane of a major syncline interpreted from structural determinations in adjacent volcanics; a relationship suggesting that the sediments are at or near the top of the greenstone sequence in the area. No evidence for unconformity was found at the poorly defined contacts.

West of Garnet Bay, large areas of the sedimentary belt are hidden under muskeg and masked by thick vegetation; a few outcrops of fine-grained tremolite schist and cherty iron formation were found, as well as graphite schist and argillite, near Seahorse Lake. Cherty silica is found near Garnet Bay, also highly metamorphosed argillaceous greywackes and banded carbonate rock. Contact metamorphism in the argillaceous sediments has given rise to a variety of schists and hornfelses, the most common being garnet-mica schist, which forms most of the band between Garnet Bay and Pinecone Lake. Lean banded iron formation occurs between Spool and Pinecone lakes and extends eastward along the north shore of Pinecone Lake as a high cliff. Graphitic argillite occurs as narrow lenses in argillaceous greywacke on the south side of Pinecone and Cryderman lakes. Iron formation extends from Cryderman Lake eastward to the east end of Hematite Lake, and a large lens of argillite overlying it forms the south half of the belt at Hematite Lake. Siderite and massive sulphide are found associated with interformational breccia at, and near, the contact of the iron formation and argillite in this area. Iron formation overlying metamorphosed argillaceous greywackes occurs at the east end of Hematite Lake and east of van Nostrand Lake.

East of Brush Creek, the rocks in the sedimentary belt become more schistose and, in the few places seen, are altered to quartz-sericite schist.

#### Iron formation

The various phases of the fine-grained cherty silica formations found at various places along the main belt of sediments are described under this heading. Much of it resembles a fine-grained quartzite in the field, but its general cherty character, its association with iron minerals, and a petrographic study of the different types has led to incorporation of the various phases under this main heading. Parts of it resemble most of the smaller zones of fine-grained cherty quartz, being white or buff weathering, generally fine-grained, and showing various degrees of banding. No part of it was found, in the field or in petrographic study, to resemble the quartzite near Hook Lake mentioned in a previous section.

The eight phases of the iron formation are:

- Cherty magnetite iron formation
- Recrystallized magnetite iron formation
- Cherty silica
- Banded silica and siderite
- Pisolitic siderite-chert
- Massive siderite
- Massive sulphides
- Inter- and intraformational breccia

The iron formation, in its various phases, occurs mostly in the northern part of the main band of sediments but is not continuous over the complete length. It ranges from narrow ½-inch bands in argillite, carbonate rock, and banded schists up to zones ¼ mile in width. Near the granite contacts, considerable recrystallization has taken place. Crystalline limestone occurs within it and is described separately. Some of the phases to be discussed are exposed only in the diamond-drill core from the Mathieu property but show features worthy of special description.

*Cherty Magnetite Iron Formation.*—Outcrops of fine-grained, cherty, magnetite iron formation were observed at two widely separated localities in the sedimentary belt, i.e. at the southeast shore of Seahorse Lake, and on a small island at the north end of Keewatin Lake. At both places, the rock consists of finely banded chert and magnetite. Narrow bands of magnetite 1/16–¼ inch in width are interlayered with lighter-weathering siliceous bands to ½ inch, in which minute magnetite crystals are disseminated. The magnetite bands weather to a dark reddish brown, whereas the siliceous bands weather to a medium grey or light orange.

Microscopic study of the siliceous bands in the iron formation at Seahorse Lake shows a fine granular mosaic of quartz grains averaging about 0.05 millimetres in diameter. The grains show no evidence of recrystallization such as sutured boundaries. Some of the quartz grains in the mosaic show wavy extinction. The granular nature of the rock is emphasized by red iron oxide stain that penetrates most of the intergrain contacts.

Anhedral crystals or groups of crystals of magnetite up to 0.02 millimetres in diameter occur disseminated throughout the siliceous bands; they constitute less than 5 percent of the rock. Iron oxide staining and fine acicular crystals of goethite are associated with the magnetite. Minute needles of actinolite, none exceeding 0.02 millimetres in length, occur throughout the section studied, mainly as inclusions in the quartz.

*Recrystallized Magnetite Iron Formation.*—A lens of magnetite iron formation about 300 feet wide occurs between Spool and Pinecone lakes and extends along the north shore of Pinecone Lake. It is probably a recrystallized equivalent of the type of iron formation similar to that described in the previous section. It consists of alternating bands of light-blue, grey, or red silica and black siliceous magnetite. The bands are commonly about ¼ inch, but in places are 1 inch or more in width. The dark bands are composed of mixed fine-grained magnetite and silica. The siliceous bands resemble a medium-grained vitreous quartzite. The iron content is probably not more than 20 percent.

In thin section, siliceous bands of this rock are seen to be composed of about 95 percent quartz and 5 percent pyroxene, magnetite, uralite, and calcite, with minor oxide staining.

The quartz occurs as irregular, interlocking grains up to 5 millimetres in diameter, and contains many inclusions of pyroxene, and magnetite, and zones of minute gaseous and liquid inclusions, some of which appear to outline the position of pre-existing quartz grains. Patches of quartz of different orientation occur within the large irregular grains. The quartz is highly strained, all grains having wavy extinction; the boundaries between the large grains are much serrated.

The pyroxene is a pale-green, slightly pleochroic augite occurring as corroded anhedral crystals averaging 0.2 millimetres in diameter. Some crystals have central zones of brown to yellow ferro-augite, and most have peripheral zones of alteration to the pale-green fibrous amphibole, uralite, which in most places 'sprouts' into radial arrangements up to 2 millimetres in size of long, curved needles, which invade the quartz grains.

Magnetite is in about the same proportion as pyroxene, being in subhedral crystals and crystalline aggregates up to 0.5 millimetres but averaging about 0.2 millimetres in size. Many small particles occur with pyroxene as inclusions in the quartz.

A very minor amount of calcite also occurs as patches of anhedral crystals within quartz.

This zone of iron formation has been subjected to contact metamorphism by the intrusion of Algoman (?) granite to the north and south. It is probable that the granite does not lie very deep below the surface in the area between the intrusives.

The contact metamorphism is marked here by changes in a rock of extreme silica composition, with a small amount of ferric iron, calcium, magnesium, and other elements. The metamorphism has reached the stage where the quartz has been completely recrystallized, with few recognizable traces of a fine-grained mosaic quartz as seen in the cherty magnetite iron formation, to larger interlocking grains with considerable evidence of strain.

*Cherty Silica.*—Under this heading are included those fine-grained, white- to buff-weathering, sugary-textured phases of the iron formation. This type of cherty silica (called quartzite in the field) was observed on the north side of Garnet Bay, between Cryderman and Keewatin lakes, and along the shores of Hematite Lake; it has also been intersected by diamond-drilling near Hematite Lake. It is relatively resistant to erosion and forms prominent hills; its association with weakly resistant carbonate rock accounts for the considerable relief in the

**Lenticular structure in cherty iron formation on north side of Garnet Bay.**

Pinecone-Hematite lakes area. Except where it is locally banded with carbonate rock, banding is not very prominent. Usually it consists of bands of white silica with narrow and irregular bands of pale buff-coloured silica; these bands are up to several inches wide. In places graphitic material occurs as narrow irregular discontinuous bands, which may give rise to shaly partings. A few pyrite cubes and siderite rhombs can be seen on fresh surfaces.

A small cliff on the north shore of Garnet Bay shows a lenticular structure in white cherty silica. The lenses are 1–2 feet long and 4–6 inches thick, and show faint laminal banding. They are exposed only in two dimensions, so their exact shape is not known. They resemble somewhat cherty lenses in the andalusite-biotite-garnet schist on the south side of the entrance to Garnet Bay. It is suggested that these cherty lenses were originally masses of gel silica formed on the bottom of a basin of deposition, perhaps because of slight agitation during precipitation of silica, which caused accretion about nuclei during the rolling around of the gel masses. The lenticular shape is due either to collapse under its own weight, or later deformation, or both.

A thin section of a typical specimen from the east end of Cryderman Lake shows, under the microscope, a fine-grained quartz mosaic with a granoblastic texture, forming about 97 percent of the rock. The quartz grains range from 0.05 to 0.3 millimetres in size.

Siderite occurs as small grains, as fine-grained aggregates, and as isolated rhombs, associated with cryptocrystalline aggregates of goethite and a small amount of granular calcite.

The cherty silica phase at Hematite Lake grades southward by an increase of siderite content into pisolitic siderite and massive siderite. At other places, as at the east end of Cryderman Lake, this siderite member is lacking. With an increase of iron carbonate, the rock weathers more rusty and red, until the weathered product is a sinter-like gossan.

**Folded banded silica and siderite iron formation near collar of No. 4 drill hole on Mathieu property; shows colour gradation across some bands, and micro-faulting across the fold structures.**

*Banded Silica and Siderite.*—Banded siliceous iron formation of the type described under this heading is well exposed near the east shore of Keewatin Lake. The best exposure shows well banded chert and cherty siderite highly folded and closely fractured and faulted. The bands vary from 2 inches to less than $\frac{1}{16}$ inch in width, and weather to black, brown, reddish-brown, buff, and white. The lighter, cherty layers show an apparent 'graded bedding' of coarse-to-fine granular chert with a corresponding change of colour from light to dark. This 'graded bedding' is uniform over the outcrop and nearby outcrops, and if bedding of clastic grains was being dealt with would suggest that the strata faced towards the east.

To the south of this outcrop similar banded iron formation has been uncovered by stripping, and heavy limonite gossan overlies bedrock over a considerable area on the hill to the northeast for several hundred feet.

A thin section of a drill-core sample of this type of rock, cut normal to the banding, shows, under the microscope, granoblastic quartz mosaic bands and carbonate bands. The quartz mosaic bands show a gradation of grain size across the bands. Some of the bands are almost pure quartz and these are generally coarser grained than those bands containing more carbonate. Across an average band the amount of disseminated siderite increases as the average size of quartz grains diminishes. Some of these siliceous bands grade by increase of siderite into the dark siderite bands; other siderite bands have sharp contacts with quartzose bands. The carbonate bands are composed of fine-grained siderite as anhedral aggregates and crystals averaging about 0.01 millimetres; cherty fine-grained quartz forms up to 30 percent. Within these bands occur fine, fairly continuous, parallel zones composed of an exceedingly fine-grained mixture of siderite, graphite, and stilpnomelane. Dark-brown pleochroic needles of stilpnomelane up to 0.5 millimetres in length and a few small (0.1 mm.) anhedral crystals of pyrrhotite occur in the siderite bands.

The axial plane of the folds in the banded iron formation, at the exposure mentioned above, strike about N75°W. and dip about vertical. Many minor faults strike about parallel to the axial planes, strike separations being from a fraction of an inch to several feet.

*Pisolitic Siderite-Chert.*—The diamond-drill cores from recent drilling on the Mathieu property at Hematite Lake provide much information about the siderite iron formation that cannot be obtained from surface exposures because of heavy gossan and iron-stained bedrock.

A pisolitic phase between massive siderite and sulphide on the south and more or less pure cherty silica on the north was observed in core from drill hole No. 5, of the 1952 program, at 208 feet deep.

A prominent oölitic or pisolitic structure was noted on the core surface and was prominent on a flat saw cut made across the core. According to Pettijohn,[1] such structures, if over 2 millimetres in diameter, should be termed pisolites rather than oölites.

The pisolites are roughly round in shape, averaging about ¼ inch in diameter. They are composed of alternating bands of creamy siderite and fine-grained chert, a single pisolite being composed of four or five alternating bands. Where a saw cut crosses the exact centre, a small pyrite crystal may show as a nucleus.

In thin section, the pisolites show as generally round or oval, ranging up to 0.6 millimetres in diameter, and are composed of at least two rings of fine-grained siderite and cherty quartz arranged around a small pyrite crystal. The interstitial areas between pisolites are composed of a cherty quartz mosaic, recrystallized in places.

Minor needles and sheaves up to 1 millimetre in length of pale-green stilpnomelane, and minor patches of chlorite occur within the siderite bands.

The presence of pisolitic siderite is an important consideration in the study of the origin of the siderite iron formation. There is no agreement in literature on the origin of oölitic or pisolitic structures. Some theories demand direct or indirect intervention of organisms, others require their formation in a gel medium, whereas still other theories claim they are a replacement structure. Aldrich[2] describes siderite oölites in granular chert beds in the Gogebic range of Wisconsin and claims that they were originally siderite, partially or completely replaced by microcrystalline quartz, leaving a residuum of finely divided iron oxide distributed in the same way as the remaining carbonate to prove that the oölites were originally siderite.

[1]F. J. Pettijohn, *Sedimentary Rocks*, Harper and Bros., New York, 1949, p. 75.
[2]H. R. Aldrich, *Geology of the Gogebic Iron Range of Wisconsin*, Wis. Geol. Nat. Hist. Surv., Bull. No. 71, 1929, p. 157.

*Massive Siderite.*—As has been mentioned, the siderite-chert formations, including the pisolitic siderite-chert, grade in general southward into zones with a greater proportion of siderite near the contact with argillite. Several such zones, up to 40 feet in width, have been intersected by diamond-drilling in the area between Hematite and Keewatin lakes. Closer drilling is necessary before an estimation of the size and grade of these zones can be made. Pyrite crystals and disseminated pyrrhotite form 5–10 percent of the lenses intersected.

Two zones of this type of mineralization were encountered in diamond-drill hole No. 3, of the 1950 drilling program on the Mathieu property, 500 feet east of the west end of Hematite Lake on the north shore. Most of the core had been removed for assay, so that the complete section could not be examined. The mineral composition is indicated in assays provided by Candela Development Company, given below.

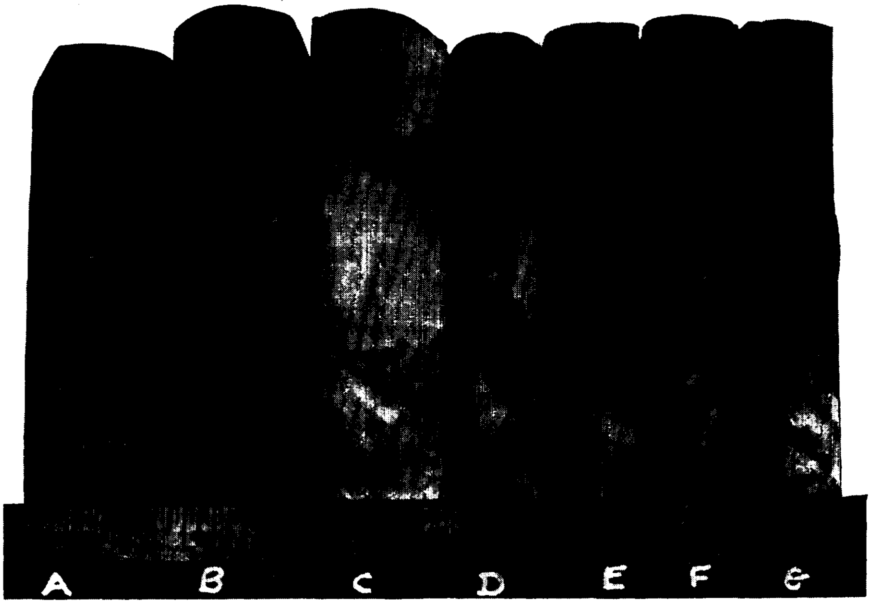
MINERAL COMPOSITION, DIAMOND-DRILL HOLE NO. 3, CANDELA DEVELOPMENT CORPORATION LIMITED

| Zone | Total Iron | Iron due to Siderite | Manganese | Iron: Manganese Ratio | Silica | Sulphur |
|---|---|---|---|---|---|---|
| | percent | percent | percent | | percent | percent |
| 249–299 ft. of massive siderite with some pyrite and pyrrhotite | 23.86 | 23.09 | 1.65 | 13.9 | 3.75 | 0.77 |
| | 30.03 | 26.90 | 1.94 | 13.9 | 19.50 | 3.13 |
| | 26.94 | 25.51 | 1.80 | 14.1 | 26.20 | 1.43 |
| | 29.70 | 25.96 | 1.76 | 14.7 | 21.90 | 3.74 |
| | 26.46 | 25.36 | 1.75 | 14.5 | 26.90 | 1.10 |
| 360–375 ft. of massive siderite with some pyrite | 32.30 | 31.04 | 2.32 | 13.4 | 10.65 | 1.26 |
| | 37.33 | 36.41 | 2.32 | 15.7 | 9.20 | 0.92 |
| | 34.09 | 33.49 | 2.51 | 13.3 | 2.85 | 0.60 |

Allowing for the iron content of the pyrite and pyrrhotite as estimated at a 1:1 ratio with sulphur, iron:manganese ratios were calculated and are included in the accompanying table. The iron:manganese ratio remains fairly constant with widely varying amounts of total iron, sulphur, and silica and indicates that the manganese is associated with the iron carbonate, the carbonate mineral actually being a mangano-siderite with about 7 percent manganese. Variations from the average iron:manganese ratio of 14.2:1 probably arise from errors in the iron:sulphur ratio estimation due to varying proportions of pyrite and pyrrhotite. The close and uniform relationship of the manganese and iron is suggestive of a sedimentary origin for the siderite, as the manganese and iron cycle are closely related.

*Massive Sulphides.*—A zone of pyrrhotite-pyrite mineralization occurring in the iron formation at the contact with argillite has been traced by diamond-drilling for a distance of about 2 miles in the Hematite-Keewatin lakes area. It is possibly a continuous zone. The widths of this zone (or zones), as indicated by diamond-drilling, range from several to over 100 feet. A pair of holes, inclined at 45°, drilled north and south of a site east of Keewatin Lake by Candela Development Company, intersected respectively 291 feet of disseminated sulphides assaying 23.4 percent sulphur, and 273 feet assaying 20.9 percent sulphur; these holes were possibly drilled along the strike of the formation, which is considerably folded in this area. Several narrow lenses of concretionary graphite schist, similar to that exposed in the pit at Cryderman Lake, have also been intersected in the argillites near the contact.

The sulphide mineralization consists of disseminated to massive pyrrhotite and pyrite, which occurs in various proportions. The most common and typical appearance is of cubes and pyritohedrons of pyrite up to ½ inch in diameter scattered throughout massive pyrrhotite or throughout pyrrhotite disseminated in chert. Pyrrhotite occurs also as minor narrow stringers in chert and graphite schist, and as ½-inch-long lenses within the breccias in the argillite near the contact.




**DRILL CORE FROM MATHIEU PROPERTY**

**A. Greywacke showing graphitic streaks.**
**B. Intraformational breccia in graphitic argillite.**
**C. Intraformational breccia in cherty silica-siderite.**
**D. Interformational breccia at iron formation – argillite contact.**
**E. Intraformational breccia in banded silica and siderite.**
**F. Banded silica and siderite.**
**G. Interformational breccia at iron formation – argillite contact.**

In the sulphide zones at Hematite Lake, well-crystallized pyrite contrasts sharply with the massive or finely disseminated pyrrhotite. Two generations of pyrite are suggested within one crystal. The older inner part of the pyrite crystals shows less definite boundaries and has more inclusions and cracks than the pure, massive, outer peripheral rim, which shows extremely sharp straight contacts with surrounding minerals. No other sulphides have been reported. Candela Development Company has assayed the sulphides for cobalt and nickel, but all results have been negative; one assay of 0.005 ounces of gold has been reported; all other assays have returned no gold.

The occurrence of the sulphides concentrated along, and near, the argillite contact over a distance of 2 miles suggests an origin either closely related to the origin of the iron formation or a hydrothermal origin with deposition structurally controlled by the contact. The author believes that the early pyrite is probably syngenetic sedimentary, similar in origin to the pyrite of the concretionary argillite. The later pyrite and pyrrhotite is possibly hydrothermal and may be genetically associated with the van Nostrand stock.

*Interformational and Intraformational Breccias.*—At many places in the drill core from the sediments at Hematite Lake, the cherty silica, siderite, and sulphide zones and argillite show zones of breccia. Some of the breccias may be due to microfaulting such as that seen in the outcrop of banded silica-siderite described previously. Most of the breccia noted appears to be of interformational and intraformational origin, although some of it may be of tectonic origin. It occurs as definable zones of various widths within the cherty silica, in the siderite and sulphide zones at the iron formation–argillite contact, and within the argillite.

Several surface exposures show brecciation within the cherty silica formation; at the east end of Cryderman Lake narrow curved fragments of white granular chert up to 2 inches in length occur in a buff-weathering, impure, cherty silica with some graphitic material.

In a drill hole near the east shore of Keewatin Lake a 2-foot zone of intraformational breccia, within the banded chert-siderite formation, is composed of fragments of chert, siderite-chert, and banded chert and siderite in a matrix of dark-buff-weathering sideritic chert. The fragments are angular to lenticular, have been considerably moved and rotated from their original positions, and are arranged in shape and size so as to show an indistinct bedding.

In other drill holes to the east, intraformational breccia is found in the siderite-chert zones; here, angular fragments of cherty silica averaging 1–2 inches in diameter are enclosed in a matrix of buff- to creamy-weathering chert with minor disseminated siderite. In some holes, at the contact with the argillites, a zone of interformational breccia occurs; this consists of angular fragments of pure cherty silica or sideritic silica in a dark-grey or black argillaceous matrix. The fragments are irregular and angular in shape, range in size from an ⅛ inch up to 2 inches, and have sharp contacts with the matrix.

Within the graphitic argillite, zones of intraformational breccia are found; the fragments are not easily recognizable being about the same colour and texture as the matrix. They are about ½–1 inch in size, tend to be fairly closely packed, and are slightly elongate parallel to the bedding.

### Discussion of Iron Formation

The general occurrence and nature of the breccias across the various phases of the iron formation and argillite may provide a means of identifying the top of this part of the sedimentary belt.

An intraformational breccia is the product of the breaking up of a bottom sediment by desiccation or by currents into fragments which, with little or no transportation, are redeposited in a matrix of more or less similar composition. Such a breccia indicates no great break in deposition.

In places where chert grades southward into pisolitic or massive siderite or passes directly into argillite, the nature of the breccia and its value for determining the top of the formation is well shown. Where a gradual change from pure chert to siderite-chert occurs, a zone of breccia will be composed of angular fragments of pure white chert in a matrix of slightly sideritic chert, or of sideritic chert fragments in a chert of higher siderite content. These breccias are believed to be true intraformational breccias and suggest that both the silica and siderite are primary sediments, and that minor brecciation of the deposits at the bottom was perhaps contemporaneous with, or closely followed by, deposition of gel silica bearing relatively more siderite. It has been noted that pisolitic and oölitic structures are common associates of intraformational breccias.[1]

[1]F. J. Pettijohn, *op. cit.*, pp. 210, 211.

The interformational breccia, at the contact of the chert and argillite, is composed of fragments of chert in an argillaceous matrix. This could be caused by a post-consolidation (pre- or post-crystallization?) breaking up of the chert beds by desiccation, by bottom currents, or by slumpage, the resulting fragments being cemented by muds and clays, which now form the base of the argillite.

The intraformational breccia in the argillite follows a similar pattern; the finer, more graphitic matrix being later than the lighter-coloured fragments.

In the area where drill core was available for study the tops of the formations are towards the south. The dips range from 85°S. to vertical.

If we conclude from the foregoing observations that siderite has been deposited in greater amounts towards the top of the cherty iron formation, we may then apply this conclusion to the banded silica-siderite phase and assume that the "graded bedding" described previously can be used for top determination as though it were graded bedding in clastic sediments.

If the proportion of iron entering the basin of deposition in the colloidal state was gradually increased during the time represented by the deposit, we will have a decreasing amount of silica in the precipitated gel, and in general, with each successive penecontemporaneous brecciation, an increase in the amount of siderite present in the matrix. The bands in the banded silica-siderite phase would thus represent a local normal occurrence of differential chemical precipitation.

The gradual increase of siderite being deposited along, and in places rhythmically with, silica from north to south may be due to an increase in the amount of iron being transported into the basin because of a change of climate with changing weathering conditions, or to the uncovering of a more basic rock type. A change of water temperature or a gradual decrease in the $CO_2$ content of the atmosphere, with resultant change of pH of the environment of deposition, could produce the same result. The gradual change was the possible forerunner of the abrupt change from chemical to clastic deposition that occurred after periods of local penecontemporaneous deposition.

The highly folded condition of the banded silica-siderite phase of the iron formation is a striking feature. The origin of complex folding in such a hard and brittle rock has long been a subject of discussion. Moore and Maynard,[1] in discussing complex folding of iron formations, suggest that crystallization of the silica-iron gel did not occur until the weight of overlying rocks pressed the water out, and accompanying heat caused the gel to crystallize; thus, before it was fully crystallized, the soft rock readily flowed and became highly contorted.

A study of the breccias at Hematite Lake indicates that the chert has been broken into sharply angular fragments before the deposition of the argillaceous matrix. Similarly the banded chert-siderite is brecciated and cemented by sideritic chert, indicating that the gel had crystallized, or at least become brittle, shortly after deposition. The highly complex folding in the banded silica siderite bands resembles in its variety the folds produced by slumping of unconsolidated or plastic material on bottom slopes. If we assign such an origin to the complex folding, the later brecciation can be attributed to desiccation, bottom currents, or more probably to further slumpage after crystallization of the silica-iron gel.

[1]E. S. Moore and J. E. Maynard, "Solution, Transportation and Precipitation of Iron and Silica," *Economic Geology*, Vol. 24, 1929, pp. 272-303, 365-402, 506, 527.

James,[1] in a description of the Iron River iron formation, arrives at a like conclusion concerning the origin of somewhat similar interformational breccias and also suggests that:

> The breccia records the beginning of a tectonic disturbance that was to terminate the epoch of chemical sedimentation and usher in an epoch of clastic deposition . . . The breccias would be the normal result of local increases in submarine slopes, with consequent slumping and sliding of the partly consolidated sediments.

The iron formations of the Lumby Lake area are similar to iron formations found elsewhere in the Precambrian Shield. The small lenses interbanded with Keewatin-type lavas and the banded magnetite-silica phase of the main band of sediments resemble the usual form of Keewatin iron formations, consisting of thin alternating layers of cherty quartz and magnetite or hematite. The iron formation of the Hematite Lake area resembles in some respects the ranges of the Michipicoten area, and though exploration is still in its early stages it has suggested the presence of siderite bodies as large as some of those at Michipicoten. It compares also with the siderite bodies of the Iron River range of northern Michigan. Though similar in size and mineralogy, the geological setting and stratigraphy differ. The accompanying table is given for comparison.

COMPARISON OF IRON FORMATIONS

| Michipicoten(1) (Keewatin (?)) | Hematite Lake (Keewatin (?)) | Iron River(2) (Huronian) |
|---|---|---|
| Basic lava | Greenstones | |
| Banded silica (0–675 ft.) | Pyritic argillite and greywacke (0–1,400 ft.) | Greywacke (100–400 ft.) |
| Pyrite member (0–120 ft.) | Sulphide member (55 ft.) | Breccia (0–200 ft.) |
| Carbonate (0–240 ft.) | Carbonate (0–41 ft. (?)) | Chert and siderite (150–300 ft.) |
| Acid volcanics | Banded silica (0–1,300 ft.) | Graphitic and pyritic slate (20–50 ft.) |
| | Greenstones (several 1,000 ft.) | Siltstone (500 ft.) |
| | | Greenstones (several 1,000 ft.) |

(1) W. H. Collins and T. T. Quirke, ***Michipicoten Iron Ranges***, Geol. Surv. Can., Memoir No. 147, 1926, pt. 1.
(2) H. L. James, "Iron Formation and Associated Rocks in the Iron River District, Michigan," ***Bulletin***, Geol Soc. Amer., Vol. 62, 1951, p. 253.

No pisolitic or oölitic siderite has been reported from Michipicoten, and the siderite is generally believed to have been formed by replacement of acid lavas, a type of rock absent from the sequence of Hematite Lake. James[2] considers the siderite of the Iron River range to be sedimentary, but also reports[3] that no oölitic structures in siderite have been found in northern Michigan. Aldrich[4] reports syngenetic pisolites of siderite from the Gogebic range. The Hematite Lake range has, in its sulphide phase, a high proportion of pyrrhotite, and it differs thus from the "range pyrite" of Michipicoten, which has about 10 percent magnetite and pyrrhotite.

[1] H. L. James, "Iron Formation and Associated Rocks in the Iron River District, Michigan," *Bulletin*, Geol. Soc. Amer., Vol. 62, p. 259.
[2] *Ibid.*, p. 263.
[3] H. L. James, "Current U. S. Geological Survey Investigations in the Iron Ranges of Northern Michigan," (Abstract pt. B), *Economic Geology*, Vol. 45, 1950, p. 386.
[4] H. R. Aldrich, *Geology of the Gogebic Iron Range of Wisconsin*, Wis. Geol. Nat. Hist. Surv., Bull. No. 71, 1929.

The Hematite Lake iron formation (despite the name given to the lake) does not, as far as is known, contain any hematite and has not been enriched by leaching of silica; it thus differs from many of the iron ranges of the Lake Superior district in having been protected from oxidation and leaching solutions since its origin. The banded silica-siderite phase is not particularly common; it is reported from the Cayuna range and the Iron River range but does not occur in the Menominee range and is only minor in the Mesabi and Vermilion ranges.

Graphitic schists and slates are commonly associated with iron formations, but few have the remarkable development of pyrite concretions characterizing the graphitic argillites of the main band of sediments in this area.

#### Crystalline Limestone

Crystalline limestone occurs at various places within the main band of sediments, as a series of lenses at no particular stratigraphic level mainly within the lower chemical sediments. In places it is interlaminated with cherty silica and, although minor association with fine-grained greywacke was noted, nowhere was it observed in association with graphitic argillite. Most occurrences are in zones of dragfolding, and in the Garnet Bay area it occurs in the crests and troughs of large dragfolds.

It is generally banded and may be white, pink, brown, or grey in colour. Texture ranges from fine grained, banded to coarsely crystalline, massive, near granite contacts. Near Seahorse Lake pure crystalline limestone—finely banded, fine-grained blue-grey marble—outcrops in a fault-line valley and on the lakeshore.

In the Garnet Bay area crystalline limestone is associated with cherty silica and banded garnet-mica schists and conglomerate; it is concentrated in the crests and troughs of dragfolds as outlined by the conglomerate bed and is itself intricately dragfolded. At Garnet Bay, on the north shore of Spool Lake, and at the west end of Pinecone Lake, it has been recrystallized by the intrusion of the Algoman (?) granite, and textures vary from medium to coarse grained with, at Garnet Bay, the development of up to 20 percent diopside and minor magnetite.

From Pinecone Lake eastward no massive crystalline limestone was observed. A zone of fine-grained limestone, similar to that at Seahorse Lake, occurs in a dragfolded zone at the east end of Cryderman Lake but is banded with chert and merges southward into cherty iron formation carrying minor siderite. Other outcrops of banded limestone and chert occur at Keewatin Lake and at the east end of Hematite Lake, both occurrences being associated with dragfolding. No limestone was seen in the sediments east of the van Nostrand stock.

The limestones are similar to limestones in the Steeprock series around Steeprock Lake, described by many who have visited that area. Moore[1] describes it as being recognizable in the field by its bluish colour and distinguishes it from the ferruginous carbonate, which weathers brown or red:

> The blue limestone is largely crystallized and highly deformed, and part of it is silicified. Numerous stringers of silica traverse the beds and laminate the formation, and very intricate structural patterns may be observed.

Moore believes the Steeprock limestone was formed in the deeper parts of the basin in which the Steeprock series was deposited, where clearer waters prevailed.

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[1] E. S. Moore, *Geology and Ore Deposits of the Atikokan Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2, pp. 12, 13.

Limestone has been reported from other Archean-type rocks in northwestern Ontario. A narrow lens of limestone resembling that west of Seahorse Lake, from near Mine Center in the Rainy River area, is described by Lawson.[1] Other occurrences of crystalline limestone in the North Spirit Lake area, and Sandy Lake area respectively, are described by Bateman[2] and Satterly.[3]

The limestone probably originated as a chemical precipitate, being deposited from waters carrying calcium bicarbonate into the basin of deposition. Possibly, local increases of temperature, causing an increase in the pH of the water through removal of $CO_2$, took place periodically so that calcium carbonate would be precipitated as lenses.

The observation, in many of the limestone outcrops, of complex dragfolding, and the association with large dragfolds at Norway Lake suggest that the origin of the rock may be connected in some way with the dragfolds, such as by the replacement of dragfolded zones. However, the dragfolds at Garnet Bay were caused by forces accompanying the intrusion of the granite, and the limestone shows the metamorphic effect of this intrusion. Also, lamprophyre of Algoman (?) age cut the folded limestones at Garnet Bay; the age relationships thus indicate that the limestone is not a replacement of pre-existing rocks derived from Algoman igneous activity.

The association with dragfolding may be due to squeezing of the easily recrystallized, incompetent limestone between competent layers into these folded zones, corresponding to a thickening in a fold arch whereas competent bands maintain an even thickness. Folding would be concentrated in the limestone because of its incompetency. Differential stresses would therefore be relieved by flowage largely within the limestone.

#### Conglomerate

Conglomerate occurs at several places along the main belt of sediments as small lenses interbedded in the iron formation and argillaceous greywackes.

The largest bed is found along the southwest side of Norway Lake where it forms an excellent horizon for tracing dragfolds in the metamorphosed sediments. Smaller lenses occur at various stratigraphic levels in the band of sediments.

The smaller beds contain closely spaced, stretched pebbles and boulders of greenstone in a garnetiferous argillaceous matrix and are less than 10 feet thick and are traceable for only a few tens of feet along strike.

The folded bed at Norway Lake contains pebbles, cobbles, and boulders up to 6 inches in size, of andesite, porphyritic greenstone, hornblende schist, quartz, and chert. Fine-grained greenstone predominates in the cobble and pebble size; chert and quartz occur only as rounded pebbles less than 1 inch in diameter; porphyritic greenstone occurs in the few fragments of boulder size observed. A rough gradation of grain size and type was noted over a 60-foot width at one exposure. On the north side, cobbles and boulders, with a few pebbles, occur in a chlorite matrix; southwards the matrix becomes more quartzose, and the fragments become smaller with more quartz and chert appearing; still farther south garnets start to appear in the matrix, and the fragments decrease in size until the conglomerate gives way to a banded garnet-mica schist in which no clastic material can be seen.

[1]Andrew C. Lawson, *The Archean Geology of Rainy Lake Re-studied,* Geol. Surv. Can., Memoir No. 40, 1913, p. 44.

[2]J. D. Bateman, *Geology of the North Spirit Lake Area,* Ont. Dept. Mines, Vol. XLVII, 1938, pt. 7, pp. 60, 61.

[3]J. Satterly, *Geology of the Sandy Lake Area,* Ont. Dept. Mines, Vol. XLVII, 1938, Pt. 7, p. 22.

### Argillaceous Greywacke, and Metamorphic Derivatives

A large part of the band of sediments is composed of fine-grained, light- to dark-grey, metamorphosed, argillaceous greywackes, described in the field mainly as garnet-mica schists or as hornfelses derived from greywackes. Argillaceous greywacke occurs along most of the length of the belt of sediments and forms the southern part of the belt. It ranges in thickness up to 1,000 feet. In the area west of Norway Lake, the distribution is concealed by overburden. From Garnet Bay eastward to Pinecone Lake, at Keewatin Lake, and at the west and east contacts of the van Nostrand stock, garnet-mica schists and hornfelses occur.

The argillaceous greywacke grades along and across the strike into carbonaceous argillite with decrease of grain size, decrease in the amount of cherty quartz, and increase in the amount of disseminated carbon and iron sulphides. Contacts with cherty iron formation, though rarely observed, are fairly sharp. The greywacke is more or less typical Archean greywacke. Nowhere does it show ripple marks, or cross bedding, rare features in Archean sediments. It is generally dark in colour, well indurated and, where the clastic nature is preserved, is composed of angular detrital fragments set in a prominent to dominant clay matrix. Banding derived from the original bedding ranges from 1/8 inch to 6 inches in width, the average being about 1/2 inch.

A study of the least metamorphosed type, found at Hematite Lake, shows the greywacke to be composed of subangular to very angular fragments of quartz, plagioclase feldspar, chloritic greenstone, and epidote set in a matrix of sericite, chert, feldspathic material, calcite, and minor graphite.

The most common metamorphosed form taken by the greywacke formation is the banded garnet-mica schist. Other more or less metamorphosed forms are common, ranging from banded hornblende-biotite schist with incipient garnets to schists of greater degree of metamorphism containing 35 percent garnet. At intrusive contacts garnet-cordierite-biotite hornfelses have been formed.

Thin sections of these metamorphic derivatives studied microscopically show little evidence of the clastic origin of the original rock. Cherty cryptocrystalline silica is almost always present between the grains of metamorphic minerals. No fragments of feldspar, and only a few grains of clastic quartz remain.

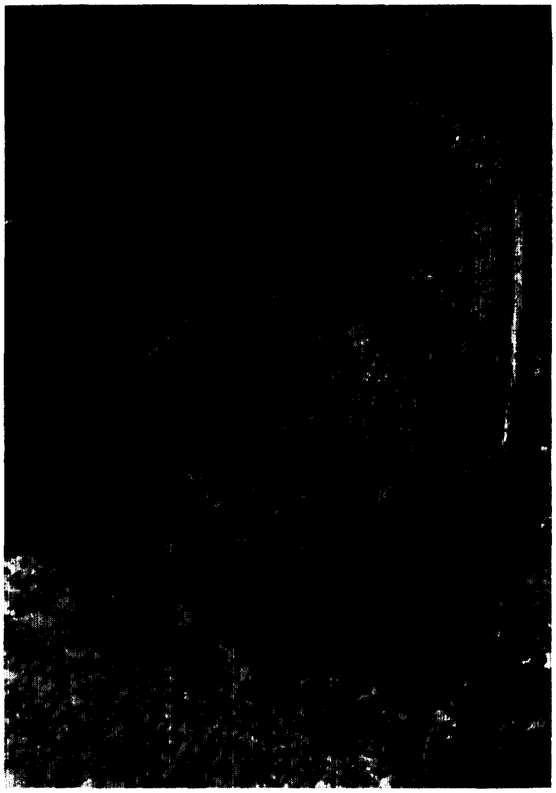
A zone of greywacke of high alumina content is represented by a banded andalusite-biotite-garnet schist exposed at the entrance to Garnet Bay. This rock consists of about 30–35 percent andalusite as subhedral impure crystals, 25 percent biotite, 25 percent cherty quartz, and 10 percent of opaque minerals (magnetite, pyrite, and graphite).

Medium-grained garnet-biotite-cordierite hornfels occurs at the west side of the granite plug at Spool Lake. It shows a characteristic sugary texture and no banding. It is composed of: cordierite, about 20 percent; quartz, 15; biotite, 25; garnet, 30; plagioclase feldspar, 5; and magnetite, 5 percent.

The variety in the types of banded schists developed, mainly garnetiferous, is a reflection of the kind and relative amount of argillaceous material, which, along with a varying amount of silica, was deposited in the sedimentary basin. The original greywacke appears to have been clay or silt with a varying amount of clastic material, or both. The variations in the metamorphic derivatives indicate the variations in the kind and amount of the clay minerals and silt originally in the matrix of the greywacke.

**Argillite and Metamorphic Derivatives**

Graphitic argillite and its metamorphic derivatives are found in many places as separate lenses within the argillaceous greywackes in the southern part of the main band of sediments. A few isolated lenses are found in the volcanics north and south of the sedimentary band.



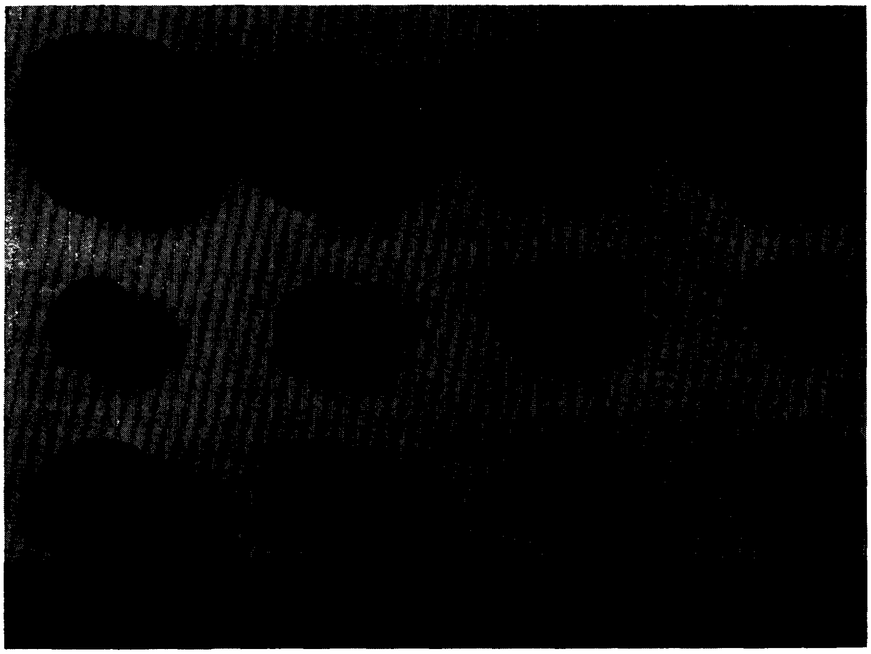
Pit in graphitic argillite at Pinecone Lake. Fine earthy material is impure native sulphur, white efflorescence is soluble iron sulphate.

A narrow band of black graphitic argillite extends east and west from Cross Lake. Lenses of spotted graphite schist, and graphitic argillite occur at Spool, Pinecone, and Cryderman lakes; it is doubtful if these occurrences are part of a single zone, although outcrops are scarce in the intervening areas. The largest lens, up to 1,400 feet thick, occurs at Hematite Lake; here it is generally more slaty, with zones of graphite schist, highly polished on slip faces. East of van Nostrand Lake graphitic slates outcrop on the haul road to Oldman Lake.

The argillite group ranges from a dense, hard, bedded type, through slate, to a fissile graphite schist. Mostly it is black or dark grey in colour. Graphite is a common constituent especially of the slaty and schistose facies. Magnetite, pyrite, and pyrrhotite occur in places, with concretions of pyrite common at Cryderman and Hematite lakes.

Under the microscope, the argillite shows disseminated chert throughout, with minor sericite and tremolite. Pale yellow needle-like crystals of tourmaline compose about 5 percent of the rock at Pinecone Lake. Flakes of graphite render thin sections almost opaque. A specimen of the graphitic argillite from a pit at Pinecone Lake, submitted to the Provincial Assay Office, showed 13.70 percent carbon. The purity of the flake graphite is not known.

Spherulitic concretions of pyrite occur in the more graphitic parts of the argillite lenses. At a test pit on the south shore of Cryderman Lake, spherical concretions averaging ¾ inch in diameter have weathered free and occur loose in great numbers. The concretions do not occur uniformly distributed throughout the rock but are concentrated in bands up to 1 foot thick separated by narrow bands of black argillite. These bands, representing the original bedding, strike east and dip vertically.



**Typical pyrite concretions from pit at Cryderman Lake. Broken weathered concretions show internal concentrically laminated structure.**

The internal structure of the pyrite concretions can be seen best on the weathered surfaces of broken concretions. Most have a concentrically laminated internal structure with radial structure in some of the laminae. Radial structure is present in the peripheral ring about ⅛ inch wide in most concretions. A few concretions show a similarity of patterns in the concentric rings, suggesting simultaneous periods of growth in response to some external influence during diagenesis.

Pyrite concretions such as those described have been reported in Keewatin rocks from a few localities. Baker[1] reports on occurrence of pyrite concretions in Keewatin-type ash rocks at the Alexo Nickel mine in the Timiskaming district. Tanton[2] describes a black, carbonaceous, slate-like rock in the Harricanaw-Turgeon Basin of Quebec, which contains abundant pyrite concretions.

[1]M. B. Baker, *Alexo Nickel Mine, Timiskaming District*, Ont. Bur. Mines, Vol. XXVI, 1917, p. 272.

[2]T. L. Tanton, *The Harricanaw-Turgeon Basin, Northern Quebec*, Geol. Surv. Can., Memoir No. 109, 1919, pp. 30, 31.

Native sulphur occurs in the test pits at Cryderman and Pinecone lakes, and an efflorescence of white and yellow iron sulphate, one of the minerals of the halotrichite family, occurs in the pit at Pinecone Lake where it is protected from the elements. The sulphur and iron sulphate appear to have been formed in the zone of weathering by decomposition of the sulphides in the presence of carbon.

The graphitic and concretionary argillite so resembles some post-Cambrian black marine shales that it must be concluded that it originated as a black mud, rich in organic material derived from primitive organisms. Pettijohn[1] attributes an organic marine origin to the pyrite- and carbon-bearing greywackes and their associated slates in the Canadian Shield. Graphitic rocks in the Huronian of the Iron River area of Michigan, described by James,[2] have been found to contain carbon of known organic origin.

The lenses of graphitic argillite are considered to represent zones of stagnation or restricted circulation in the sedimentary basin in which organic material decayed, and in which iron brought into the basin was precipitated directly as sulphide concretions or as black sulphides of iron diagenetically changed to pyrite concretions.

#### Discussion of Sediments

Top determinations in the volcanics north of the main belt of sediments are all towards the south; south of the sediments good exposures of pillow lavas indicate that the tops are towards the north. The general picture is that of a closed, upright syncline with the axial plane at or near the south side of the east-west band of sediments. There is no indication of symmetry in the band of sediments as might be expected if the axial plane of the fold lay within the sediments, and it is concluded that it is a homoclinal series, which lenses out at depth and does not therefore reappear on the south limb of the syncline. No indication of unconformity at the contacts with volcanics was noted, which suggests that the sediments are of the same general age as the Keewatin-type volcanics.

The main band of sediments represents a much longer, more widespread, and more varied type of sedimentation than is represented by the smaller zones. It may be divided into two main epochs; the earlier being mainly of chemical sedimentation, the later being of clays and muds with some coarser clastic material. With cessation of volcanic activity the period of chemical precipitation started with deposition of colloidal silica in a quiet basin with local precipitation of calcium carbonate and deposition of minor clastic material. As the precipitation of chert continued, the amount of iron being brought into the basin increased, and an increasing amount of siderite, or ferric iron hydrosol subsequently reduced to siderite, was deposited. Local brecciation of bottom deposits became more and more frequent, and as the depositional environment changed, more pyrite was deposited along with the chert and siderite. This period ended with local brecciation, and a general change from chemical to clastic sedimentation took place. Fine-grained greywackes were laid down as clay and silt, with lenses of black concretionary graphitic argillite representing zones of restricted circulation where organic material was preserved from oxidation, and where iron sulphide was deposited as pyrite concretions or as amorphous sulphide diagenetically concentrated into concretions. Colloidal material continued to be precipitated

[1]F. J. Pettijohn, "Archean Sedimentation," *Bulletin*, Geol. Soc. Amer., Vol. 54, 1943, pp. 925–72.

[2]H. L. James, "Iron Formation and Associated Rocks in the Iron River District, Michigan," *Bulletin*, Geol. Soc. Amer., Vol. 62, 1951, p. 259.

along with the clastic material, and indeed much of the clayey material itself may have been colloidal. Coarse clastic material was deposited locally with the fine-grained material, forming conglomerates with argillaceous and quartzose matrices.

## Keewatin-Type Intrusives

### METADIORITE

A large part of the igneous rocks of the greenstone belt is composed of sills, dikes, and irregular bodies of fine- to medium-grained metadiorite, many of which are undoubtedly associated with the igneous activity giving rise to the extrusive rocks; and from which they are difficult to distinguish. Within the greenstone area, the basic intrusives have massive and schistose phases. They occur as narrow lenses, seldom over 200 feet in width, parallel to the regional schistosity. Separate mapping within the greenstone area was not possible.

The rock is dark grey to green on fresh surfaces and weathers to a rough medium-green surface. Textures vary from medium to coarse grained, with fine-grained border phases; traces of diabasic texture were noted. The original feldspar is completely altered to a mass of epidote, chlorite, calcite, and albite. The original pyroxene is completely altered to secondary actinolite and chlorite. Sphene is a common constituent locally and is associated with skeletal crystals of ilmenite.

The Keewatin-type metadiorite and post-Laurentian metadiorite are similar in appearance and petrography.

### SERPENTINITE

Bands of serpentine rock, representing serpentinized dikes and sills of peridotite, were observed in the Oldman and Gargoyle lakes area. They appear to be 100–200 feet wide, striking parallel to the general trend of the area. The age relationship with the Laurentian granite is not known, though the intrusive at Oldman Lake is near or at the contact.

The rock is light grey to brown weathering, dark green to black on fresh surfaces. In thin section it appears as a mesh of serpentine derived from the alteration of an original dunite. Serpentine occurs as kernels pseudomorphous after olivine. The typical cracks of the crystals are filled with minute cross fibres of serpentine with magnetite, and the interstitial material between the pseudomorphs consists of fibrous serpentine, minor chlorite, epidote, and magnetite.

## Laurentian(?) Intrusives

### SOUTHERN GRANITE

The granitic rocks on the south side of the Lumby Lake greenstone belt have been assigned a Laurentian age by various geologists in the adjacent areas. The term Laurentian was used at the time of the earliest investigations to refer to the complete assemblage of granite and gneisses throughout the region. Lawson[1] used the term to refer to the granite underlying the Steeprock series and proposed the term Algoman for younger rocks in the same area. Since that time these terms have attained a widespread and unfortunate usage that implies correlation in time in areas far removed from the type areas. Hawley[2] and Moore[3] and others in the Rainy River–Steeprock–Sapawe Lake area have sup-

[1]Andrew C. Lawson, *The Archean Geology of Rainy Lake Re-studied*, Geol. Surv. Can., Memoir No. 40, 1913, p. 51.

[2]J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6.

[3]E. S. Moore, *Geology and Ore Deposits of the Atikokan Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2.

ported this concept of two ages of granite and have continued to use the names proposed by Lawson. The assemblage of granite and gneiss extending eastward from the Steeprock–Finlayson Lake area and forming a mass of batholithic proportions has been considered by them to be of Laurentian age (in the sense of being older than the Steeprock series).

Although it was possible for the author to investigate only a narrow zone of these rocks along the south side of the map area, distinct differences were observed between these granites and the fresher granite on the west and north sides of the area. Because of these differences and certain geological relationships, it was concluded that the southern granite is earlier than the granite on the north and west sides of the greenstone belt. A small zone of possibly older granite occurs at Pyramid and Little Chill lakes.

Along the western part of the south contact, from Richardson Lake to beyond Jet Lake, is a zone averaging 1 mile in width of so-called quartz porphyry, which is considered to be a contact phase of the southern granite. In many places in and near this contact zone, small bodies of altered diorite and gabbro are associated with the Laurentian(?) rocks. Some of these are clearly intrusive into the granite or its contact phase, showing chilled borders, cutting across the gneissosity of the granite, and containing inclusions of granite. They are so numerous in the contact phase of the Laurentian(?) rocks that the whole was mapped as a quartz porphyry–diorite complex. Many inclusions of greenstone occur within the contact zone and in the granite and are difficult to separate from the later fine- and medium-grained metadiorite. Two possible ages of basic rocks are indicated at several places, one cut by, and one cutting, the granite; the older may be a recrystallized volcanic rock. The diorite bodies are absent in the Oldman Lake area and increase in number westward from Richardson Lake, and in the area bounded by Jet, Top, Longhike lakes and Sawbill Bay underlie about 50 percent of the area.

Much of the Laurentian(?) rock has been subjected to intense shearing and alteration, the resulting fissile sericite schists in places being difficult to distinguish from schists derived from greenstones, as in the shear zones southwest of Redpaint Lake and between Lumby and Hutt lakes.

The Laurentian(?) granite is grey to pink in colour, light weathering, and medium grained; a high chlorite content gives a light-green colour locally. Thin sections show considerable textural and mineralogical variety. The feldspar is sodic oligoclase or albite; potassic feldspars were seen only in specimens from Oldman Lake. The plagioclase is generally considerably saussuratized and may itself be a secondary feldspar–being derived by soda metasomatism from a more basic plagioclase. The ferromagnesium minerals of the granite, biotite, and hornblende, have been largely altered to aggregates of epidote, chlorite, quartz, and calcite. Quartz composes up to 45 percent of the granite and is concentrated into granular masses about 3 millimetres in size and is also disseminated throughout the rock as very small anhedral crystals less than 0.1 millimetres in size. Evidence of mylonitization of the Laurentian granite is shown in its fractured and strained quartz, fractured and bent laths of plagioclase, and bent biotite and chlorite fibres.

### THE CONTACT ZONE

The term quartz porphyry is applied to a light-weathering, dark- to medium-coloured acid rock characterized by the presence of numerous blue opalescent quartz eyes, which occurs as a contact zone between the Laurentian (?) granite ann the greenstone It inntrudes the Keewatin-type volcanics locally near the south contact as narrow lenticular dikes and sills; these are so numerous in the area south of Lumby Creek that the complex of greenstone, quartz porphyry, and diorite was impossible to map on the scale used. It is well illustrated on the map of the L. C. Anderson property. (In map case.)

A rough gradation across the contact zone from south to north was noted; from altered granite, through porphyritic granite, granite porphyry, to intrusive(?) rhyolite porphyry at the contact with the greenstones. Some of the

Angular inclusions of greenstone in Laurentian (?) granite at Oldman Lake. Greenstone retains ellipsoidal structures.

rock so mapped is not a "quartz porphyry", but the presence of blue opalescent quartz is typical of the contact phase. The area is one of considerable mylonitization, and the mapping of the acid rocks of the contact area is made difficult by the crushing and shearing that has affected them.

The characteristic blue opalescence of the quartz is seen in thin section to be due to countless minute cracks and strains, and to innumerable liquid and gaseous inclusions, in some of which Brownian movement of minute gas bubbles in liquid can be detected.

It is possible that some of the rhyolite porphyry near the contact with the greenstone represents original Keewatin-type rhyolite flows, but the general sequence across the contact zone and the lack of primary flow structures suggest that it is part of the single period of granite intrusion.

Hawley[1] has observed a somewhat similar sequence on the south side of this Laurentian(?) batholith in the Sapawe Lake area. Here, the quartz porphyry (felsite and micropegmatite) passes northward into the grey granite with increase of feldspar and ferromagnesium minerals. In the vicinity of the contact, porphyritic granite contains small blue eyes of quartz. The apparent gradation of the

[1] J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, p. 13.

contact of the porphyries northward into the grey granite may, according to Hawley, be taken as evidence that they are more or less contemporaneous and are both the result of one period of igneous intrusion.

Moore has mapped the area near the contact of the Laurentian granite and greenstone in the Steeprock Lake area as a mass of hybrid rocks containing a mixture of granite and Keewatin greenstone, which grades eastward into a body of granite with few remnants of greenstone. The map accompanying the report by Bartley[1] on the Steeprock area shows many diorite intrusives cutting the Laurentian(?) granite.

## Algoman(?) Intrusives

### METADIORITE

Within the contact phase, in the greenstone area, and to a lesser extent within the Laurentian(?) granite occur a great number of exposures of medium- to fine-grained metadiorite of medium to dark-green colour. As mentioned above, many of the diorite masses within the greenstone area are related to the Keewatin volcanic activity. Those in the contact phase of the southern granite are undoubtedly in part Keewatin in age, being extensively intruded by the porphyries. However, within the contact phase and within the Laurentian granite, a post-granite age is indicated for some of the diorite; it is tentatively assigned to the Algoman. Possibly it represents a late stage of Laurentian igneous activity or an early stage of Algoman activity, or even an intermediate stage as indicated by volcanic material in the Steeprock series. That it is older than Algoman is suggested by the degree of alteration affecting it.

Since the earliest investigations in the region, the problem of two ages of diorite in relation to the Laurentian(?) granite has been discussed. McInnes[2] says that generally the diorite is older than the Laurentian rocks throughout the Seine River area, but that locally the diorite is the intruding rock.

Most of the intrusives of metadiorite occur as lenticular bodies, approximately parallel to the regional trend. A small stock of metadiorite at the east end of Twobay Lake has a dike-like apophysis that cuts quartz porphyry.

Thin sections of the metadiorite show its considerable alteration. The rock is composed of about 60 percent actinolite, locally fibrous; about 20 percent altered plagioclase feldspar of the composition of albite ($Ab_{91}An_9$); 10 percent secondary quartz; the remainder of the rock being the alteration products epidote, chlorite, calcite, and sphene.

The presence of albite was noted in the petrographic study of many of the greenstones, metadiorites, and the Laurentian(?) granite. Its presence is interpreted as the result of a widespread albitizing reaction associated with one of the periods of intrusion.

### GRANITE AND GRANITE GNEISS

Large masses of generally fresh-appearing granite and granite gneiss of possible Algoman age have intruded the greenstones and early granite on the west and north sides of the greenstone belt, and smaller intrusives occur within the greenstones. The granite west of Redpaint Lake resembles, and is probably continuous with, the large area of granite in the northwestern part of Moore's map[3] of the Atikokan area, which was assigned an Algoman age by him on the basis of Lawson's definition of the term.

[1] Map No. 48b (to accompany Ont. Dept. Mines, Vol. XLVIII, pt. 2, 1939).

[2] William McInnes, "Report on the Geology of the Area covered by the Seine River and Lake Shebandowan Map Sheets," Geol. Surv. Can., *Annual Report*, 1897, Report H., p. 28.

[3] Map No. 48a (to accompany Ont. Dept. Mines, Vol. XLVIII, pt. 2, 1939).

The Algoman(?) granite is the youngest Precambrian rock of the area. Though diabase dikes of Keweenawan age has been reported from the map area, none were found during the mapping of the area.

In general the Algoman(?) granite is fresh, medium to coarse grained, light pink to red on fresh surfaces, and weathers to a pink or cream colour. It has many lithologic phases and may vary in composition and appearance over short distances. Pegmatitic varieties occur locally. Generally it is found to be potash-bearing, contrasting thus with the soda-rich southern granite of earlier age. Hornblende and biotite varieties predominate, but muscovite granite is locally important.

Jointing is well developed in this younger granite, and the relationship of the jointing with the direction of glaciation has been a dominant factor in the location of glacially plucked lake basins, especially the Irish-Scotch lakes chain where the lake basins are related to the nearby granite-greenstone contact.

Emplacement of the granite intrusive appears to have been effected by brecciation and stoping of intruded rocks or by *lit par lit* injection into schists giving a narrow contact zone of injection gneiss; in other places emplacement has been accomplished by forceful pushing aside of the surrounding schists.

Thin sections of typical Algoman(?) granite show a number of mineralogical variations. The common minerals composing the granite are: quartz averaging 25 percent; plagioclase feldspar, 10–35 percent; microcline and orthoclase, 20–25 percent; augite, hornblende, and biotite are commonly present and form up to 15 percent of the rock. Accessory minerals noted include sphene, apatite, zircon, ilmenite, and fluorite.

## APLITE

Fine- to medium-grained aplite and granite dikes and sills up to 25 feet in width, apophyses from the main intrusive mass of Algoman(?) granite, cut the greenstones and sediments near Norway Lake, Pinecone Lake, and east of Irish Lake. A few dikes of aplite cut a syenitic contact phase at Viking Lake.

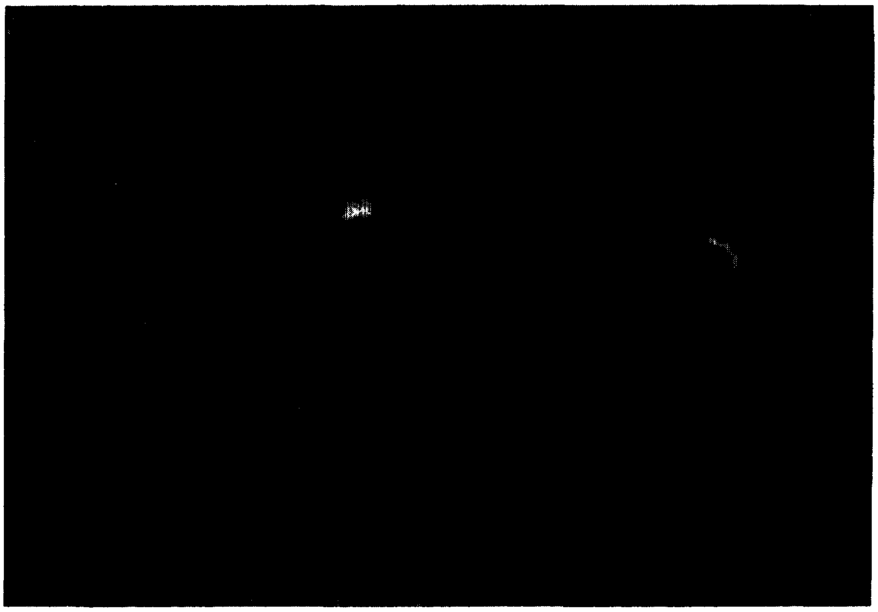
The aplite dikes at Norway and Pinecone lakes are fine to medium grained, pink to white in colour, have a characteristic sugary texture and are usually finer grained than the parent granite. Larger dikes east of Irish Lake resemble Algoman(?) granite and do not have the sugary texture of aplite.

## LAMPROPHYRE

Narrow lamprophyre dikes, probably related to the main period of Algoman(?) intrusion, cut schist and andesite at Redpaint Lake, limestone at Garnet Bay, iron formation at Hematite Lake, and argillaceous greywacke at van Nostrand Lake. These dike rocks are considerably altered and the original mineral constituents largely destroyed, though some show original biotite both as phenocrysts and in the groundmass. The mineralogical content suggests that the rock was originally a kersantite or minette. A single outcrop of a lamprophyre dike containing phenocrysts of hornblende was found at Garnet Bay.

## OTHER ALGOMAN(?) INTRUSIVES

At various places within the north part of the greenstone belt, small plugs and stocks of granite, syenite, and associated hybrid rocks, whose fresh appearance and general occurrence suggest a correlation with the Algoman intrusives, have intruded the earlier rocks. A common feature of these intrusives is the presence of a contact phase of more basic rock. In some the range of petrographic character is extreme, the earlier crystallized or contaminated border facies having the composition of gabbro, hornblendite, or syenite. The contact phase of a small plug of syenite at Bar Lake is a hybrid rock with the composition of an olivine gabbro; probably deeper erosion would show a granite core to the syenite. The Spool Lake plug is a hornblende granite with a narrow border of hornblende augite syenite. A hybrid border phase occurs at the contact of the massive granite of Norway Lake and the van Nostrand stock. Small areas of fresh intrusive basic and intermediate rock such as at the small lake north of Cross Lake are believed to be hybrid contact rocks of unexposed granite intrusives. Such border phases are lacking at other places where the mode of emplacement may have been different, perhaps owing to the differences in the physical-chemical characteristics of the intruding magma.



**Outcrop surface of porphyritic microcline granite of central part of van Nostrand stock; on haul road north of van Nostrand Lake.**

#### van Nostrand Stock

The small stock of Algoman(?) granite between Hematite and van Nostrand lakes is referred to as the van Nostrand stock. It is composed of a main central zone of porphyritic microcline granite remarkably uniform in colour and mineral composition, with no banding or lineation of any kind. Near the contacts, the granite grades, by decrease in amount of potash feldspar, into a border zone of grey-to-white, non-porphyritic pyroxene syenite about 200 feet wide.

The central part of the stock, underlying about 4 square miles, is a porphyritic granite composed of pink microcline in phenocrysts averaging about ½ inch long, with quartz, biotite, and hornblende in the groundmass. Accessory minerals, seen in thin section, are sphene, apatite, and magnetite.

The intrusive contacts with the schists and sediments are fairly regular with relatively few apophyses extending out from the stock. Metamorphic effect of the intrusion on the intruded rocks has been slight; the greenstone schists have been changed to hornblende schists for a few tens of feet from the contact; metamorphic effects are more noticeable in the argillaceous greywackes, which have been altered to garnet-mica schist. Where the contact can be observed it is very sharp, with no evidence of assimilation of the country rock. Part of the contact with the volcanics on the southwest side of the stock is an intrusive breccia, about 300 feet wide, consisting of large fragments of hornblende schist in a matrix of the border phase.

On the north side of the stock a few narrow dikes extend out from the stock; one type is similar to the non-porphyritic syenite border phase, whereas another type resembles the porphyritic granite of the centre part of the stock. This latter type was observed to cut the border phase exposed at Pipestem Lake. These relationships suggest that the non-porphyritic border zone is an early crystallized phase composed of the early crystallizing minerals of a granite magma. Before the final crystallization of the central part of the intrusive, the solid border phase cracked, and the fluid crystal mush forced its way into the fissures leading through the border phase into the greenstones and consolidated as narrow porphyritic dikes.

The granite stock is probably a cupola on the Algoman(?) granite batholith exposed over a large area north of the greenstone belt. The regional east-west trend of schistosity has been diverted near the contacts with the stock to be almost parallel to the contact. Dips in the schists are steep and away from the contact. It is believed that a cylindrical mass of intrusive magma forcibly pushed its way upwards through the schist cover, with most of the expansion northward because of the buttress of old granite to the south.

## Pleistocene

The area has been extensively glaciated. Bedrock is very unevenly covered by a sheet of glacial material consisting of variously sized boulders in sandy clay. From Redpaint Lake east to longitude 90°15'W. bedrock is extensively exposed; on some traverses over 75 percent of the walking was on bare outcrop. Eastward from longitude 91°15'W., the relative amount of overburden increases, until only scattered knobs of outcrop are found. East of Brush Creek most of the area is covered by muskeg.

In the western part of the area two hills, composed of sand and gravel of glacial outwash origin, were mapped. Other outwash deposits of sand and gravel are exposed on lumber roads north and east of Norway Lake. Outwash deposits of stratified gravel occur at the old lumber camp south of Pyramid Lake, and also near the lumber camp at the west end of van Nostrand Lake. Similar gravels have been obtained for road building along the road southward towards Sapawe. Dune or beach sand is exposed on the winter road near Hawk Lake in the extreme northeast corner of the map area.

Varved clay, overlain by gravel and Recent stream sand occurs at the east end of the logging sluice at the outlet of Oldman Lake; at places further up Brush Creek the banks are composed of clay, but no varves were seen. The clays were probably deposited in the same glacial lake as the varved clays recently exposed by the lowering of Steeprock Lake; this glacial lake was given the name Lake Johnston by Antevs.[1]

Glacial striations on bedrock exposures are very common throughout the area and offer abundant proof that the last direction of ice flow was towards the southwest between S.1°W. and S.60°W. Most measurements lie between S.15°W. and S.30°W. On a stripped area at Lumby Lake a set of striations striking S.60°W. was observed superimposed on an older set striking S.15°W.

[1]Ernst Antevs, "Glacial Clays in Steeprock Lake, Ontario, Canada," *Bulletin*, Geol. Soc. Amer., Vol. 62, 1951, pp. 1223–62.

## Recent

Recent deposits in the area are confined, with one exception, to unconsolidated sand and silt in rivers, creeks, and lakes. Recent sands of river origin, reworked glacial material, overlie varved clay at Brush Creek, and a delta of fine sand and silt is being built in Oldman Lake at the outlet of Brush Creek. Fine white quartz sand occurs along most of the Seine River in the map area, and natural levees, 8 feet high, occur along its banks south of Oldman Lake.

Minor tillite, several feet thick, has been formed by the cementation of glacial debris by limonite gossan over the sulphide bodies at Hematite Lake and is so thoroughly consolidated as to core easily in diamond-drilling. Plant roots, twigs, and small logs have been replaced by limonite and retain the outline of their internal structure.

**Boulder clay exposed on roadside south of Hematite Lake.**

# STRUCTURAL GEOLOGY

## Primary Structures in Volcanics and Sediments

Useful structural data were found in a few places within the volcanics. The shape and packing of pillow structure was used most extensively, but only in about fifty outcrops was this found sufficiently undeformed to indicate the direction of the flow top. Because of the relatively few top determinations, and because of some contradictory determinations, it is acknowledged that the fold pattern is probably considerably more complex than the somewhat generalized picture outlined below.

Although bedding, and banding derived from bedding, are generally well exposed in the sediments and assist in the general structural interpretation, primary features valuable for determining the facing of the sediments are relatively rare being confined to graded bedding and the sedimentary breccias; no ripple mark, or cross-bedding was found.

## Areal Structure

The general structural picture is that of a folded Keewatin-type greenstone sequence downfolded between, and intruded by, granite masses of two ages, cut by faults and fractures, and extensively sheared. The fold system has been deeply eroded.

### AREAL TRENDS

Two main trends have been outlined in the greenstone area mapped. The main part of the greenstone area trends about N.80°–85°W., the strike and dip of the regional schistosity being parallel to marker horizons, which can be traced for some distance. A smaller area of greenstone extends from the main part of the belt into the area between Upper Scotch and Leach lakes; the trend in this belt is N.25°–30°E. and is approximately parallel to the contacts with the granite.

Linears due to faults, fractures, and joint intersections in the granite areas trend about N.30°E. Near the contacts with the greenstones, gneissosity is approximately parallel to the schistosity within the greenstone area.

### SCHISTOSITY

The general strike and dip of the schistosity in the greenstones in the area is about parallel to the few formations traceable for any distance. The dip is very steep or vertical, varying locally in angle and direction. North of the main band of sediments most measurements indicate a steep dip southward, whereas south of this zone most measurements indicate a steep northward dip. Near intrusive contacts, schistosity may be locally crumpled or may be developed parallel to the contact. Schistosity has been crumpled to produce dragfolds within the stronger shear zones, and superimposition of S-surfaces of severely dragfolded zones has produced splintery schists with a lineation parallel to the dragfold axes. Locally, as at the junction of the Scotch Lake trend and the main greenstone belt, two sets of schistosity appear to have been imposed on the rocks, producing a measurable lineation.

## Folding

### MAIN FOLD PATTERN

The greenstone area may be divided into two main fold structures. The more important of these is the main east-west structure extending from Redpaint Lake to the east side of the map area. Structural data in the volcanics on each side of the main belt of sediments and within the sediments indicate a major syncline with the trace of the axial plane at or near the south side of the belt of sediments. There is no indication of symmetry in the sequence of formations on the limbs of the fold, and the absence of the sediments on the south limb is explained by postulating a basin of deposition of limited areal extent. A few top determinations in volcanics west of Lumby Lake indicate an anticline overturned towards the south and striking parallel to the main east-west syncline. The direction and amount of plunge, if any, is not known. A curved, northeastward-trending syncline is indicated by the attitude of schistosity between Irish and Leach lakes.

The intrusion of the Laurentian(?) batholith followed the original compression and folding of the Keewatin-type greenstone into isoclinal folds, which were only locally affected by the disturbances preceding and accompanying the Algoman(?) igneous activity. It is possible that the forces of the Algoman(?) revolution duplicated, to some degree, the earlier forces, intensifying or modifying the earlier imposed structures.

The north-east trending band of hornblende schist between Upper Scotch and Leach lakes appears to be a fold structure imposed by compression by orogenic forces preceding the intrusion of Algoman(?) granite, and then truncated by the Algoman(?) intrusive. Superimposition of sets of schistosity has locally complicated the structure where it joins the main belt.

## DRAGFOLDING

Local variations in the dip of schistosity noted throughout the area may be due to dragfolding associated with major folding in the area. The tongue of iron formation that diverges from the main band of sediments at Cryderman Lake and extends westward towards a smaller tongue extending eastward from Fine-

**Dragfolds in limestone-chert beds at Garnet Bay, showing lineation parallel to the axial lines. Siliceous bands project above limestone bands on this water-washed outcrop.**

cone Lake may be a doubly plunging local dragfold on the north limb of the main syncline; the axial plane is convex upwards, so that erosion has cut through the higher part of it.

Many of the dragfolds within the schists can be related to differential movement on local or major shear zones, or to intrusion of igneous bodies. Those dragfolds in shear zones range in size from minute crenulations, a fraction of an inch across, in shears involving interlaminal slip planes, 1 inch or so apart, to folds many yards across in a zone of dragfolding $\frac{1}{4}$ mile wide.

Dragfolds, due to forces derived from igneous intrusives or by later movement along the contact, are best developed in the sediments along and near the contact with the Algoman(?) granite in the Norway Lake area. A conglomerate marker horizon has been folded into steeply plunging dragfolds up to 700 feet wide. Many small dragfolds were observed in the hornblende schist near the Algoman(?) granite northwest of Seahorse and Timlin lakes.

## Faulting and Fracturing

The rocks of the area have been broken by a number of faults, shear zones, and joints. Some of these occupy linear valleys and can be readily distinguished on air photographs of the area. The pattern of faults and joints is to a considerable extent reflected in the drainage pattern.

### SHEAR ZONES

#### Lumby-Spoon Lakes Shear Zone

A sheared zone, 100–2,000 feet wide, extends eastward from the west end of Lumby Creek, along a line of lakes to Hutt Lake, and disappears in the vicinity of the Pogo Lake portage. It dips northward at 70°–80°, with a few local dips as low as 45°. It occurs mainly within the area mapped as a quartz porphyry–diorite complex; most of the rock within the shear zone is a quartz-sericite schist, for, except near the contacts with sericite schists, the diorite is not much affected by the shearing. Differential movement is indicated at Spoon Lake by a small vertical lamprophyre dike being offset at a shearing at a contact of quartz-sericite schist and diorite. The movement gave rise to a right-hand strike separation of 3 feet.

Slickensides on shear planes in the sheared zones at Spoon Lake pitch 30°–35°E., microcorrugations in sericite schists nearby pitch nearly vertically, and vertical dragfolds in sericite schist south of Jefferson Lake indicate a relative movement of the north side eastward, which agrees with the strike separation observed on the dislocated vertical lamprophyre dike. The slip vector of the total movements occurring on the slips of this shear zone could not be determined.

The rocks in and near this shear zone are mineralized with sulphides at Lumby Lake and Spoon Lake. Thorough prospecting appears to be warranted throughout the area affected by the movements.

#### Minor Shear Zones

Minor shear zones parallel to the regional trend, and other evidence of differential movement parallel to the schistosity occur throughout the area. The more important of these are shown on the map. The minor shear zones are recognized by a high degree of foliation, with slickensides, polish, or microcorrugations on the planes of schistosity; by the presence of dragfolds; and topographically by gullies and elongated lakes. Where the pitch of the lineation can be measured on the planes of schistosity, it is generally very steep to vertical. As these shears are strike shears, no horizons are available for determining the amount and direction of the movement. Dragfolds developed by the shearing are useful locally in this respect and provide the means for determining the last direction of movement; no uniformity of results over the area was observed.

#### Redpaint Lake Shear Zone

One of the main structural features of the area is the zone of rupture that enters the map area southwest of Jet Lake and extends northeast to beyond Riverview Lake. It is part of a regional structure that extends from the Steeprock Lake area to the north end of Cloven Lake, a distance of about 35 miles; over most of this distance it occupies a pronounced valley occupied by elongated lakes. Within the map area, faulting has occurred on this zone of rupture. South of Redpaint Lake it forms a sheared zone in quartz porphyry, diorite, and greenstone, up to 1,500 feet wide, which narrows southward. At Redpaint Lake it is associated with a zone of intense crumpling of the chlorite schist, and northeastward it passes through Riverview Lake as a fault-line valley.

Various formations have been brought into contact along the fault zone. In the extreme southwest the Keewatin-type greenstone is brought up against the sheared quartz porphyry–diorite zone; from Jet Lake to Redpaint Lake, Algoman(?) granite is in fault contact with this contact zone and forms a prominent scarp; at Redpaint Lake greenstone may be in fault contact with Algoman(?) granite under the lake.

Movement on the main regional fault has produced a right-hand strike separation in the Jet Lake area of at least ½ mile, and north of Redpaint Lake of about 300 feet. The amount of relative movement is not known, but dragfolds in the shear zone south of Redpaint Lake indicate a relative movement of the northwest side upward of 10°–20° and towards the northeast. The schists in the shear zone dip vertically or very steeply; both east and west dips were measured. It is possible that the greenstone area in the southwestern part of the map area was the faulted continuation of the Lumby Lake greenstone belt, but evidence for differential movement on the regional fault suggests an opposite direction of movement. It is possible that it joins up with a greenstone area south of the map area, but this could not be checked in the time available.

Associated with the shear zone on the east side of Redpaint Lake is a zone of intense crumpling and fracture cleavage in the greenstone. From this crumpled zone, and possibly extending through it to coalesce with the regional structure, a fault occupying a fault-line valley passes northeastward and dies out in the greenstones northeast of Seahorse Lake. The amount and direction of movement on this fault is not known; the occurrence of limestone on the west side of the fault suggests that the sedimentary belt, extended to the southwest from this, has either been faulted upward on the west side and eroded away, or downfaulted on the west side so that only minor parts appear.

The zone of crumpling and fracture cleavage in the greenstones on the east shore of Redpaint Lake is a prominent feature closely related to the regional structure. Dragfolding is well developed at many places along the shear zone, and some of the folds in the crumpled zone may be associated with movement on the shear zone. The crumpled rocks are dark- to medium-green chlorite-carbonate schist and splintery sericite-carbonate schist derived from Keewatin-type volcanics. The folds actually observed in the schists range from ¼ inch to several feet from crest to crest. In general they decrease in amplitude and become more open eastward, gradually dying out about ½ mile east of Redpaint Lake. The attitude of schistosity varies greatly throughout this area, indicating folds several hundred feet across. The folds are generally chevron type, but U-shapes are common; most are fairly open.

The axial planes of the folds strike between N.25°–44°E.; dips range from 80°E. to vertical, to 87°W.; the axial lines plunge 80°–90° towards the northeast. Lineation due to intersection of S-planes is common and, where well developed, has produced a soft, splintery sericite schist. At the Alcock showing, mineralized quartz-carbonate veins up to 5 feet in width occur in the crests of folds up to 15 feet across in sericite schist. Brecciation and slickensides occur in the rocks adjacent to a fault-line valley at this showing.

Locally, along the east shore of Redpaint Lake and on nearby islands, fracture cleavage is well developed. A prominent set, fairly uniform in attitude for a distance of 2,000 feet along the shore, strikes N.20°E. and dips 16°W.; the average spacing of the fractures is about 4 inches. This closely spaced jointing is, in part at least, a shear phenomenon since certain fractures pass into a series of *en échelon* tension cracks aligned at 30° from the main fracture. Much more closely spaced fracture cleavage occurs on small islands off the east shore of Redpaint

Lake; a thin section shows the fractures to be a shear phenomenon, being small reverse faults, which die out over a few inches into minute corrugations of schistosity. No definite conclusions regarding differential movements in the shear zone could be reached from a study of the attitudes of the fracture cleavage.

Evidence in the Redpaint Lake area suggests that, in this vicinity, the general east-west formational trend, prior to the regional rupturing, changed to a southwest-northeast trend and was possibly continuous with the Finlayson Lake belt extending into the Steeprock area. This is further suggested by the southwestward trend of the Laurentian(?) intrusives unaffected by the main shearing, and by the occurrence of patches of sheared pillowed volcanics within the shear zone at the south end of Redpaint Lake.

The zone of crumpling now marks the zone of a rather abrupt change of schistosity. It is probable that at one time, perhaps before the Algoman(?) disturbance, the foliation curved uniformly around the early granite mass. With the intrusion of the Algoman(?) granite, or by later forces from the northwest and associated in time with the main regional break, the foreshortening by crumpling of greenstones took place.

An important factor in the development of the shear zone and associated crumpled zone is the presence of the early granite mass, which acted as a buttress, around and against which the schists have been buckled. With an increase of pressure from the west, impinging upon the greenstone and early granite equally and in a direction normal to the direction of major folding, the greenstone crumpled as the buttress held fast: an indication of this is the increasing amount and width of crumpling northward from the quartz porphyry–diorite complex. It is possible that the shortening of the greenstone section continued until the angular relationship of the buttress and edge of the greenstone was parallel to a shearing component of the force from the west strong enough to overcome the weaker resistance in that direction. Differential movement from such shearing would be of the west side towards the northeast.

The force producing the Redpaint Lake structure may be the same as that proposed by various geologists in the Steeprock area to account for the buckling of the Steeprock series and underlying Keewatin-type greenstones against the Laurentian granite on the east to form a series of folds with their axial planes trending northward. Hawley[1] suggests an east-west couple with the north block moving eastward and states that the age of the deformation is Algoman. Bartley[2] indicates a later compressive force in the north-south direction, which produced cross-faulting and slight overturning to the south, and which he believes to be associated with the Algoman igneous activity.

### CROSS-FAULTS AND FRACTURES

Cross-faults and fractures trending N.30°–50°E. are common features of the western part of the area and are expressed topographically by valleys and gullies cutting across the east-west ridges. Although the strike separation could not be accurately determined for any of the faults, evidence for faulting lies in the dragfolding, slickensides, and brecciation that occurs in the rock adjacent to the fault-line valleys. Some of the linear valleys that mark faults or fractures curve eastward and disappear as they pass northward from the Laurentian(?) granite into the greenstone area.

[1] J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, pp. 20, 21.

[2] M. W. Bartley, *Iron Deposits of the Steeprock Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2, p. 40.

The post-Algoman(?) fault that enters the greenstone area at Lumby Lake can be traced by its topographic expression across the greenstone belt and into the granite at Norway Lake. It appears to displace the vertical agglomerate-tuff bed on the north side of Lumby Lake, giving rise to a strike separation of 300 feet, and the contact at Norway Lake by the same amount. These strike separations are deduced by extrapolation of indicated trend and may be in error.

An interesting observation concerning this fault is the gradual bending eastward in the southern part of the greenstones, and the bending back northward in the northern part. This may be due to post-faulting differential movement on the slip planes of the Keewatin-type schists; or it may be due to the contrast in physical characteristics between granite and schists, causing the fracture to assume different directions in different rock types. Examples have been noted where fractures curve to align with regional trends as they pass into a less competent rock.

Several cross-fractures, probably with some movement, occur in the Spoon Lake area. Two of these, adjacent to the points of land in Spoon Lake, appear to be associated with the main east-west shear zone and appear only on the north side of the shear zone. A third fracture cuts the shear zone between Spoon and Herontrack lakes, curves northeastward and disappears in the greenstones. These cross-faults or fractures at Spoon Lake are important in the localization of mineralization at Spoon Lake; galena, sphalerite, chalcopyrite, and gold are reported from the points on the north shore.

The Bar Creek fault follows the contact of the quartz porphyry–diorite complex and Laurentian(?) granite for almost ½ mile, but it is not known if this distance represents a strike separation along a fault.

Several other northeast-trending valleys occur in the area, and some are occupied by faults. These valleys become fewer eastward perhaps because of the greater amount of overburden masking bedrock.

Faults associated with the greenstone–Algoman(?) granite contact occur north of Pinecone Lake and north of Gargoyle Lake; both are marked by gullies. No indication of the direction of movement was noted on the former; dragging adjacent to the latter suggests that the south side moved downwards vertically in relation to the north side.

No definite conclusion can be reached regarding the nature and origin of these cross-faults. The northeast-southwest-trending faults may be unduly emphasized, since the valleys that mark their courses are approximately parallel to the direction of flow of the ice sheet over the area and thus might be accentuated by glacial scour.

## Brecciation

Fault breccias and intrusion breccias occur at several places throughout the area. Other less readily identifiable breccias are found locally. An important zone of brecciation occurs along the north shore of Pinecone Lake and between Pinecone and Spool lakes. It is best exposed on the north side of the east end of Pinecone Lake where it forms a cliff 50–75 feet high and is composed of irregular, angular fragments of basalt up to 3 inches in diameter set in a calcite matrix with minor chert. At the base of the cliff a few fragments of garnetiferous schist occur in the breccia, suggesting that along this part of the brecciated zone, the breccia is at the contact of the volcanics and sediments. The brecciation in the volcanics dies out northward over 100–200 feet. Between Pinecone and Spool lakes, and at Spool Lake, the breccia is composed of angular fragments of sediments and hybrid rocks in a calcite matrix. These breccias are part of one zone of brecciation, which may be the result of post-Algoman(?) movement concentrated in and near the band of sediments. The calcite of the matrix may have been derived by solution from the limestone occurring in the vicinity.

Breccia, intersected in the iron formation and graphitic argillite by diamon - drilling at Hematite Lake, has been described under intraformational and interformational breccias. Some of the microfaulting in the banded silica-sericite is so intense as to produce a breccia.

Minor zones of brecciation, too weak or too small to be mapped, are common throughout the area. Those occurring in the area between Magnesium, Irish, and Gargoyle lakes are no more than closely spaced intersecting joints in greenstone, opened by slight movement and filled with carbonates.

## ECONOMIC GEOLOGY

The area has not yet been thoroughly prospected, but minor finds have been made occasionally since the discovery of gold near Longhike Lake in the 1890's. Early prospecting was an extension of investigations farther south, where the Sawbill and Hammond Reef mines were operating about the turn of the century. One of the early geologists in the area, McInnes,[1] noted the presence of pyrite and chalcopyrite in float about the shores of two small lakes near the height-of-land south of Norway Lake.

With the failure of the early gold properties, no further interest was shown in the area until the discovery of gold at Lumby Lake in 1937 renewed prospecting, and finds of copper and zinc were reported. Development work was unsuccessful, and the claims lapsed.

The Alcock gold property at Redpaint Lake was staked in 1946 in the vicinity of old locations near the Bonheur trail. In 1948 and 1950 the Lumby Lake showings were restaked, and the report that Noranda Mines Limited and Newkirk Company Limited had optioned the claims caused considerable speculative staking in 1950–51. Many of the claims staked at that time have lapsed.

Investigations, since 1950, of the iron formation on the Mathieu property at Hematite Lake have revealed the presence of iron sulphides and siderite, and, in 1952, Candela Development Company explored these zones as a source of iron and sulphur.

### Metallic Minerals

#### GOLD

Gold has been reported from many places in the area, but only a few of these were visited. Gold occurs in quartz veins and in quartz-carbonate veins cutting both massive and sheared Laurentian(?) granite and Keewatin-type greenstones. It is also found associated with base metal sulphides disseminated in sheared quartz porphyry and greenstone.

Gold was first discovered in the area near Longhike Lake, and the development at the Golden Winner mine was carried on for about a year and a half in 1899 and 1900. Production amounted to 15 tons for a total value of $70 at the price for gold in 1900. The exact location of the old mine is not known, it is described by Bow[2] as being

> situated on a small lake 4 miles northeast of Sawbill lake and a mile and a half east of the Bonheur-Sawbill road . . . The workings are about one-quarter mile northeast of the lake on which the camps are situated. The buildings consist of stamp mill, hoist house and blacksmith shop at the mine, and office, storehouse and boarding camps on the lake.

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[1]William McInnes, *Summary Report*, Geol. Surv. Can., Vol. IX, 1896, Report A, p. 35.
[2]J. H. Bow, *Mines of Northwest Ontario*, Ont. Bur. Mines, Vol. X, 1901, p. 109.

The geology is described by Bow as follows:

The deposit as exposed down the shaft is a large body of chloritic schist interbanded with quartz lenses and stringers all more or less highly impregnated with iron pyrites and dipping about 45 degrees south.

The underground development and installation of a stamp mill is a further example of the lack of judgment evident in the early mining development throughout the Kenora–Rainy River district. The work dates back to an era when the discovery of native gold was considered sufficient justification for sinking a shaft, and followed a pattern all too frequent in the early days. The reasons for the failure of the district as a gold producer are outlined by Bruce.[1]

A shaft is also reported to have been sunk to a depth of 30 feet on location E. S. 20, about 1 mile south of the east end of Spoon Lake, by the management of the Golden Winner mine in 1899. The old workings were not seen by the author, but from the described locality it appears to be in the area underlain by Laurentian(?) granite.

In 1937, Albert Wren, with a Geological Survey of Canada survey party, picked up a piece of float at the west end of Lumby Creek, which on assay gave a gold content of many ounces per ton. The report of the high assay resulted in considerable prospecting in the immediate area, considerable trenching and stripping, and a small amount of diamond-drilling by the Wilson-Wren interests and Red Cedar Gold Mines Limited. Copper and zinc deposits, with some gold values, were found during this prospecting.

Gold occurs in the Lumby Lake shear zone and is concentrated in siliceous zones and associated with copper, lead, zinc, and silver. The gold content is very low however; a siliceous zone with disseminated sulphides is said to have assayed 0.034 ounces per ton over 20 feet; with Ag, 0.57 ounces per ton; Cu, 0.25 percent; Zn, 0.22 percent. A grab sample taken by the author from a test pit in sheared porphyry at Spoon Lake assayed 0.05 ounces of gold per ton; with Ag, trace; Cu, 0.29 percent; Zn, 6.74 percent; Pb, 1.75 percent.

On the Alcock property, gold occurs in and near rusty quartz-ankerite veins occupying the crests of folds in sericite-carbonate schists and is associated with pyrite and chalcopyrite. Assays up to 1.99 ounces per ton are reported from grab samples of the vein material. Smaller quartz-ankerite veins occurring in minor flexures in schists at Gargoyle Lake carry only traces of gold.

Visible gold is said to occur at several places in the vicinity of Pyramid Lake. A test pit ¼ mile south of Brushport Lake reveals considerable pyrite and minor sphalerite in a dike of altered quartz porphyry. A grab sample, taken by the author, and assayed by the Provincial Assay Office, showed 0.09 ounces of gold per ton and a trace of silver.

## COPPER

Copper deposits were found in the Lumby Creek area during prospecting for gold in 1938-1939, the original discovery being made at the junction of the creek from Morris Lake and Lumby Creek west. Further exploration in 1951 revealed deposits at several places in a mineralized shear zone along Lumby Creek. Chalcopyrite occurs as fillings in the selvages of pillow structure in andesite and disseminated in siliceous zones within sheared quartz porphyry. Minor diamond-drilling in 1938 by Wilson-Wren interests and Red Cedar Gold Mines Limited and a larger drilling program in 1951 by Noranda Mines Limited in this zone, failed to give encouraging results.

[1]E. L. Bruce, *Gold Deposits of Kenora and Rainy River Districts*, Ont. Dept. Mines, Vol. XXXIV, 1925, pt. 6, pp. 1, 2.

Minor chalcopyrite mineralization has been noted at several other showings in the area, notably at Spoon Lake, Rea Lake, Redpaint Lake, and at Blowout Lake.

#### LEAD

Galena crystals up to ½ inch occur in a narrow quartz vein cutting chlorite schist on the north side of Lumby Lake. Galena, associated with sphalerite, occurs in sheared, altered quartz porphyry on the north-central point of Spoon Lake on the Little Long Lac option, where considerable trenching and stripping has been done.

#### ZINC

Sphalerite occurs disseminated in the siliceous zone in sheared quartz porphyry at the west end of Lumby Creek on the Anderson property; one channel sample was reported to assay 0.5 percent over 5 feet. A grab sample taken by the author from a test pit at Spoon Lake and assayed by the Provincial Assay Office gave 6.74 percent zinc; gold, 0.05 ounces per ton; silver, trace; copper, 0.29 percent; lead, 1.75 percent.

#### IRON

There appears to be a good possibility of discovering economic deposits of iron in the area. No bodies of hematite are known, but persistent reports of hematite float in the Norway Lake area, plus the occurrence at Norway Lake of carbonate rock resembling the Steeprock limestones, have given rise to minor prospecting in this vicinity. Small lenses of magnetite iron formation have been found in the volcanics north of the band of sediments, and within the main sedimentary band at Seahorse Lake and Pinecone Lake. The iron content of these rocks is too low for economic extraction.

Magnetic attractions, some of them quite strong, occur at a number of localities mainly in or near the sediments, and may indicate magnetite or pyrrhotite bodies and thus warrant investigation. The most important of these magnetic attractions are shown on the map.

Lenses of siderite, partly very siliceous and partly fairly massive, have been intersected by diamond-drilling in the Hematite Lake area, where Candela Development Company explored bodies of sulphide in the iron formation. These siderite lenses contain up to 37 percent iron and range up to 40 feet in thickness. These have been intersected in drill holes spaced over a length of 4,000 feet between Hematite and Keewatin lakes.The occurrence of siderite in pisolitic form and its association with intraformational breccias and banded silica suggests a syngenetic sedimentary origin.

### Industrial Minerals

#### GARNETS

Dark-red garnets of the almandine-pyrope variety occur in varying amounts in the argillaceous sediments, especially near the intrusive granite contacts at Garnet Bay, Pinecone Lake, and Hematite Lake. The crystals are generally well formed trapezohedrons and range up to ¼ inch in diameter. The garnet content averages less than 10 percent of the rock, but in certain zones west of Garnet Bay, the garnet content is estimated at 35 percent.

#### ANDALUSITE

A thin section of a specimen of metamorphosed sediments exposed at the south end of Norway Lake shows about 30 percent andalusite, as small, impure, disseminated metacrysts. This rock should be investigated as a source of ceramic material.

### GRAPHITE

Lenses of graphitic argillite and graphite schist are common in the southern part of the main band of sediments, from Cross Lake to east of van Nostrand Lake. Graphite occurs in these rocks as fine flakes disseminated throughout and forms highly polished films on slip surfaces. A grab sample taken by the author from the pit at Pinecone Lake and assayed by the Provincial Assay Office, contains 13.70 percent carbon (C). The purity of the flake graphite is not known. The graphite content of the argillite appears to be highest where the rock contains many pyrite concretions of syngenetic or diagenetic origin, a fact that suggests an organic origin for the carbon.

### SULPHUR

As noted in the section on iron, exploratory drilling on the Mathieu property has revealed bodies of massive and disseminated pyrite and pyrrhotite in the iron formation that might be significant as a source of sulphur. Pits at Pinecone and Cryderman lakes expose small lenses of massive sulphide in concretionary graphite schist. A small amount of native sulphur, derived from weathering of the sulphides, was found in both these pits. Traces of nickel and copper were reported by the Provincial Assay Office in a sample of massive pyrrhotite from Cryderman Lake.

## Discussion, and Recommendations for Prospectors

Most of the gold and base metal deposits of the southern part of the area show an obvious areal relationship with the Laurentian(?) soda-granite. Even a casual inspection of the claim maps shows a concentration of old mining locations in the area underlain by the Laurentian(?) batholith extending southward to the Sapawe Lake area. Most of the locations were staked on narrow, gold-bearing quartz veins in small shear zones in granite, but none was large enough to be mined at a profit.

Conditions in the contact area of the Laurentian(?) and Keewatin-type rocks appear to have been favourable for the deposition of gold and base metals. The so-called Lumby Lake shear zone and its associated cross-faults may have provided the main channelways for the mineralizing solutions. Deposition has occurred in and near these channelways, in favourable zones such as the pillowed parts of flows, subordinate shears, and parts of the main shear close to cross-faults and fractures. This shear zone and its associated structures warrant thorough prospecting over the known length from Lumby Lake to the area south of Jefferson Lake.

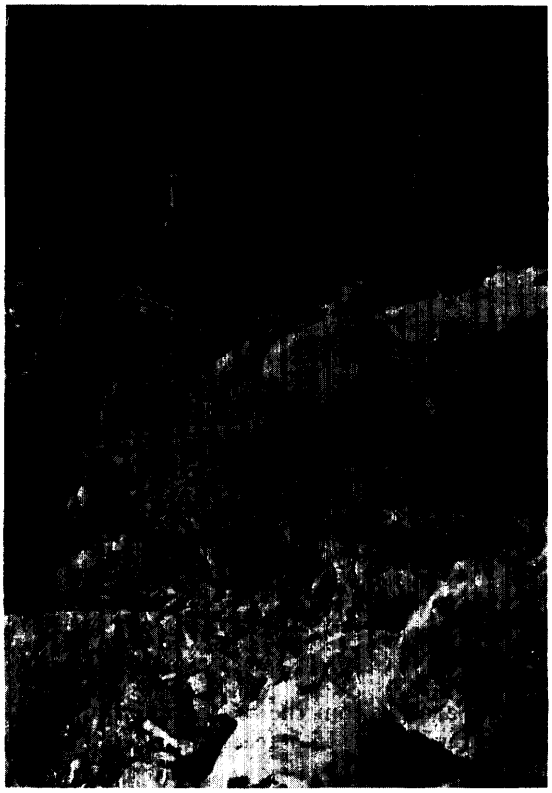
Though the areal relationship of these deposits with Laurentian(?) rocks is obvious, the time of deposition of the ore minerals is not definite. The association with cross-fractures at Spoon Lake has been noted, but the relative age of these fractures cannot be definitely established. On some of them, and on the Lumby Lake shear zone, possible post-Algoman(?) and post-mineralization movement has occurred. The gold-quartz veins, containing little or no carbonate, occurring in the greenstones and early granite, appear to associate with Laurentian(?) rocks, whereas gold-bearing quartz-ankerite veins within the greenstones are associated with, or are later than, the intrusion of the Algoman(?) granite.

Iron deposits are confined to the iron formations interbedded in the volcanics and in the sedimentary belt. None of the magnetite iron formation in the main belt or in the smaller zones is thought to be of commercial importance at present prices for iron. Siderite and at least some of the pyrite at Hematite Lake is of syngenetic sedimentary origin; the pyrrhotite and later pyrite may possibly be of hydrothermal replacement origin, the mineralizing solutions emanating from the magma of the van Nostrand stock, or of an unexposed Algoman(?) intrusive.

## DESCRIPTION OF PROPERTIES

### 1. L. C. Anderson

Original staking in the area of the Anderson property was done in 1938, and the property was held until 1940 by Red Cedar Gold Mines Limited, and by the Wilson-Wren interests. A group of 50 claims was restaked by L. C. Ander-



**Mineralized shear zone in schisted andesite at main trench on Anderson property.**

son of Port Arthur in 1948 and 1950. Newkirk and Company Limited optioned the property and amalgamated their holdings with 38 adjacent claims held by Noranda Mines Limited, who were in charge of the exploration on the 88 claims. Work was started in February, 1951; an electromagnetic survey was done before breakup, and diamond-drilling, mapping, and trenching continued until July, 1951, when Noranda withdrew from the property, and the 50 claims reverted to Newkirk and Company. Nine holes totalling 2,417 feet were drilled in this program.

The property extends from Twobay Lake to the east side of Herontrack Lake and is underlain by Keewatin volcanics, chlorite and chlorite-sericite schists, and by intrusive quartz porphyry. All these rocks have been affected by shearing. The contact with the Laurentian(?) granite lies about ½ mile south of the property. The schistosity of the rocks throughout the property strikes about N.85°–90°W., and dips 65°–75°N.

A strong east-west shear zone extends through the eastern part of the property. Most of the mineralization on the property is found in or near this shear zone. A cross-fault cuts across this shear zone at Lumby Lake, and a fault zone was intersected by drilling under Morris Lake.

Sulphide mineralization occurs in many places on this property, but the strongest concentration is in, and near, the shear zone west of Lumby Creek where gold, copper, silver, lead, and zinc have been found. Mineralization has been found in the quartz-sericite schist derived by shearing from quartz porphyry, and in sheared and unsheared volcanics.

Gold, silver, zinc, and copper occur in a silicified zone in sheared quartz porphyry at the west end of Lumby Creek. A series of trenches in this area show pyrite, chalcopyrite, and sphalerite disseminated over widths up to 20 feet. A compilation of assays supplied by Noranda Mines Limited, over a 20-foot width in the westernmost trench is as follows: Au, 0.034 ounces per ton; Ag, 0.57 ounces per ton; Cu, 0.25 percent; Zn, 0.22 percent.

On the east side of the creek, float containing chalcopyrite and sphalerite has been found. Diamond-drilling in this area revealed several mineralized siliceous zones, indicating a possible eastward extension of the zone west of the creek. Assay values were generally low, and good mineralization was confined to narrow widths.

The copper occurrence in the trench at the east side of the creek flowing north from Morris Lake into Lumby Creek is thought to be the original copper discovery of the area. Sulphide mineralization occurs in two zones of pillowed andesite in this trench; chalcopyrite and pyrite have been deposited in the selvages between the pillow structures and clearly outline their shape. The southern zone is 14 feet wide and assays (south to north) as follows:

| Length<br>Feet | Copper<br>Percent |
|---|---|
| 4.0 | 0.19 |
| 5.0 | 1.30 |
| 5.0 | 0.81 |

The north zone, separated from the south zone by 20 feet of low-grade material, is exposed for a width of 16.5 feet and a length of 25 feet and assays (south to north) as follows:

| Length<br>Feet | Copper<br>Percent |
|---|---|
| 5.0 | 1.18 |
| 5.0 | 1.37 |
| 6.5 | 0.68 |

The gold and silver content is reported to be very low. The assays above were supplied by Noranda Mines Limited.

Sulphide mineralization is exposed in trenches in quartz-sericite schist (sheared quartz porphyry) along Lumby Creek, between the trench mentioned above and the west end of Lumby Lake. Minor chalcopyrite and pyrite occur in a trench adjacent to the collar of Noranda's No. 1 drill hole. A channel sample over 6 feet, assayed by Noranda Mines Limited, gave: Cu, 0.66 percent; Au, trace; Ag, trace; and a contiguous 6-foot channel sample gave; Cu, 0.39 percent; Au, trace; Ag, trace.

## 2. Noranda Mines Limited

Noranda Mines Limited holds a group of 38 unpatented claims extending westward from the L. C. Anderson property to Redpaint Lake and south of the Alcock property. Considerable prospecting had been done earlier in this area, probably about 1895–1900 and again in 1937–38. These claims were staked in 1950, and exploratory work was done in the spring and summer of 1951.

The claims are underlain by an assemblage of rock types mapped as a quartz porphyry-diorite complex, which is a contact phase of the Laurentian(?) granite. The assumed contact of this complex with the Keewatin greenstones crosses the northern part of the property. A wide zone of shearing and folding, trending N.30°E., occurs along the west side of the property near Redpaint Lake.

Two shear zones containing gold-bearing quartz veins were drilled by Noranda in 1951. The Blowout showing occurs in a spruce grove between Claw and Blowout lakes on claims K.14520 and K.14517. The company reported that no significant gold assays were obtained in any of the six short drill holes put down on the showing.

A showing on claim K.14521 on the east shore of Redpaint Lake, ¼ mile north of the narrows, consists of a quartz vein 3 feet wide exposed for a length of 25 feet in a narrow shear zone in diorite. Four short holes were drilled in August, 1951, but gold assays were nil. One 6-foot channel sample across the shear zone gave an assay of 4.8 ounces of gold per ton, but other channels gave only nil to traces of gold. (Assays by Noranda Mines Limited.)

## 3. C. A. Alcock

This group of 13 unpatented mining claims is situated on the east side of the north end of Redpaint Lake. Several old mining locations are shown on the claim maps in the vicinity; early prospecting was done about 1895–1900. The present claims were staked by C. A. Alcock in 1946. The claims are underlain by greenstones and sericite-chlorite schists and lie near the west margin of the greenstone belt, astride a wide zone of strong NE.–SW. shearing and crumpling that extends along the east shore of Redpaint Lake.

Many rusty quartz-carbonate veins occur on this property, and all those examined appear to be associated with the folding, in most places occupying the crests and troughs of different sized folds in the highly contorted schists.

The main showing lies about 600 feet south of the north bay of Redpaint Lake, on claim K.11821, and consists of six test pits and strippings extending for 125 feet along the southeast side of a gully trending N.35°E. The valley marks the trace of a strong regional fault. Quartz-ankerite veins up to 5 feet in width occur in the crests of folds, in splintery sericite-carbonate schists associated with this fault. Mineralization consists of pyrite and chalcopyrite; no visible gold has been noted. Mr. Alcock reports that grab samples from this showing assayed 0.07–1.99 ounces of gold per ton, and that a channel sample, taken across 4.5 feet, assayed 1.38 ounces of gold. A grab sample, taken by the author and submitted to the Provincial Assay Office, yielded 0.35 ounces of gold per ton and 0.48 percent copper. Gold is reported to occur in the wallrock schists as well as in the veins.

A grab sample from a vein 500 feet southwest of this showing is reported by Mr. Alcock to have assayed 0.08 ounces of gold per ton. About 300 feet northeast of the main showing, near No. 1 post of claim K.11821, a rusty quartz-carbonate vein of unknown width is exposed in a small outcrop on the valley side. These veins are probably extensions of the main showing.

The following additional veins were observed on the property: on claim K.11825, a 5-foot quartz-carbonate vein with considerable pyrite in both vein material and altered wallrock occurs at the beaver dam in the pond near the east side of Redpaint Lake. Mr. Alcock reports an assay of 0.03 ounces of gold from a grab sample from this vein. On claim K.11825, a 3-foot vein occurs in small folds on the north shore of the small bay on the east side of Redpaint Lake. On claim K.14471, a test pit south of the point at the north end of Redpaint Lake shows minor pyrite and chalcopyrite in wallrock adjacent to a 3-foot quartz-carbonate vein. On claim K.11822, a 10-foot trench exposes a 1-foot quartz-carbonate vein in crenulations with pyrite and minor chalcopyrite mineralization in the vein and in carbonatized wallrock. A grab sample, taken by the author and submitted to the Provincial Assay Office, yielded 0.16 ounces of gold per ton.

### 4. Little Long Lac Gold Mines Limited (Option)

Little Long Lac Gold Mines Limited holds by option a group of 32 unpatented claims, staked in 1950, adjoining the east end of the L. C. Anderson property. The claims were prospected in 1951, and considerable stripping and trenching was done in the Spoon Lake area.

The claims are underlain by Keewatin volcanics, and by a complex of intrusive quartz porphyry and diorite. Laurentian(?) granite occurs about 1 mile south of the property. A shear zone extends the length of the property along Spoon Lake, and mineralization is concentrated in and near this shear zone, apparently localized near cross-faults and fractures.

On the west point on the north shore of Spoon Lake, a number of trenches exposed crystals of pyrite up to ⅛ inch, disseminated in sheared quartz porphyry. Gold has been reported, but assays are very low.

On the centre point of Spoon Lake, copper, lead, zinc, gold, and silver occur in altered sheared quartz porphyry. Mineralization may be associated with unsheared diorite masses and appears to be localized by small crenulations in the schistosity produced by cross movements. A test pit in the northeast corner of claim K.14599 exposes chalcopyrite, galena, sphalerite, and pyrite as small masses and disseminations in a silicified zone 8 feet wide. A grab sample, taken by the author from this pit and assayed by the Provincial Assay Office, yielded Au., 0.05 ounces per ton; Cu., 0.29 percent; Zn., 6.74 percent; Pb., 1.75 percent; Ag., trace.

### 5. J. A. Mathieu

The Mathieu property includes the block of unpatented mining claims K.12409, K.12412-20, K.12424, K.12426-27, K.15779-89, and K.16637-39, optioned by Candela Development Company from J. A. Mathieu, and two blocks K.16609-17 and K.16627–35, staked by Candela.

According to Bartley,[1] the presence of limonite gossan at Hematite Lake was first reported in 1914, but no concerted effort to investigate the underlying bedrock was made until 1948-49, when diamond-drilling was done from the ice of Hematite Lake. In 1950, four holes totalling 2,001 feet were drilled for Mathieu interests in search of iron ore, the work being directed by M. W. Bartley of Port Arthur. In 1952, Candela Development Company, a subsidiary of Freeport Sulphur Company of New York, optioned the property. During the summer of 1952, 13 holes totalling 3,192 feet were drilled.

[1]M. W. Bartley, *Report on the J. A. Mathieu Property*, private report, 1950.

The main belt of sediments crosses the property from east to west, varying in width from 400 feet to over 2,500 feet. The strike of the sediments ranges from N.80°W. to N.85°W., with some flexures and dragfolding; dips are very steep to vertical, with local variations. The sediments may be subdivided into two divisions, the northern part being mainly siliceous iron formation up to 1,200 feet wide, and the southern part argillaceous greywacke and graphitic argillite. The largest lens of graphitic argillite occurs at Hematite Lake. A stock of Algoman(?) granite intrudes the greenstones and sediments of the east end of Hematite Lake. Iron sulphide and siderite occur largely within the iron formation at and near its contact with the argillite, but locally concretionary pyrite zones in the argillite are important. Mineralization consists of massive to disseminated pyrite and pyrrhotite, underlain by lenses of siderite. The siderite is in part pisolitic, and is, along with at least some of the pyrite in the iron formation, probably of sedimentary origin. The pyrrhotite occurs as finely crystalline aggregates, suggestive of replacement of chert, and is later than some of the pyrite. The pyrrhotite, and a later, well-crystallized pyrite may be of hydrothermal origin and associated with the van Nostrand granite stock.

Three zones of mineralization had been outlined by drilling up to 1952. The A zone, on the south side of Hematite Lake, is about 2,100 feet long. Sulphides were intersected by four drill holes, but core lengths were less than 50 feet, and estimated sulphide content was about 40 percent; no siderite was reported from this zone.

The B zone is a possibly continuous band of sulphides in the iron formation; the average width is about 55 feet. Sulphur content of material sampled and assayed by Candela Development Company averaged 15–36 percent sulphur, an approximate average for the zone being 20 percent. The zone is folded north at the west end, so that a pair of holes, drilled north and south from one set-up east of Keewatin Lake, totalled 574 feet of iron sulphides averaging 22.2 percent elemental sulphur.

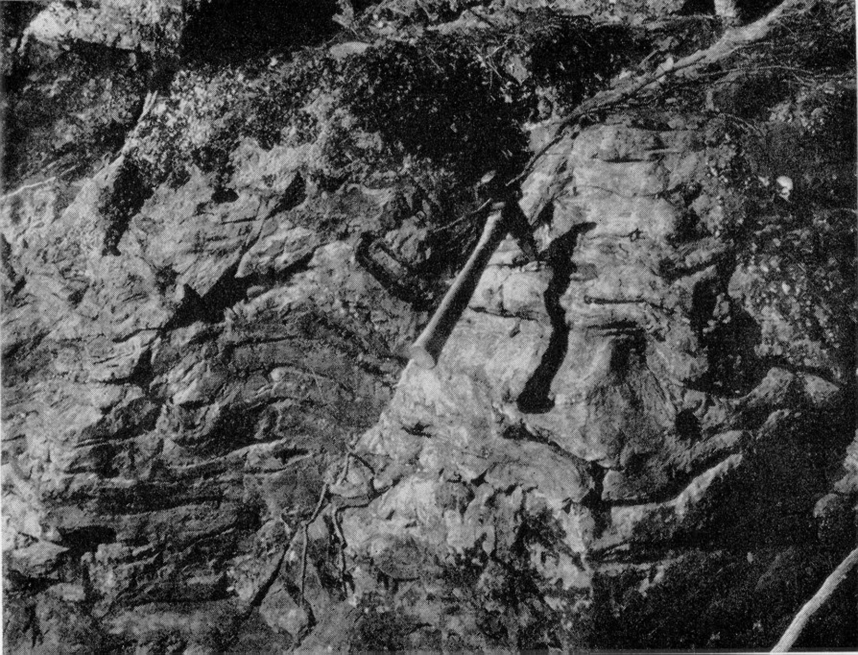
North of the sulphide zone, and in places interbedded with sulphides, lenses of siderite occur; the iron carbonate contains varying amounts of silica and small amounts of iron sulphides and iron silicates, grading with increasing silica northward into cherty silica zones of low iron content. The siderite zones intersected range up to 40 feet in true width and vary considerably in iron and silica content. Four bands of siderite were intersected in drill hole No. 3 of the 1950 drilling. The widest zone was intersected between 249–299 feet and represents a true width of 41 feet. Assays provided by M. W. Bartley are as follows: Iron, 27.60 percent; manganese, 1.80 percent; silica, 19.63 percent; sulphur, 2.03 percent.

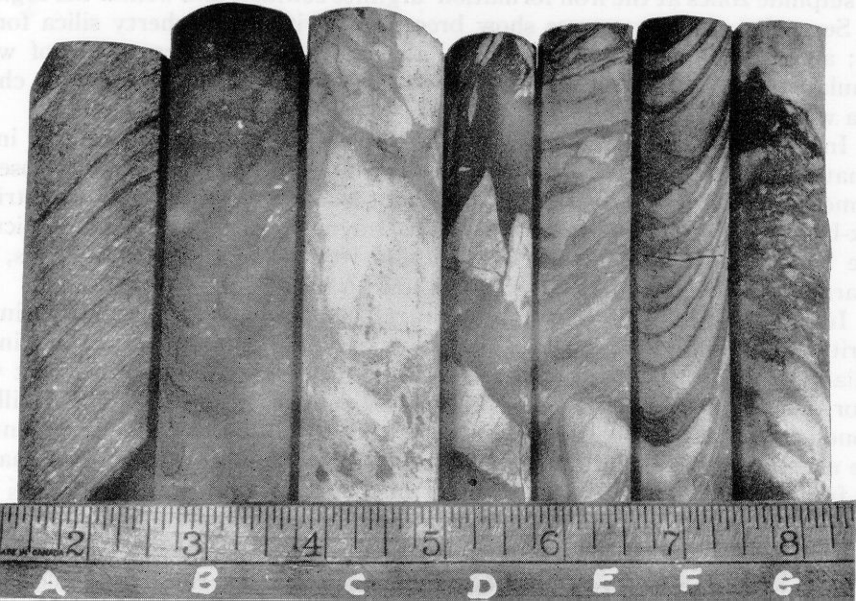
It is possible that the siderite lenses form a zone extending the entire 4,000 feet of the B zone and may prove to be of an economic grade and width in a form readily amenable to modern methods of beneficiation.

The C zone, west of Keewatin Lake, had, until 1952, only limited exploration. Mineralization consists of pyrite concretions in argillite, and disseminated pyrrhotite in the chert on the north. The zone is about 400 feet long, with 15.6 percent sulphur over a core length of 115 feet being reported. No notable siderite mineralization was intersected.

In brief, the sulphide zones, especially B zone, would appear to be a promising source of sulphur and iron. The siderite associated with the sulphides may be developed into an economic source of iron.

# INDEX, PART 5

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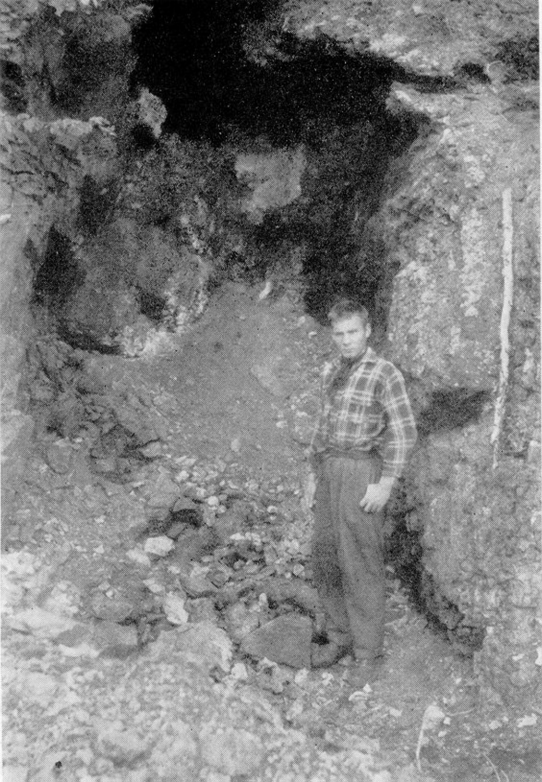


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