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Geology of the Spragge Area

District of Algoma

By
JAMES A. ROBERTSON

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ABSTRACT

This report describes the stratigraphy, structure, and economic geology of Long, McGiverin, Esten, and Spragge Townships, and that part of the Serpent River Indian Reserve (I.R. No. 7) lying south of Spragge Township. Pronto Mine, the initial uranium discovery of the Blind River camp, is located in the map-area and operated from 1954-1960, producing U_3O_8, valued at about $48,000,000. To the end of 1964 the Pater copper mine at Spragge has produced copper, valued at over $10,000,000.

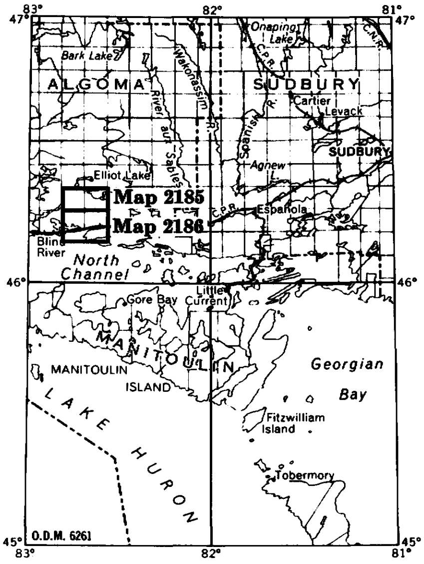

Figure 1 — Key map showing location of the Spragge area. Scale, 1 inch equals 50 miles.

Geologically the area may be divided into two parts, separated by the Murray Fault, which runs from west to east close to the shore of the North Channel of Lake Huron.

The oldest rocks in the map-area are metavolcanics and metasediments exposed in the northeast corner of Esten Township. They lie at the southwest margin of the Keewatin(?) belt underlying the eastern portion of the Quirke Syncline. Chloritic and amphibolitic inclusions in the Algoman granites probably represent similar rocks.

The greater part of the area north of the Murray Fault is underlain by granitic rocks. Relicts of older rocks and gneissosity become more pronounced as the Keewatin(?) zone is approached.

Huronian sedimentary rocks are exposed in the southern and western parts of the map-area. Rocks of unquestionable Huronian age are found south of the Murray Fault at Algoma. Huronian sedimentation began with coarse-grained sediments derived from a weathered granitic terrane. The Bruce Group is represented by the Lower, Middle, and Upper Mississagi Formations (the author wishes to raise these three to formal formational status and to use the term Mississagi formation as an informal designation only), Bruce Formation, and possibly the Bruce Limestone Member of the Espanola Formation. The Bruce Group is overlain unconformably by the Gowganda Formation of the Cobalt Group.

These rocks were folded about an anticlinal axis striking slightly north of west and plunging gently west. Nipissing-type diabase (approximate age 2,100 million years) was then intruded as dikes and sills. Locally albitization, chloritization, and the introduction of sulphide mineralization are associated with these diabase intrusions. Early movement on the Murray Fault may be of this age.

The Cutler batholith was intruded about 1,750 million years ago. This is a quartz-rich, two-mica granite characterized by an abundance of simple pegmatite. Metavolcanics at Spragge and schists and quartzites between the Murray Fault and the batholith were long thought to be Archean (Sudbury Group) in age but may be metamorphosed Thessalon Greenstone and Lower and Middle Mississagi Formations. Pending clarification of regional correlation these rocks have been named the Spragge Group. Sill-like bodies of epidiorite associated with the Spragge Group may represent the Nipissing diabase. Inclusions of the metamorphic rocks are common within the Cutler batholith and are aligned parallel to a characteristic gneissosity. The Cutler Granite is cut by northwest-trending dikes of olivine diabase (Keweenawan age, 1,170 million years).

Pleistocene glaciation resulted in the removal of soil; sand and gravel flats, particularly in the southern part of the area, represent former extensions of Lake Huron or ice-dammed lakes.

The area has been extensively prospected: particularly for uranium, mainly in the Huronian outcrop area; and for copper, mainly in the Spragge Group rocks and near major faults or diabase intrusions. Pronto Mine developed the only significant uranium discovery in the area and this deposit is essentially worked out. The Pater copper mine has been in operation since 1960. The reserves of the Twin Lakes copper showing of Cadamet Mines Limited in Esten Township were estimated at 76,900 tons grading 1.73 percent copper. Sand and gravel has been intermittently quarried near Highway 17; it is mainly used for road construction and maintenance.

Geology
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Spragge Area
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By

James A. Robertson[1]

INTRODUCTION

Following the discovery in 1953 of uranium in commercial grade and quantity in Long Township, E. M. Abraham of the Ontario Department of Mines, who had a field party in the Iron Bridge area, carried out mapping in the vicinity. Further mapping near the discovery was performed during the field seasons of 1954 and 1955 but it was not until 1960 that the author was instructed to supervise routine mapping of the Spragge area. Long and McGiverin Townships were mapped in 1960 and Esten and Spragge Townships and that part of the Serpent River Indian Reserve (I.R. No. 7) lying south of Spragge Township were mapped in 1961. Preliminary maps P.70, P.73, P.130, and P.131 were issued in 1960 and 1961 (Robertson and Abraham 1960a and b; Robertson 1961b and c).

The map-area lies halfway between Sudbury and Sault Ste. Marie. It is served by the Canadian Pacific Railway (Sault Ste. Marie branch) and the Trans-Canada Highway (Highway 17). Highway 108, which connects Elliot Lake and the adjacent mines with Highway 17, leaves Highway 17 near the southeast corner of Spragge and runs in a northerly direction close to the east margin of the area.

The principal communities are: Spragge, Pronto Mine, Pronto East subdivision, and Algoma, the latter lying in Long and Striker Townships. Passenger rail service is available at Spragge and sidings are located at Stanleigh siding, Rio Algom siding, Denison siding, Spragge, Stanrock siding, Texaco depot, Pronto East subdivision, and Algoma.

Deep water for navigational purposes is available in the Serpent River estuary at Spragge. Spragge was formerly an important lumber port but the docking facilities have been totally destroyed.

Prospecting throughout the North Shore of Lake Huron has been carried out since the discovery of copper at Bruce Mines in 1846. Several gossan areas, sulphide localities, and the majority of quartz veins show signs of early prospecting. Samples from one of the early prospects led to the discovery of the Pronto uranium deposit and to the ultimate development of the Blind River-Elliot Lake uranium camp. Subsequent exploration for uranium drew attention to an old copper prospect at Spragge. The latter became the Pater Mine. Extensive prospecting including geophysical exploration and diamond drilling has been carried out since 1953 in the search for uranium and copper.

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[1]Geologist, Ontario Department of Mines, Toronto. Manuscript received by the Director, Geological Branch, 2 December 1966.

Spragge Area

In 1953 Abraham mapped a mile wide strip between the east end of Lauzon Lake in Long Township and the Spragge-Lewis township boundary. A preliminary map and report were published (Abraham 1953).

In 1954 and 1955 this area was remapped by the author and others and the mapping was continued westward between Lauzon Lake and the north shore of Lake Huron to correlate with Abraham's routine mapping in the vicinity of Iron Bridge and Blind River. Traverses were run perpendicular to the strike of the formations at approximately quarter-mile intervals. The field data were plotted on a scale of 1 inch to ¼ mile on transparent acetate sheets attached to air photographs. These photographs had been taken in 1949. Control was provided by readily identifiable points.

The author was instructed to supervise the completion of the mapping in the Spragge area during the 1960 and 1961 field seasons. The original data and that collected in the 1960 and 1961 field seasons were transferred, using a sketchmaster to correct for scale and tilt, from the air photographs to cronaflex basemaps. These basemaps were provided by the Cartographic Unit of the Ontario Department of Mines at a scale of 1 inch to ¼ mile.

Preliminary maps were made available to the public in 1960 and 1961: P.70, McGiverin Township; P.73, Long Township; P.130, Esten Township; and P.131, Spragge Township and Indian Reserve No. 7, west half (Robertson and Abraham 1960a and b; Robertson 1961b and c). The final map, on the scale 1 inch to ½ mile, was prepared for publication by the Cartographic Unit of the Ontario Department of Mines. The larger-scale preliminary maps (uncoloured) remain available, at a nominal charge, from the Department's publications office.

ACKNOWLEDGMENTS

The following men took part in the field work, as indicated:

1953: Southeast Long Township and south Spragge Township:
E. M. Abraham, D. H. Williamson, J. M. Brander, J. R. Lill, G. E. Bourchier. Messrs. Abraham, Williamson, and Brander were responsible for the mapping.

1954-55: Remapping of above area and southern Long Township:
E. M. Abraham, W. J. Pearson, G. E. Bourchier, J. A. Robertson, D. K. Brodie, D. S. Sinclair, and A. E. Wilson. Messrs. Abraham, Pearson, Bourchier, and Robertson were responsible for the mapping.

1960: Long and McGiverin Townships:
J. A. Robertson, D. S. Sinclair, G. E. Bourchier, J. M. Johnson, Raimonds Balgalvis, Tony Nou, Thomas Stem, and C. J. Hodgson. Mr. Sinclair was responsible for the organization of and undertook much of the field mapping in southern McGiverin Township and northern Long Township. Mapping was carried out by Messrs. Robertson, Sinclair, Bourchier, and Johnson. The writer mainly mapped in the northern part of McGiverin Township and the southern part of Long Township, and he also carried out the compilation. The final drafting was undertaken by Mr. Balgalvis.

1961: Esten and Spragge Townships, and I.R. No. 7 (west):
J. A. Robertson, D. B. MacDermott, D. N. Glassey, Raimonds Balgalvis, C. J. Hodgson, and H. M. Aarden. Mapping was carried out by Messrs. Robertson,

MacDermott, and Glassey. Mr. MacDermott was responsible for the organization of and undertook much of the field mapping of the southern two-thirds of Esten Township and the northwest part of Spragge Township. The writer mapped mainly the northern third of Esten Township and the southern and eastern parts of Spragge Township. All groups participated in the mapping of the Serpent River Indian Reserve, I.R. No. 7. The writer carried out the compilation and the final drafting was completed by Mr. Balgalvis.

Throughout the years of field work many local residents, businessmen, tourists, and representatives of mining companies freely rendered services, information, and hospitality. During both the 1960 and 1961 field seasons living quarters and office facilities were rented from Rio Algom Mines Limited (Pronto Division). Particular thanks are due to the manager, Paul Young, and to the security officer, William Spark, for the many courtesies rendered to the writer and his assistants. In the period 1953-1955, S. W. Holmes, chief geologist, and J. M. Brander, geologist, aided the field party in the geology of the Pronto deposit. The writer was given considerable assistance in collecting data on Pronto by P. C. Masterman, formerly chief geologist at Pronto Mine, and by C. J. Knight, geologist. C. J. Knight, chief geologist for Pater Mine since it was taken over by Pronto, and graduate student at the University of Toronto, has greatly aided the writer, particularly regarding the geology and history of the Pater Mine and the geology of the Spragge Group.

MEANS OF ACCESS

As described, Highways 17 and 108 provide the major access to the area. The greater part of Esten Township and the northeastern part of McGiverin Township are traversed by a lake and river system forming part of the Serpent River system. From Highway 108 the lakes are Depot Lake, Trout Lake, Grandeur Lake, Marshland Lake, Esten Lake, and Mink Lake. The route may be shortened by portaging from Depot Lake to the east end of Esten Lake. An overgrown wagon road connects Highway 108 to the west end of Marshland Lake via the north end of Christie Lake. In 1960 this road was drivable by jeep to Christie Lake. Portages or trails at one time connected McGiverin Lake to Magog Lake in Mack Township, McGiverin Lake to Rossmere Lake, and Rossmere Lake to Pistol Lake in Mack Township, but only traces of these trails were found. McGiverin and Rossmere Lakes are best reached by float-plane. Turtle Lake, in the northwest part of Spragge Township and southwestern part of Esten Township, can be reached from Highway 108 by canoe at highwater but is best reached by air. The region between Turtle Lake and Marshland Lake and between Turtle Lake and Long Lake (just north of Pronto Mine) can be reached by walking the Ontario Hydro-Electric Power Commission transmission line that leads to Elliot Lake. The southern part of Long Township is readily accessible from Lauzon Lake. Hastie Lake is reached by trail from Lauzon Lake. Intersect Lake (locally called Lake Toumey) at the northwest corner of Long Township is best reached from Magog Lake in Striker and Mack Townships.

The greater part of that portion of I.R. No. 7 included in the map-area can be reached by water from Spragge or from a road leading southwest from the community of Cutler to the shore of the North Channel and thence by boat. That part of the reserve lying near the Serpent River can be reached on foot from the railway bridge just west of the eastern limit of the map-area.

The greater part of the area is thus readily accessible using some combination of motor transport, float-plane, canoe or boat, and foot travel. Float-plane service is available from Lauzon Lake or from Elliot Lake.

PREVIOUS GEOLOGICAL WORK

After the discovery of copper at Bruce Mines in 1846, the North Shore of Lake Huron became the scene of much geological activity. Between 1847 and 1858 considerable work was done by W. E. Logan and Alexander Murray, the pioneer officers of the Geological Survey of Canada. The results of the mapping, largely Murray's responsibility, are given in "The Geology of Canada" (Logan 1863) and a map "showing the distribution of the Huronian rocks between Rivers Batchewahnung and Mississagui" (Logan 1863, atlas, p. 21) is included in the atlas accompanying this work. The eastern limit of this map lies a few miles west of the present map-area but the structures shown continue into the Spragge area. The major structure is an anticline, the south limb of which is cut and repeated by a major westerly-striking fault.

By 1913 the need for field work and correlation between the "original Huronian" of Bruce Mines and the rocks of the Sudbury-Cobalt area was obvious. In 1914, A. P. Coleman published "The Pre-Cambrian rocks north of Lake Huron with special reference to the Sudbury Series". Coleman's table of formations, in so far as it applies to the Spragge area, is given in Table 1. In a preface to Coleman's paper (Coleman 1914, p. 202-203) W. G. Miller introduced the term Algoman, defined by A. C. Lawson (1913) in the Rainy Lake area, for the bulk of the granitic rocks of the North Shore of Lake Huron. Coleman considered that those rocks which he called Sudbury Series were sedimentary and metasedimentary Archean rocks which were intruded by the Algoman granites of Miller.

Starting in 1914, W. H. Collins of the Geological Survey of Canada carried out systematic mapping in the North Shore region (Collins 1917; 1925). In this he was assisted by T. T. Quirke (Quirke 1917) and, later, by Pentti Eskola (Collins 1925). Certain areas were selected; each was mapped and then correlated with the others on the basis of lithology and structure. Collins' table of formations is given in Table 1. Collins was able to give formal names to many stratigraphic units, several of which could be correlated with Murray's nomenclature (see Table 1). The presence of Murray's great fault was confirmed and it was named the Murray Fault. Within the present map-area Collins thought that the Murray Fault underlay Lauzon Lake in Long Township (that fault is the Beaver Pond Fault) and that it followed the Canadian Pacific Railway in Spragge Township (which is the position of the Murray Fault on the present map for this area, Map 2186, back pocket). To the north of the fault lay Huronian sedimentary rocks overlying the Algoman granites with pronounced unconformity. Both were cut by numerous diabasic intrusions believed to be of Keweenawan age. South of the fault lay a series of metavolcanics and metasediments which Collins believed to be westward extension of the Sudbury Series.

Table 1 COMPARISON OF STRATIGRAPHIC NOMENCLATURE USED FOR NORTH SHORE OF LAKE HURON. MODIFIED FROM ROBERTSON (1967).

Logan and Murray as in Logan 1863	Coleman 1914	Collins 1925		Abraham 1953; 1956; and 1957		Roscoe 1957 as in Pienaar 1963; and Roscoe 1960		Robertson 1965a North of Murray Fault		Robertson 1965a South of Murray Fault		Coleman 1914 and Collins 1925 South of Murray Fault		Rock Types
Greenstone intrusions	Intrusions	Keweenawan	Olivine diabase	Keweenawan	Olivine diabase	Keweenawan	Olivine diabase	Keweenawan		Keweenawan		Keweenawan	Olivine diabase	Olivine diabase
			Granite		Granite		Granite			Cutler Granite			Granite	Granite
			Diabase including Thessalon Greenstone		Diabase		Diabase	Nipissing		Nipissing			Diabase	Diabase dikes
														Gabbro sills
Upper formations	Upper Huronian	Cobalt Series	Upper formations	Cobalt Series	Lorrain	Cobalt Group	Upper formations	Cobalt Group	Upper formations	Cobalt Group	Not present in area mapped	Cobalt Series	Upper formations	Quartzites
Upper slate conglomerate			Gowganda		Gowganda		Gowganda		Gowganda				Gowganda	Conglomerate, quartzite
Limestone	Lower Huronian	Bruce Series	Serpent	Bruce Series	Serpent	Quirke Group	Serpent	Bruce Group	Serpent	Bruce Group	Serpent	Bruce Series	Serpent	Quartzites
			Espanola		Espanola		Espanola		Espanola		Espanola		Espanola	Dolomite, siltstone, limestone
Lower slate conglomerate			Bruce		Bruce		Bruce		Bruce		Bruce		Bruce	Conglomerate
White quartzite			Mississagi		Upper Mississagi	Hough Group	Mississagi		Upper Mississagi		Upper Mississagi		Mississagi	Quartzite
					Middle Mississagi		Pecors		Middle Mississagi	Sprague Group	Middle Mississagi			Argillite ± quartzite → schists
							Whiskey						Ramsay Lake	Conglomerate → schists
						Elliot Group	Nordic		Lower Mississagi		Lower Mississagi	Sudbury Series	McKim	Argillite ± quartzite → schists
Chloritic slates					Lower Mississagi		Matinenda (Upper)				Pater Volcanics		Wanapitei	Andesite → meta-andesite
														Quartzite
Grey quartzite							Matinenda (Lower)				?			Quartzite - arkose ± uranif. conglomerate
Laurentian Granite	Laurentian Granite	Algoman Granite		Algoman Granite		Algoman Granite		Algoman Granite				Schist Complex (Keewatin)		Granite, etc.
	Sudbury Series	Sudbury Series		Keewatin		Greenstone		Keewatin						Sediments
	Granites and Keewatin	Schist Complex												Volcanics

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The Sudbury Series rocks were metamorphosed and then intruded by pegmatites and granites of the Cutler batholith; this batholith forms the greater part of the Serpent River Indian Reserve (I.R. No. 7).

Eskola showed that sedimentary rocks on islands in the North Channel of Lake Huron, believed to be Huronian in age, were more strongly metamorphosed close to the Cutler Granite and it was therefore concluded that the Cutler Granite was post-Huronian or Killarnean in age (Collins 1925, p. 89).

When discussing the area to the east of the present map-area Collins (1925), Quirke (1917), and both men in Quirke and Collins (1930) suggested that both Huronian and pre-Huronian sedimentary rocks occurred to the south of the Murray Fault, but they reported difficulty in delineating any unconformity between those rocks assigned to the two units.

Considering a number of aspects, including the field relationships in the vicinity of Algoma, A. C. Lawson (1929) suggested that the Sudbury Series was in fact the Cobalt Series of the Huronian.

In 1940, W. A. Rice, graduate student at Yale University, completed a detailed study of the Blind River-Spragge area. This work confirmed and amplified much of Collins' work but it was shown that the Murray Fault followed the shore of Lake Huron rather than Lauzon Lake thus confirming Lawson's (1929) contention that the Gowganda Formation of the Cobalt Series continued eastward from Algoma at least as far as Spragge.

As already indicated (see "Introduction"), E. M. Abraham, formerly a geologist with Ontario Department of Mines, carried out field work in the Spragge area between 1953 and 1955. However, apart from a preliminary report and a brief paper (Abraham 1957, p. 59-62) no data were published. Collins' original nomenclature was used (see Table 1) and his work was confirmed with the modifications independently proposed by Rice (1940); Rice's work was unknown to Abraham.

In 1954 and 1955 the Ontario Department of Mines published a series of aeromagnetic and radioactivity survey maps covering individual townships of the Blind River uranium area on a scale of 1 inch to 1,320 feet. Such maps are available for each township included in the present area (O.D.M. 1954a, b, c, d, and e).

Throughout 1954 and 1955 considerable surface exploration and diamond drilling was carried out within the area. This failed to reveal any potential orebodies other than the Pronto and Pater deposits and failed to find a faulted continuation of the Pronto deposit. A drilling program performed in the area south of the Pronto Mine in 1958 and 1959 also failed to find a continuation of the Pronto orebody. In 1962 and 1963 further surface exploration and drilling for copper deposits was undertaken in the area south of the Murray Fault but the results were negative.

The nomenclature used in this report is that used by the writer throughout the Blind River-Elliot Lake area and is essentially that used by Collins as modified by Abraham (see Table 1).

J. P. McDowell (1957; 1963) who carried out a regional study of sedimentary structures in the Mississagi Formations has used a similar nomenclature. S. M. Roscoe (1957; 1960) and P. J. Pienaar (1963) of the Geological Survey of Canada have, however, introduced a new nomenclature. Table 1 shows the various nomenclatures used within the Blind River area, particularly as they apply to the Spragge map-area.

In addition to the work of mining companies and government agencies, many geologists and mineralogists working either in conjunction with the above, or independently, have published papers of significance. Of special interest have been radioactive age determinations carried out on granitic rocks, the uranium ores, and the post-Huronian diabase intrusion (see "General Geology").

TOPOGRAPHY

Topographically, the map-area shows the features that characterized the North Shore area as a whole, namely a lack of major relief contrasted with rugged detail (cf Collins 1925, p. 8-14; Quirke 1917, p. 4, 9-18). The general uniformity of the skyline is a reflection of the peneplanation of the Precambrian Shield. The surface rises from 600 feet near Lake Huron to 1,100 feet near the northern boundary of the map-area. Maximum local relief is generally less than 150 feet. Relief of 200 to 300 feet is found over diabase intrusions near Hastie Lake in Long Township and over massive quartz monzonite in the vicinity of Esten and Nordic Lakes. In the Lauzon Lake-Spragge area, topography shows a marked geological control. Prominent valleys have developed over major faults such as the Murray Fault, the Pronto Thrust Fault, and the Beaver Pond Fault, and over the more readily eroded members of the Huronian and of the Spragge Group. Ridges have developed over the less easily eroded members of the Huronian, over some of the post-Huronian diabase intrusions, and over the epidiorite masses in the Spragge Group. Relief in this latter area may reach 250 feet and is particularly sharp where epidiorite is contrasted with the mica schists of the Spragge Group. The Cutler batholith forms generally high ground but is broken by valleys following the gneissosity and zones of numerous inclusions, giving the area extremely rough terrain. John Island, to the south of the batholith, is formed of nearly vertical Upper Mississagi Quartzite and has a relief of over 200 feet. The other islands are smaller and show less relief but are sufficiently rugged to make the Whalesback Channel scenically attractive.

Apart from the valley of the Serpent River and an abandoned farm south of the Pronto Mine there is little land suitable for agriculture.

DRAINAGE

Drainage throughout the area is by sluggish streams, with predominant east and southeasterly trends, connecting the lakes. The northern parts of Esten and McGiverin Townships drain to the Serpent River system. A tributary river flows from Mink Lake through Esten, Marshland, Grandeur, and Trout Lakes to Depot Lake, from there it flows eastward to join the Serpent River at McCarthy Lake. The Serpent River flows south near the eastern limit of Proctor and Lewis Townships, turns westward along the northern boundary of the Serpent River Indian Reserve, enters the present map-area east of Spragge village, and opens into the estuary known as Serpent Harbour. Southern McGiverin Township is drained by the Pistol Lake (Mack Township)-Rossmere Lake-McGiverin Lake system. From McGiverin Lake, Magog Creek flows southwesterly by Magog Lake in Striker Township to join Blind River in Lake of the Mountains. Christie Lake acts as a focal point for the drainage in southern Esten and is drained by a creek flowing southwest to join Black Creek which flows southeast to the Serpent River system in Lewis Township.

Blanche Lake drains to Turtle Lake and Black Creek which joins the Serpent River in Lewis Township. Laderoute Lake is also drained by Black Creek.

Intersect and McFadden Lakes in northwest Long Township drain to Magog Lake in Mack Township.

The greater part of Long Township is drained by Lauzon Lake which has a controlled outlet to Lake Huron at Algoma. Hastie Lake and Surprise Lake both drain to Lauzon Lake. Long Lake to the north of Pronto Mine is drained by Spragge Creek which enters Serpent Harbour at the abandoned Spragge docks. Waugush Lake to the northeast of Spragge village also drains into Serpent Harbour. Apart from the exceptions listed under access the drainage systems are not normally navigable by canoe.

The marked easterly, southeasterly, and, to a lesser extent, northeasterly components to the drainage are a reflection of geological structures such as joints, faults, and dikes, which are oriented in these directions. The southeasterly (northwesterly) direction, particularly in Spragge Township, is a direction of gneissosity in the granites.

RESOURCES

The principal industry in the area is the copper mine at Spragge and the associated milling and concentrating operation at the former Pronto Mine. The Pronto Division of Rio Algom Mines Limited is willing to undertake custom milling of suitable copper ores; however, only small tonnages shipped on a trial basis from the vicinity of Iron Bridge have been processed. Both Algoma and Spragge were formerly important lumber towns but the lumber industry is now centred on Blind River. Cutting of pulpwood has been carried out in eastern Spragge Township and southeastern Esten Township, and lumbering near the northern boundary of the map-area. The pulpwood is trucked to the Kalamazoo Vegetable Parchment (K.V.P.) Company[1] pulp mill at Espanola. The lumber has been cut by Roddis Lumber & Veneer Co. of Canada Ltd.[2] whose mill is located just south of Elliot Lake. With the exception of low ground near the Serpent River, east of Spragge, no area is currently being actively farmed. Commercial fishing in Lake Huron is based on Algoma but in recent years this trade has been much reduced, in part owing to the ravages of the lamprey eels.

Wild life abounds within the area, particularly in the more remote parts. Bear, deer, fox, and moose, as well as many smaller animals, are common. The beaver population has increased markedly since the first mapping. Of the game birds, there are several varieties of duck and partridge. Most of the lakes provide good fishing.

[1]K.V.P. pulp mill in Espanola was taken over by Brown Forest Industries Limited in 1967.
[2]Name changed December 31, 1962 to Weyerhaeuser Canada Limited.

Facilities for hunting, fishing, and aquatic sports, together with the easy access, make the region popular with tourists. There are several summer homes on Lauzon Lake. The Ontario Department of Lands and Forests has acquired land at the east end of the bay of Lauzon Lake at Algoma and the land extends southward to the north shore of Lake Huron. An integrated park and campsite is being prepared on this property.

GENERAL GEOLOGY

The map-area is extensively underlain by the granitic core of the Chiblow Anticline which forms the southern limb of the Blind River reverse-S structure. Huronian sedimentary rocks, forming the southern limb of this structure, are exposed in the southern part of Spragge Township and southern and western Long Township. The following units are exposed: Lower Mississagi Formation (quartzite, arkose with or without radioactive conglomerate); Middle Mississagi Formation (argillite overlying conglomerate in the north and interbedded quartzite, argillaceous quartzite, and argillite in the south); Upper Mississagi Formation (quartzite); Bruce Formation (conglomerate); and, possibly, the Bruce Limestone Member of the Espanola Formation. All of the preceding are in the Bruce Group which is overlain unconformably by the Gowganda Formation of the Cobalt Group. The Upper Mississagi Formation is repeated south of the Murray Fault at Algoma and on John Island; the former locality lies at the east end of the belt including the original type locality for the Mississagi Formation (Winchell 1887) but physical continuity with the latter locality (John Island) is obscured by the waters of the North Channel.

After the deposition of the Cobalt Group the area was folded and faulted; the Chiblow Anticline and, possibly the Murray Fault, were formed. Dikes and irregular sill-like bodies of Nipissing-type quartz diabase were intruded. These dikes and sills, along with faults and joints, are particularly numerous in the granitic area. Subsequent to the intrusion of the Nipissing-type diabase (post-Huronian mafic intrusions) the main Penokean orogeny took place (Robertson 1966, p. 125; and page 12, this report).

In the southeast part of the area a series of quartzites, argillites, and greywackes of possible Huronian age were metamorphosed to metaquartzite and mica(-cordierite)-staurolite-garnet-quartz-feldspar schists. Underlying these metasediments are mafic metavolcanics comprising amphibolitic massive lava, pillow lava, and amygdaloidal lava with minor interbedded metasediments including possible pyroclastics. This volcanic sequence, as noted by Collins (1925, p. 76) is similar to the Thessalon Greenstone which Frarey (1961a; 1961b; 1962) believed to be of early Huronian age. Intrusive mafic rocks, thought to have been Nipissing diabase, are represented by epidiorite, amphibolite, and hornblende schist. Folding took place during and subsequent to metamorphism; both folding and metamorphism are most easily studied to the east of the present map-area (Robertson 1965a, b, and c; 1966). The granitic rocks of the Cutler batholith were intruded into the above sequence of folded metamorphosed sedimentary, volcanic, and mafic intrusive rocks.

Table 2 TABLE OF FORMATIONS FOR SPRAGGE AREA

		CENOZOIC
		RECENT[1]
		Swamp, lake and stream deposits
		PLEISTOCENE[1]
		Gravel, clay, till, sand
		Unconformity
		PRECAMBRIAN
		PROTEROZOIC
		KEWEENAWAN
14	14	Olivine diabase
		Intrusive Contact
		FELSIC INTRUSIVE ROCKS
		CUTLER GRANITE
13	13a	Muscovite-biotite granite
	13b	Pegmatite
		Intrusive Contact
		METAMORPHIC ROCKS
		MAFIC INTRUSIONS (probably equivalent to post-Huronian intrusions)
12	12b	Metadiabase, epidiorite, amphibolite, amphibolite gneiss
		SPRAGGE GROUP (probably equivalent to parts of Lower and Middle Mississagi Formation)
		Metasediments
11	11	Undifferentiated metasediments
	11a	Muscovite, chlorite, biotite, cordierite, staurolite, garnet, quartz-feldspar schists
	11b	Quartzite
	11c	Conglomerate
		Metavolcanics
10	10a	Massive hornblende, biotite, chlorite, garnet, metavolcanics
	10b	Pillow lava
	10c	Amygdaloidal lava
	10d	Chlorite, biotite, hornblende, plagioclase metagreywacke (with or without 10a, 10b)
		Metamorphic contact, not visible in map-area
		MAFIC INTRUSIVE ROCKS
		POST-HURONIAN MAFIC INTRUSIONS[2]
12	12a	Diabase, gabbro, and diorite cut by later felsic and mafic dikelets
		Intrusive Contact
		HURONIAN ROCKS
		COBALT GROUP
		Gowganda Formation
9	9a	Polymictic conglomerate with or without interbedded quartzite, argillite, siltstone, greywacke
	9b	Feldspathic quartzite with or without interbedded conglomerate, argillite, siltstone, greywacke
	9c	Greywacke with or without interbedded conglomerate, argillite, siltstone, quartzite
	9d	Argillite, siltstone, with or without interbedded quartzite, greywacke, conglomerate
		Unconformity

BRUCE GROUP

Espanola Formation[2]

Bruce Limestone

8 — 8 Limestone with some interbedded siltstone

Conformable Contact

Bruce Formation

7 — 7a Polymictic conglomerate with occasional lenses of quartzite and siltstone
- 7b Impure quartzite

Conformable Contact

Upper Mississagi Formation

6 — 6a Feldspathic quartzite, quartzite, arkose
- 6b Feldspathic quartzite, arkose with pebble bands of quartz, chert, jasper
- 6c Greywacke and argillaceous quartzite
- 6d Polymictic conglomerate
- 6e Calcareous laminated quartzite

Middle Mississagi Formation

5 — 5a Greywacke and argillaceous quartzite with minor siltstone, argillite
- 5b Quartzite with greywacke, siltstone, argillite
- 5c Argillite with minor quartzite and greywacke

Lower Mississagi Formation

4 — 4a Feldspathic quartzite, arkose
- 4b Polymictic conglomerate
- 4c Oligomictic conglomerate

Great Unconformity

ARCHEAN

3 — 3 Granite regolith[3]

ALGOMAN

YOUNGER

2 — 2a Massive granite, quartz monzonite, granodiorite, and allied rock types with or without mafic inclusions
- 2b Porphyritic granite, quartz monzonite, etc.
- 2c Aplite dikelets common (individual dikelets too small to show on map)

Intrusive Contact

OLDER

- 2d Variable granite, granite gneiss, and allied rock types with occasional mafic inclusions (probably partly of metamorphic origin)

Intrusive Contact

KEEWATIN(?)

1 — 1 Undifferentiated metavolcanics and metasediments (as inclusions in granite)
- 1a Metasediments, quartzite, greywacke

NOTES

[1]Post-Huronian mafic intrusions in the Blind River-Elliot Lake area have been traditionally classified as Keweenawan but recent age determinations indicate the bulk of these are older. The term Nipissing is gaining favour as a name for this unit; Keweenawan is now restricted to the olivine diabase.

[2]The upper members of the Espanola Formation were removed by pre-Gowganda erosion.

[3]Granite regolith takes the colour of the underlying parent rock.

Olivine diabase of Keweenawan age occurs as northwest-trending dikes which cut the Cutler Granite and the associated metamorphic rocks. A similar dike is found between McFadden and Intersect Lakes in northwest Long Township and can be traced into McGiverin and Mack Townships. The dikes cutting the Cutler Granite have strong magnetic anomalies associated with them and these anomalies are displaced across the Murray Fault. The displacement is about 6,000 feet north side east (Ontario Dept. Mines, Provincial aeromagnetic and radioactive survey map, No. 51). It is not clear if this represents post-diabase movement or whether the dikes were deviated along the fault. Drag folds adjacent to the fault indicate both right- and left-hand slips as well as dip slip. It is probable that the Murray Fault has a long and complex history with major movements both before and after the intrusion of the Cutler Granite (see "Murray Fault" section in this report).

A major northeast-trending fault with the right-hand strike-slip of about three-quarters of a mile strikes into McGiverin Township, from Mack Township, reaching McGiverin Lake where it joins a fault system defining McFadden Lake, McGiverin Lake (SE shore), Marshland Lake, and Trout Lake. Movement on this fault, the Lake of the Mountains Fault, is later than the intrusion of the olivine diabase; the southwesterly continuation of the Lake of the Mountains Fault displaces the Murray Fault west of Blind River.

Recent age determinations indicate the following approximate dates for the major events:

Keweenawan	olivine diabase	1,225 million years
Penokean	metamorphic event?	1,400 million years
....	Cutler Granite	1,750 million years
....	metamorphic event	not dated
Nipissing	quartz diabase	2,155 million years
Huronian	sediments	....
Algoman	granites	2,500 million years

These dates were taken from a variety of sources including Fairbairn *et al.* (1960; 1965); Lowdon (1960; 1961); Wetherill *et al.* (1960); Lowdon *et al.* (1963); Leech *et al.* (1963); Van Schmus *et al.* (1963); Stockwell and Williams (1964); Van Schmus (1964; 1965); Knight (1967); Robertson (1966; 1967).

The Precambrian Shield was flooded by shelf seas during Early Paleozoic time; the nearest Paleozoic rocks are exposed on islands in Lake Huron south of the present map-area. Since Early Paleozoic time the region has remained a relatively stable positive area subject to periodic rejuvenation. The present immature topography was developed at the expense of the modified Precambrian peneplane essentially prior to the Pleistocene glaciation.

Glaciation removed the soil that had developed and glaciofluvial clays, sands, and gravel, were deposited. The greater part of the drainage system shows marked geological control. Glacially rounded, grooved, and polished outcrops, scoured softer beds, striae, and chatter-marks are all common. These indicate the regional direction of ice flow was about S15°W.

The recent mapping has added more detail to the early mapping completed by Collins (1925) and modified by Rice (1940), particularly regarding the distribution of diabase and other specific rock-types, and the structure of the area. The outstanding work of Collins (1925) received its deserved recognition when his mapping guided the prospectors during the Blind River uranium boom.

ARCHEAN

Throughout the Blind River-Elliot Lake region the Archean rocks consist of two main types: Keewatin-type metavolcanics interbedded with metasediments (these rocks are generally mafic in character and strongly chloritized although locally amphibolite may be present); and the Algoman granitic rocks, which are subdivided into two broad classes: the first comprising grey to pink, massive to gneissic, granodiorite to granite; and the second, possibly younger, comprising red, massive, equigranular to porphyritic quartz monzonite. Within the map-area Keewatin-type rocks are found mainly in the northeast corner of Esten Township; elsewhere they are usually found as partially assimilated inclusions in the granite. Porphyritic quartz monzonite is found north of Esten and Depot Lakes. However the greater part of the map-area north of the Murray Fault is underlain by the variable granite group.

KEEWATIN(?)

Keewatin-type interbedded metavolcanics and metasediments form a broad, southeast-trending belt underlying the eastern part of the Quirke Syncline (see Robertson 1961a; 1962; 1968) and the area to the southeast. The margins of the belt of Keewatin-type rocks are migmatitic in nature; in these rocks it is possible to see the changes from a zone of granite injected *lit-par-lit* along the bedding and cleavage, through granite with abundant chloritic and amphibolitic inclusions, to granite with relict gneissosity, and finally to massive granite. The transition from recognizable Keewatin-type rocks to granite with relict gneissosity takes place within 200 to 300 yards. Keewatin-type rocks and the transitional zone through to massive granite are exposed in the northeast corner of Esten Township and at the east end of Depot Lake. The continuity of the outcrop is broken by faults. At many exposures in the map-area inclusions of mafic rock are seen scattered throughout the granite; these inclusions occasionally form as much as 30 percent of the rock by volume.

Although contact areas between granitic rocks and older "greenstone" belts are normally considered good areas for prospecting, little indication of increased mineralization was found by the writer's field party. Traces of chalcopyrite, pyrite, and pyrrhotite can be found, either disseminated throughout the rock or as thin coatings on fracture surfaces, in most samples from the Keewatin-type rocks. The Twin Lakes[1] copper showing in southeast-central Esten Township is apparently associated with a zone of chlorite schist surrounded by granite. At one locality, on the south shore of Depot Lake near the Esten-Proctor township boundary, a few flakes of molybdenite were noted in chlorite schist.

The recognizable Keewatin-type rocks in northeast Esten Township show bedding (strike northwest, dip 60°-80° northeast) and are quartzose to chloritic in character. The more chloritic bands show a well-developed cleavage that dips to the northeast more steeply than the bedding, which suggests that the beds are right

[1]Twin Lakes is the name used by Cadamet Mines Limited for Christie Lake.

way up. This was confirmed by graded bedding in less metamorphosed sediments (quartzose greywacke and cherty iron formation) exposed near Highway 108 in northwest Proctor Township. One zone of massive mafic rock consisting of hornblende, chlorite, and plagioclase and showing diabasic texture with minor traces of sulphide minerals may be a Keewatin(?) lava flow. Because of the abundance of diabase dikes in the granite-Keewatin(?) area great caution is required in the identification of mafic rocks; first impressions of rock identity are often disproved once cutting relationships have been found. Collins (1925) drew attention to this with special reference to Esten Township but it applies throughout the map-area, much of which was not traversed by Collins or his assistants.

ALGOMAN

Granitic rocks of Algoman age underlie almost the entire map-area north of the Murray Fault. In the vicinity of Pronto Mine the outcrop of granitic rocks is duplicated by faults (see Figure 3, "Pronto Mine" section).

The rocks are generally medium-grained, equigranular to subporphyritic, and range in colour from grey to pale-pink and, occasionally, red. Massive, grey to brick-red, porphyritic quartz monzonite is found in the Esten Lake-Nordic Lake-Depot Lake sector and this quartz monzonite is the southern part of a body mapped in the Elliot Lake sector of Township 155 (Robertson 1963a, Map 2014) and Township 149 (Robertson 1968, Map 2113). Red granitic segregations become more common in the southern part of the area near Pronto Mine and Spragge village.

As previously noted the granitic rocks are locally considerably contaminated by mafic material derived from the older Keewatin-type rocks. These mafic inclusions are generally chloritic in nature but may be amphibolitic. Boundaries between the inclusions and the granite may be sharp or blurred; blurred boundaries indicate a high degree of assimilation. In some sections, particularly in McGiverin Township, assimilated or partially assimilated inclusions may make up 30 percent of the rock by volume. Near the larger zones of inclusions, close to the Keewatin(?) outcrop in northeast Esten Township, and in southern and eastern Spragge Township, the granitic rocks are gneissic. The gneissosity strikes generally northwest, but in southeast Spragge Township its strike gradually swings westward, and accordingly reflects the regional structure of the Keewatin(?) belt.

The principal minerals of the granitic rocks are: quartz, plagioclase (oligoclase or albite), microcline, and chloritized biotite. The variation of lithology is a variation of proportions of the minerals present and in the composition of the plagioclase rather than a great difference in mineralogy. The colour of the rock is largely a function of the distribution of hematite dust, particularly in the feldspars. The principal accessory minerals are apatite, magnetite, monazite, sphene, and zircon. Traces of sulphide minerals, pyrite, chalcopyrite, rarely pyrrhotite, and very rarely molybdenite have been observed but it is possible that these were introduced after the formation of the rocks.

The petrography and chemistry of the granitic rocks of the Blind River-Elliot Lake district have been discussed in detail in earlier reports by the author (Robertson 1960, Chapter 6; 1961a *et seq.*). The chemical properties of the granitic rocks of the Spragge area are listed in Table 3.

Age determinations have been carried out on the granitic rocks of the North Shore of Lake Huron; the results indicate an age of 2,500 million years for the

Table 3 | CHEMICAL ANALYSES OF GRANITIC ROCKS FROM SPRAGGE AND ADJACENT AREAS (AFTER ROBERTSON 1960, P. 390-392, 395, AND 398) VALUES IN PERCENTAGES.

	ALGOMAN "GRANITES"		PRONTO GRANITES			CUTLER GRANITE	
	Grey (average)[1]	Red (average)[2]	Basement rock in mine (sample 57/13)	Red granite in thrust block (sample 57/15)	Post-ore alteration (sample 57/14)	Bartlett Point, eastern I.R.7 (sample 57/11)	North of Spanish (sample 57/10)
SiO_2	70.29	71.17	74.96	74.99	66.32	71.00	74.11
Al_2O_3	14.38	14.75	13.52	12.70	19.43	15.05	14.38
Fe_2O_3	1.07	1.10	0.57	0.69	1.00	0.59	1.12
FeO	1.66	0.88	0.44	0.85	1.05	1.76	1.30
CaO	1.91	1.06[7]	Tr	Tr	0.58	1.47	1.90
MgO	1.22[3]	0.52[8]	0.57	0.30	2.20	0.74	0.38
Na_2O	5.29	3.68	7.30	3.50	7.60	3.50	3.12
K_2O	2.66	4.70	0.79	5.45	0.52	4.07	4.00
H_2O+	0.7[4]	0.6	0.39	0.69	0.58	0.88	0.42
H_2O-	0.06[4]	0.07	0.02	0.01	0.01	0.05	0.02
CO_2	0.25[5]	0.38[9]	0.27	0.09	...	0.07	0.13
TiO_2	0.29	0.17	0.18	0.16	0.15	0.20	0.23
MnO	0.038[6]	0.016	...	0.01	0.02	0.02	0.04
Total			99.01	99.43	99.46	99.40	101.15

NOTES

Samples collected and analyzed by J. A. Robertson with the exception of Cutler Granite from Bartlett Pt. which was analyzed by D. A. Moddle, Laboratory and Research Branch, Ontario Dept. Mines.

...Not detected.

[1]Average of 18 samples, numbers 55/6, 55/8, 55/10, 55/20, 55/25, 55/26, 55/27, 55/28, 55/29, 56/3, 56/4, 57/1, 57/8, 57/19, 57/20, 57/22, 57/28, and 57/31.

[2]Average of 16 samples, numbers 55/17, 55/54, 56/5, 56/8, 56/9, 57/5, 57/9, 57/15, 57/18, 57/23, 57/24, 57/25, 57/26, 57/27, 57/29, and 57/30.

[3]Average of 17 samples, in number 57/1, trace only of MgO.

[4]Average of 16 samples, in numbers 55/26 and 55/27, only combined value for H_2O determined.

[5]Average of 16 samples, in numbers 55/6 and 57/22, Co2 not detected.

[6]Average of 17 samples, in number 55/28, MnO not detected.

[7]Average of 15 samples, in number 57/15, CaO not detected.

[8]Average of 15 samples, in number 55/54, trace only of MgO.

[9]Average of 10 samples in numbers 57/18, 57/23, 57/24, 57/25, and 57/26, Co2 not detected, and in number 57/29 trace only of CO_2.

Algoman granites, Fairbairn *et al.* (1960); Wetherill *et al.* (1960); Lowdon (1961); Lowdon *et al.* (1963); Leech *et al.* (1963); Van Schmus *et al.* (1963); Van Schmus (1964; 1965). However, progressively younger ages, believed to have been caused by isotopic readjustment, are obtained as the Penokean orogenic belt in the southern part of the area is approached.

POST-ALGOMAN INTERVAL

Throughout the Blind River-Elliot Lake area, the Huronian rocks rest with marked unconformity on the Algoman-Keewatin(?) basement complex. Within the map-area the contact of the Huronian and the Algoman rocks is well exposed: in southwest McGiverin Township; in an arc from Intersect Lake, by McFadden Lake, Hastie Lake, north of Surprise Lake, and Lauzon Lake to Pronto Mine; and again from the east end of Long Lake, along Spragge Creek swinging east along the north shore of Waugush Lake to Highway 108.

At distances of greater than 100 yards from the contact with the overlying Huronian, the granitic rocks exposed at the surface are of the normal type. However, as the actual contact is approached, the plagioclase feldspar grains become yellow, due to the development of sericite, and the ferromagnesian minerals are no longer present; the granitic texture is preserved by the quartz and microcline crystals. The above material passes into an unsorted aggregate of partly corroded quartz and microcline grains in a yellow-green matrix of sericite. Rarely angular fragments of vein quartz and patches of less-altered granite may be present. This material is overlain by sorted, sericitic arkose in which bedding and crossbedding are generally visible. In some outcrops the actual contact may be marked by a band of angular to subangular quartz fragments up to an inch across.

In drill holes, unless a basal pebble bed is present, the actual contact between the Lower Mississagi Formation and the granite is difficult to place. In consequence, in many holes the highly sericitic material was logged as "transition zone". This "transition zone" is generally interpreted as a regolith, or fossil soil, developed during the Archean-Proterozoic interval. Within the map-area the regolith varies in thickness from a few inches to 20 feet; greater thicknesses of regolith have been recorded in the Quirke Syncline. Where thin, it is presumed that regolith material was removed by erosion prior to the Huronian sediments being deposited in the particular locality. Regolith is most easily seen and studied near the glory holes and discovery locality at the west end of the Pronto workings. The Pronto orebody directly overlies regolith.

Such soils have been observed over both red and grey phase Algoman granites. Core sections also show the development of crumbly chloritic material between the greenstones and the metasediments. This has also been regarded as regolith. W. Rice (1959) believed that the regolith formed from the greenstones under a reducing atmosphere. The chemical changes observed by Rice are similar to those observed in the granites, with the exception that there is a decrease in combined water in the regolith studied by Rice.

The chemical nature of the granitic regolith has been investigated by P. J. Pienaar, formerly a post-graduate student at Queen's University at Kingston, who carried out research on the origin of the Blind River uranium deposits under the sponsorship of the Geological Survey of Canada (Pienaar 1958; 1963) and by the author (Robertson 1960). The author analyzed two samples, one from near the top of the regolith and one from near the base, from "transition zone" intersected in a drill hole at Demorest Lake (north of Chiblow Lake) in Township 167; and Pienaar (1963, p. 16) gives analyses of 1) a sample of regolith developed over red quartz monzonite (red granite) in the Quirke Lake area, Township 144, and 2) a sample of the red granite 40 feet below that regolith. In Figure 2, a straight-line diagram has been drawn showing the percentage gains and losses of the oxides (and also total iron) in the following sample pairs:

1) Red granite compared with transition material (regolith), Quirke Lake, both analyzed for Pienaar.
2) The average composition of six grey-phase granites in the Matinenda Lake area compared with that of the upper transition material developed over similar granite at Demorest Lake. All analyzed by the author.
3) The lower compared with the upper transition material developed above grey-phase granite at Demorest Lake, both analyzed by the author.

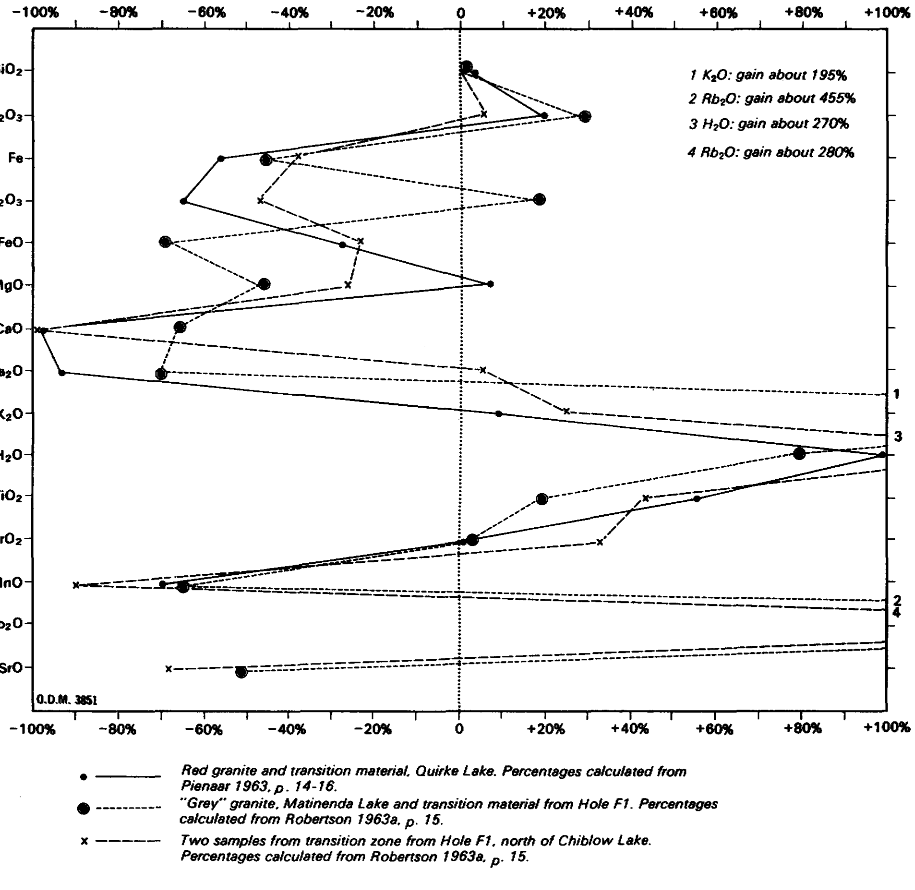

Figure 2 — Straight-line diagram showing relative gains and losses of constituents during the formation of the regolith (modified from Pienaar 1963 and Robertson 1963a).

The diagram (Figure 2) reveals the relative gains and losses of constituents during the formation of the regolith. These sets of lines show the following features:

a) In all three examples SiO_2 remains fairly constant and Al_2O_3 shows a slight increase. This differs slightly from the observations of Leith and Mead (1915, p. 3-19, 288-289); their results showed that during weathering alumina remains constant and silica is slightly reduced.
b) In two examples ZrO_2 is relatively constant and in one case it is enriched, an expression of the stability of zircon.
c) In the three cases Fe and FeO show a loss; and in two cases a much higher percentage of Fe_2O_3 is lost than FeO; but in the case where the average of the granites from Matinenda Lake is compared with the sample from the upper transition zone north of Chiblow Lake, Fe_2O_3 shows an increase. This "gain" is probably owing to a difference in the composition of the parent rock of the "transition" regolith from the composition of the average grey granites of the Matinenda Lake area, because when this "transition" regolith is compared with its own parent rock it then shows that a percentage of Fe_2O_3 was removed during weathering.
d) MgO and MnO have been partially lost. In one sample MgO shows a slight increase.
e) CaO is almost completely removed and SrO substantially removed.
f) In two cases Na_2O is almost completely removed but in the samples from the transition zone it shows a slight gain.
g) In all examples shown K_2O and Rb_2O are enriched, Rb_2O to a greater percentage than K_2O.
h) H_2O shows a marked increase.

These observations reflect: the destruction of the plagioclases and the removal of the soluble constituents; the stability of the potassic feldspars (microcline); and the formation of hydrated clay minerals represented by sericite. The trace elements follow the major elements in pairs; Mn-Mg, Rb-K, and Sr-Ca.

In all three cases, total Fe has been lost, suggesting that Fe_2O_3 has been converted to FeO and removed by leaching. Such reduction may have been owing to the exclusion of the iron from the atmosphere by overlying material or to an atmosphere deficient in oxygen.

Roscoe and Steacy (1958, p. 4-5) studied the distribution of uranium and thorium in two series of saprolite (regolith) samples from the Quirke Lake area of Township 144. "Both show uranium to be about one-third less in the most altered samples than in the freshest granite. One shows a proportional loss of thorium which is only slightly less than the loss of uranium. The other shows a net gain of thorium."

As regolithic material contributed to the formation of the uraniferous, pyritiferous, oligomictic conglomerates of the basal Lower Huronian, the presence in the regolith of FeO (ferrous iron) and the persistence of uranium normally soluble in an oxidizing environment, is of interest, whatever the cause of reduction.

After the intrusion of the Algoman granites, the area was exposed to a long period of denudation, resulting in the formation of a peneplane with local topography controlled by the character and structure of the underlying rocks, particularly those of the Keewatin(?) "greenstone" belt. Locally, especially on granitic rocks but also on the greenstones, regolithic material which formed in a reducing environment is preserved.

PROTEROZOIC

Rocks of Proterozoic age, the Huronian sedimentary rocks, the post-Huronian diabase, and granite intrusions, form the bedrock throughout those parts of the area not directly underlain by the Archean basement complex.

AREA CONTAINING UNDOUBTED HURONIAN ROCKS

The exposed Huronian rocks are divided into the Bruce Group and the unconformably overlying Cobalt Group. The Bruce Group, in the map-area, consists of the Lower Mississagi Formation, quartzite, arkose, plus or minus radioactive quartz-pebble conglomerate; the Middle Mississagi Formation, argillite overlying conglomerate in the north (beyond the map-area), interbedded quartzite, argillaceous quartzite, and argillite in the south; the Upper Mississagi Formation, quartzite and minor conglomerate; the Bruce Formation, conglomerate and impure quartzite; and possibly the Bruce Limestone Member of the Espanola Formation. Of the Cobalt Group only the basal part of the lowermost formation, the Gowganda Formation, comprising conglomerate, quartzite, greywacke, and argillite is exposed within the map-area, though many boulders of the well-known Lorrain conglomeratic quartzite are found in the drift. Huronian rocks as exposed north of the Murray Fault and also at Algoma to the south of the Fault, are normally only slightly metamorphosed and original structures such as bedding, crossbedding, and ripple-marks are present. South of the Murray Fault, in the vicinity of Spragge village and the Cutler batholith, there is found a series of metasediments overlying metavolcanics. The metasediments may represent Bruce Group rocks and the metavolcanics are similar to the Thessalon Greenstone; the Thessalon Greenstone was thought by Frarey (1961a; 1961b; 1962) to lie within, but near the base of the Huronian.

The schists and quartzites found north of and included in the Cutler batholith could have been derived from an assemblage similar to the southern facies of the Middle Mississagi Formation as exposed in the present map-area along Lauzon Lake and to the north of the Murray Fault in Spragge Township. This facies is repeated south of the Murray Fault west of Algoma in the Cobden and Striker Townships map-area (Robertson 1964, Map 2028). A similar assemblage is also found forming the upper part of the Lower Mississagi Formation in the Nordic Lake area of the southern limb of the Quirke Syncline (Robertson 1968, p. 23); and on the south limb of the Chiblow Anticline as exposed north of the Murray Fault in the Little Serpent River-Spanish area (Robertson 1965; 1966, p. 132). The thick quartzite sequence forming John Island and the other islands to the south of the Whalesback Channel (Robertson 1965b and c) was correlated by Collins and Eskola (Collins 1925) with the type area of the Mississagi Formation between

Algoma and the mouth of the Mississagi River. Although physical continuity between the two localities cannot be proven the writer has accepted the correlation.

The post-Huronian igneous rocks are the Nipissing-type diabase, the Cutler Granite, and olivine diabase of Keweenawan age. These units, in early reports, were considered to be different phases of the Keweenawan igneous cycle but recent age determinations indicate that these events were widely separated in time.

The complete Table of Formations is given at the beginning of the section on "General Geology" and a comparison of the different stratigraphical nomenclatures that have been used in the Blind River area is given in Table 1.

HURONIAN

Bruce Group

The lowermost group of the Huronian is the Bruce Group, the formations of which are described in the following pages. The uppermost formations of the group (the Espanola and Serpent Formations) are not exposed in the map-area probably because they were removed by pre-Gowganda erosion or, possibly, because they were never deposited in the area. The Bruce Limestone Member of the Espanola Formation does not outcrop but may be present in western Long Township near the Hydro-Electric Power Commission line north of Algoma. At Spragge village the Gowganda Formation rests on the uppermost members of the Mississagi Formation.

Mississagi Formations

The Mississagi Formation was originally defined by Winchell (1888) for the "Original Huronian" area (the type area lying south of the Murray Fault between the Blind and Mississagi Rivers). The formation was extended eastward by the mapping of Collins (1925) and within the Blind River-Elliot Lake region it was considered to be the oldest Huronian formation. As these rocks were found to contain commercial deposits of uranium and thorium they have in recent years attracted considerable attention. The Mississagi Formation, as mapped by Collins, may now, within the Elliot Lake area, be subdivided into three units, these are:

1) quartzite and feldspathic quartzite,
2) basal polymictic conglomerate overlain by argillite and minor greywacke,
3) arkose, quartzite, and uraniferous oligomictic conglomerate, overlain locally by argillite.

Only the uppermost of these units is equivalent to the exposed Mississagi Formation of the type area.

As "Mississagi Formation" had passed into general usage for all rocks between the Archean basement and the base of the Bruce Conglomerate (Bruce Formation), the Ontario Department of Mines decided to call the three units Upper, Middle, and Lower Mississagi Formations respectively.

P. J. Pienaar (1963) and S. M. Roscoe (1957)* of the Geological Survey of Canada introduced a new nomenclature for the Huronian (see Table 1). In the earlier version (Roscoe 1957) all rocks above the polymictic conglomerate at the base of unit 2 were termed Mississagi Group but in the later version the term Mississagi Group was dropped and the uppermost quartzite unit alone was called the Mississagi Formation. Both systems reflected an attempt to limit "Mississagi" to cover the exposed sequence at the type locality. Roscoe's formational boundaries (Table 1) generally coincide with the author's, with the exception that an argillite-greywacke sequence at the top of the Lower Mississagi Formation in Townships 155, 149, and 143 was given formational status and that the Middle Mississagi was divided into two formations by Roscoe (1960). In this report the author wishes to raise the three units of the Mississagi Formation to formal formational status and to use the term Mississagi formation as an informal designation only.

These formations and their members are easily discernible within the Quirke Syncline (Robertson 1960 *et seq.*). However, the Middle Mississagi basal conglomerate cannot be traced along the south limb of the Chiblow Anticline to the south and east of Lake of the Mountains in Striker Township (Robertson 1964, Map 2028). The argillite, when traced in a similar direction passes into a sequence of interbedded quartzite, silty quartzite, and minor argillite with arbitrary transitional boundaries to both the Lower and the Upper Mississagi Formations. A sequence similar to the latter is repeated (but poorly exposed) on the upthrow (south) side of the Murray Fault between Algoma and the mouth of the Mississagi River (Robertson 1963b; 1964, p. 25).

Lower Mississagi Formation. The Lower Mississagi Formation is exposed as follows:

1) The upper part of the formation is exposed between two faults at the northwest end of Rossmere Lake in McGiverin Township (see Map 2185, back pocket).

2) In a belt, partly interrupted by faults and diabase intrusions, extending from the southwest corner of McGiverin Township to Pronto Mine via Intersect, McFadden, Hastie, and Surprise Lakes and the north shore of Lauzon Lake (see Map 2186, back pocket).

3) From the east end of Long Lake, northeast of Pronto Mine, along Spragge Creek swinging east along Waugush Lake to the vicinity of Highway 108 where the formation is cut out by overlap against a basement topographic high (see Map 2186, back pocket).

The entire Lower Mississagi Formation is exposed only in the vicinity of Surprise Lake and the east end of Lauzon Lake, and to the east of Waugush Lake. In addition to surface data there is considerable information about this formation from diamond drilling.

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*In 1969, Roscoe published a paper "Huronian rocks and uraniferous conglomerates in the Canadian Shield", Geol. Surv. Canada, Paper 68-40, 205 p., in which he discusses Huronian nomenclature to 1968.

The Lower Mississagi Formation rests unconformably on the surface of the Algoman granites and, as noted previously under "Post-Algoman Interval", relicts of the post-Algoman soils are normally preserved. The actual base of the Lower Mississagi Formation is marked by the onset of sorting and bedding in the sediments; and unless a basal bed of quartz pebbles is present the contact may be difficult to identify, particularly in drill core.

The lowermost beds consist of poorly-sorted, angular to subangular quartz and microcline grains, up to a quarter inch across, set in a groundmass of comminuted fragments of quartz and microcline, and sericite, the latter probably derived from the weathered granite. Pyrite may or may not be present. The beds are generally crudely graded; the finer-grained, more sericitic material, being more significant toward the top. Interbedded with the arkosic quartzite are beds up to four inches thick consisting largely of sericitic feldspar debris and quartz; on weathering these beds take on a yellow-green colour more pronounced than that of the quartzite. In outcrop these green bands clearly define the bedding. The upper surfaces of both the quartzite and the green bands may show ripple-marks.

Quartz pebbles may be scattered throughout the arkosic beds or concentrated into bands; the bands are generally 1 to 3 inches thick. Usually these pebbles are subangular to well-rounded, well-sorted, and are almost entirely of vein quartz; although pebbles of chert, jasper, and, occasionally, deformed clasts similar to the sericitic green beds are found. Pyrite is usually a conspicuous component of the matrix of the pebble bands; the pyrite may be euhedral or anhedral and is restricted to the matrix. Accessory minerals are monazite, magnetite, apatite, and zircon. These pyritiferous oligomictic pebble bands are slightly radioactive (generally less than three times background). They are similar in type to the uranium-thorium ores of the Blind River camp. Within the map-area it is only in eastern Long Township and in Spragge Township at the boundary with Long Township that this conglomerate is found.

At Pronto Mine the basal bed of the Lower Mississagi Formation is a quartz pebble conglomerate which has a typical thickness of 7½ feet and has been traced laterally for 3,500 feet. Here the quartz pebbles are well-rounded and sorted, typically 2 to 3 inches in diameter, and form about 60 percent of the rock. Pyrite is the dominant component of the matrix forming about 15 percent of the rock. Uranium occurs in the minerals brannerite, uraninite, and monazite, which are distributed throughout the matrix. The grade of the ore is typically 2 to 2½ lb. U_3O_8 per ton. Thucholite is also present but is a post-deposition mineral. Uranophane and other secondary uranium minerals occur in zones of alteration or of weathering.

Apart from the Pronto occurrence, conglomerate is only found along Spragge Creek east of Long Lake. The Spragge Creek occurrence may be regarded as the selvage of the Pronto body repeated by a fault, subsequently intruded by the Long Lake diabase.

The sequence of arkose, green beds, and pebble bands passes up into feldspathic quartzite interbedded with green bands and rusty-weathering siltstone or argillite. The arenite members are now largely represented by medium-grained, white- to grey-weathering, grey, feldspathic quartzite or quartzite in which the grains are rounded and sorted; microcline now forms a smaller proportion of the rock and sericite a smaller proportion of the matrix. The grains are cemented by silica. Pyrite and rarely chalcopyrite grains are scattered throughout the rock.

Crossbedding, both planar and festoon, is conspicuous. This crossbedding indicates a southeast current-direction (McDowell 1957, fig. 5; 1963). Other directions and even reversals of the principal direction are observed, but statistically these are insignificant. This southeasterly current-direction in Lower Mississagi rocks has been observed throughout the Elliot Lake-Blind River area, (McDowell 1957; 1963; Pienaar 1958; 1963; Robertson 1960 *et seq.*).

The argillite and siltstone interbeds are up to 6 inches thick, pale- to dark-grey when fresh, and rusty when weathered. More pyrite is disseminated through these rocks than through the adjacent feldspathic quartzite. Cleavage is generally present and has a steep dip in the same sense as the bedding. The surface of these argillaceous beds may be ripple-marked and the orientations of the ripples tend to confirm a northwest source. Green bands are less common than in the lowermost part of the sequence.

The uppermost part of the Lower Mississagi Formation is characterized by well-bedded, light grey- to white-weathering, grey, feldspathic quartzite. The rock consists of an aggregate of well-sorted, subangular to subrounded quartz and microcline grains in a silica cement. Occasional grains of plagioclase, magnetite, and zircon are present. Rarely pyrite, and even more rarely chalcopyrite, may be found disseminated through the rock. Normal to planar crossbedding indicative of a northwest source is still characteristic. Ripple-marks are almost absent, as are the green sericitic bands and the rusty-weathering argillaceous beds. Quartz pebbles are rare.

In the uppermost 50 feet of the formation, as exposed along Lauzon Lake and east of Waugush Lake, argillaceous beds are again common; these beds increase in number and thickness into the Middle Mississagi Formation.

At the Long-Striker township boundary the formation may be as much as 1,250 feet thick decreasing eastward to about 700 feet at Pronto Mine; between Pronto Mine and Highway 108 the thickness varies from 300 to 600 feet but is generally less than 400 feet. In the vicinity of Highway 108, the Lower Mississagi Formation is cut out by overlap against the Archean basement and in eastern Spragge Township and the western half of Lewis Township (Robertson and Fraser 1964) the Upper Mississagi Formation rests directly on the basement. In Spragge Township the greater part of the Lower Mississagi sequence is coarse-grained arkose. The thickness figures as determined in Long and Striker Townships (Robertson 1964, p. 21-22) and the marked southeasterly current-direction suggest that a zone of increased deposition may trend southeasterly near the western limit of the map. The Pronto orebody may lie on the east margin of this zone.

Within the Spragge map-area, no Lower Mississagi Formation has been identified south of the Murray Fault. It has, however, been mapped south of the fault westwards from Algoma (Robertson 1963b; 1964).

It is not possible to estimate reliably the thickness of the Lower Mississagi Formation underlying the area between the Rossmere faults (North Rossmere Fault and South Rossmere Fault) in northwest McGiverin Township. In this locality a few hundred feet of grey-green, well-bedded, feldspathic quartzite are exposed. Weathering is grey to pink. The rock is recrystallized, fractured and cut by quartz veins, especially near the faults.

The Lower Mississagi Formation is, therefore, dominantly a coarse-grained arkose-quartzite sequence derived from weathered granite and deposited in shallow water by southeasterly flowing currents. A zone of greater thickness may lie in the southwest part of Long Township. Scattered pebble bands and radioactivity are characteristic of the lower part of the formation. Discovery of radioactive conglomerate at the east end of Lauzon Lake sparked the Blind River staking rush. That deposit was developed by the Pronto Mine, the first producing mine of the Blind River-Elliot Lake camp. Despite extensive prospecting no other significant uranium deposit has been found in the map-area.

Middle Mississagi Formation. The normal facies of the Middle Mississagi Formation, which comprises basal polymictic conglomerate followed by argillite, is not found in the map-area. In the Rossmere fault block (in northwest McGiverin Township) the Middle Mississagi Formation is poorly exposed; the only outcrops found are of argillaceous quartzite or argillite. The maximum thickness present is about 100 feet. No conglomerate is exposed. In the Elliot Lake-Gullbeak Lake area, 3½ miles to the north, the Middle Mississagi Formation is represented by about 20 feet of conglomerate and 700 feet of argillite. A thinning in the Middle Mississagi Formation similar to that found in McGiverin Township has been noted in the Emerald Lake area of Mack Township (Robertson 1964). This suggests that in Middle Mississagi time there was an area of reduced deposition in Mack and McGiverin Townships. D. S. Robertson and N. C. Steenland (1960) have suggested, on the basis of thickness distribution of the Middle Mississagi Formation, that folding of the region began in Middle Mississagi time. The writer on the other hand has contended that the thickness trends of the Middle Mississagi Formation are parallel to Archean basement structures and oblique to the post-Huronian structural trends. Within the present area there is no evidence as to which is the correct interpretation.

The normal Middle Mississagi sequence, conglomerate and argillite, can be traced around the nose of the Chiblow Anticline to Lake of the Mountains near the Mack-Striker township boundary with, as noted above, a marked thinning near Emerald Lake. However, between the southeast shore of Lake of the Mountains and the northwest bay of Lauzon Lake, continuing eastward along the north arm of Lauzon Lake to the Pronto Mine townsite, and again from Waugush Lake to near Highway 108, the Middle Mississagi Formation is represented by interbedded siltstone and quartzite with minor argillite. Individual beds are commonly only a few feet thick, but a few beds of massive siltstone are as much as 30 feet thick. The latter may be traced for considerable distances along strike. New Kelore Mines Limited reported that on their property, which straddled the Long-Striker township boundary, the outcrop of siltstone and greywacke beds coincided with low radioactive anomalies It was estimated that the siltstone-greywacke beds were twice background (the quartzite being taken as background). Exploration failed to reveal uranium or thorium mineralization of economic significance (company report filed for assessment credit, O.D.M. File 63.582).

The quartzite beds are medium - to coarse-grained, feldspathic, and may be massive, laminated, or crossbedded. It is difficult to distinguish this quartzite from the quartzites of the overlying Upper Mississagi Formation or those of the underlying Lower Mississagi Formation. Some beds, particularly thin crossbedded ones between two siltstone beds, are calcareous; differential weathering of the calcareous laminae makes the crossbedding readily visible. Crossbedding is

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Photo 1 — Middle Mississagi Formation; argillite and subgreywacke; note ripple-marks and micro-structures. Near east end of Lauzon Lake, Long Township.

generally planar to normal and indicates a southeasterly current direction. However, there are wide variations and even reversals of the dominant direction.

The silty quartzite and siltstone beds range in thickness from a few inches to 30 feet, but are normally 1 foot to 4 feet thick. These rocks are dark-grey to black when fresh but weather light- to dark-grey. A conchoidal to subconchoidal fracture is characteristic. Minute amounts of disseminated pyrite and more rarely chalcopyrite may be visible. Siltstone partings and beds, and less commonly the quartzite beds, show ripple-marks (see Photo 1). Normally these are of small amplitude and extent, no mega-ripples similar to those observed in Striker Township (McDowell 1957, p. 8-12; Robertson 1964, p. 25) have been recorded. The presence of crossbedding and ripple-marks suggest that this phase of the Middle Mississagi Formation was deposited in moderately shallow water and that the fine-grained character of many of the beds is due to a lack of coarse material in the sediment rather than deposition at depth some distance from shore.

The Middle Mississagi Formation is perhaps as much as 800 feet thick at the Striker-Long township boundary; the thickness decreases slightly eastward to Pronto Mine; east of the mine the outcrop is disrupted by faults and by a diabase intrusion at Spragge. From the east end of Waugush Lake to near Highway 108 the unit is approximately 600 feet thick. West of Highway 108 the Middle Mississagi Formation is cut out by the overlap of the Upper Mississagi Formation onto a granitic basement high. The quartzite-siltstone-argillite sequence is again found in the eastern part of Lewis Township (Robertson and Fraser 1964).

Similar rock types and thicknesses are found to the south of the Murray Fault between Algoma and Blind River and can be traced westward to the French Islands in Mississagi Bay (Robertson 1964). These rocks do not outcrop in the small area of Huronian rocks at Algoma in the southwest corner of the present map-area.

If these rocks continue eastward to the Cutler batholith it is clear that the metamorphism of the rocks of the southern facies of the Middle Mississagi Formation could give rise to the metasedimentary assemblage of the Spragge Group. It must be emphasized that no volcanic rocks have been found in the undoubted Huronian rocks north of the Murray Fault in the Blind River area nor in the sequence as exposed west of Algoma, but their presence has been suggested at approximately the base of the Middle Mississagi Formation at Thessalon (Frarey 1961a; 1962).

From the foregoing it is clear that there is considerable variation in both the thickness and lithology of the Middle Mississagi Formation. The southward thickening observed within the Quirke Syncline (Roscoe 1957; Robertson 1961 *et seq.*) does not continue into the present area; on the contrary, there is a marked thinning in the northeast-central part of the map-area. This thinning trend is demonstrated by the geology of the adjacent areas (Robertson 1960 *et seq.*). In the southern part of Long and Spragge Townships the formation re-attains a greater thickness. The facies change is such that the formation tends to lose its identity. The disappearance of the basal conglomerate reduces the reliability of the positive correlation of any conglomerate found outside the Quirke Syncline and reduces the validity of using such a conglomerate as the most useful horizon marker within the lower part of the Huronian succession (Roscoe 1957, p. 9).

Upper Mississagi Formation. The Upper Mississagi Formation is composed essentially of quartzite and feldspathic quartzite, but locally pebble conglomerate, polymictic conglomerate, calcareous quartzite, and siltstone form part of the sequence.

A few hundred feet of well-bedded feldspathic quartzite are found between the Rossmere faults in northwest McGiverin Township. The formation is exposed on the islands and the south shore of the northeast arm of Lauzon Lake and in faulted blocks near Pronto Mine. The rocks of the formation are also exposed on the south side of the Beaver Pond Fault from Pronto Mine eastward to Spragge village; in the eastern part of this belt near Spragge village the formation is overlain unconformably by the Gowganda Formation. From the east end of Waugush Lake to north of Rio Algom siding the greater part of the formation is exposed on the north side of the Spragge-Long Lake-Lauzon Heights diabase intrusion; from there eastward the southern boundary of the outcrop is the eastern extension of the Beaver Pond Fault. In the vicinity of Highway 108 the Upper Mississagi Formation overlies the granitic basement. Rocks of the Upper Mississagi Formation are exposed at Algoma, south of the Murray Fault, and also on the islands on the south side of the Whalesback Channel (Robertson 1965b and c) (see also "Area Containing Undoubted Huronian Rocks").

The typical rock of the Upper Mississagi Formation is a fine- to medium-grained, glassy, white- to grey-weathering, grey feldspathic quartzite. Planar to concave crossbedding is common and the current direction was from the northwest. Occasional grains of pyrite, chalcopyrite, or pyrrhotite have been observed. Magnetite is the only accessory mineral identified in the field.

Only the basal beds of the formation are exposed in that part of the Rossmere fault block lying in northwest McGiverin Township. In this area, as in adjacent parts of the Quirke Syncline and the westerly part of the Chiblow Anticline, there are scattered pebbles of quartz, chert, and jasper. Occasionally these may be concentrated pockets on the bedding surfaces or they may form pebble bands. Such pebbles are not characteristic of the Upper Mississagi Formation exposed elsewhere in the map-area.

McDowell (1957; 1963) studied the size distribution of chert pebbles in the formation throughout the North Shore area and suggested that this, taken with the crossbedding data, indicated a source area 130 to 250 miles west-northwest of Thessalon.

In southwestern Long Township on the south shore of the northeast arm of Lauzon Lake and on the large island in that arm there are a few outcrops of a boulder conglomerate. The conglomerate (Photo 2) is best exposed on the east side of Norway Point where a densely packed boulder conglomerate lies on a sharp undulating surface of brownish-weathering, coarse-grained, feldspathic, crossbedded quartzite. Sorting both as regards size and composition of the clasts is poor. Angular to well-rounded pebbles, cobbles, and boulders (the largest 5 feet across) of pink granite, grey granite, granitic gneiss, greenstone, Mississagi-type conglomerates, quartzite, argillaceous quartzite, and greenish siltstone, and pebbles of quartz, chert, and jasper are closely packed in a gritty feldspathic quartzite

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Photo 2 – Upper Mississagi Formation; polymictic conglomerate. Norway Pt., Lauzon Lake, Long Township.

matrix. The occasional patch of rusty- to sooty-weathering indicates a sparse distribution of sulphide minerals, dominantly pyrite. When traced westward the bed becomes a conglomeratic quartzite with fewer and smaller pebbles and better sorting.

Near the junction of Highways 108 and 17 where the Upper Mississagi Formation overlaps onto the basement it becomes medium- to coarse-grained, the feldspar content increases, and the rock takes on the greenish colour characteristic of the Lower Mississagi Formation.

The Upper Mississagi Formation, as exposed south of the Murray Fault at Algoma consists of well-bedded, medium-grained, grey, white-to rusty-weathering feldspathic quartzite with thin argillaceous partings. Pebbles of quartz, chert, and jasper are restricted in number. Ripple-marks are not common. Crossbedding is well-developed, and measurements by McDowell (1957, fig. 5) indicated that the currents were easterly-flowing within the map-area at the time these sediments were being deposited, rather than southeasterly as is characteristic of the region as a whole.

A thin bed of polymictic conglomerate, lying about 750 feet above the arbitrary boundary with the Middle Mississagi Formation, has been mapped in the vicinity of Algoma village. It is not clear whether this is correlative with the conglomerate found in the Lauzon Lake area. Collins (1925) indicated Bruce Conglomerate (Bruce Formation) as occurring on Lauzon Creek south of the Canadian Pacific railway and this is probably correct. Laminated calcareous quartzite found in Lauzon Lake west of the map-area (Robertson 1964, p. 29) has not been found south of the Murray Fault.

The maximum thickness of the Upper Mississagi Formation, exposed west of Algoma, is 1,700 feet; farther west, near Blind River the formation is apparently 2,700 feet thick.

Thus the Upper Mississagi Formation consists of medium- to coarse-grained rocks rapidly deposited in moderately shallow water by currents flowing in an easterly to southeasterly direction. Towards the south and southeast the formation normally thickens and becomes more uniform in character; however, near the Striker-Long township boundary and westward to Lake of the Mountains there is a thickening of the formation as a whole and rock types not found elsewhere are found near the western limit of the map-area. At the eastern limit of the map-area the Upper Mississagi Formation rests directly on the basement and is there lithologically similar to the normal facies of the Lower Mississagi Formation.

Bruce Formation

The Bruce Formation consisting of siliceous polymictic conglomerate with minor amounts of quartzite and greywacke is exposed in the following areas: 1) at the western limit of the map-area to the south of the northeast arm of Lauzon Lake and continuous with the formation as mapped in Striker Township (Robertson 1964, p. 31 and Map 2028); 2) from the Beaver Pond south of Pronto Mine eastward to Spragge village (see Photo 3); and 3) at the southwest corner of the map-area near Algoma. In the first two areas the rocks form a slight northward-facing scarp.

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Photo 3 – Bruce Conglomerate. North shoulder of Highway 17, west of Spragge village, Spragge Township.

The rocks here assigned to the Bruce Formation (often referred to as Bruce Conglomerate or Bruce Conglomerate Formation) are continuous with those mapped by Murray (Logan 1863, p. 55-57, atlas, p. 21), west from Blind River, as Lower Slate Conglomerate. However, in the Chiblow Lake-Blind River-Algoma sector, Collins (1925) placed the base of the Gowganda Formation at the base of this conglomerate. Miss-identification of the main branch of the Murray Fault east of Algoma, caused Collins (1925) to place in the Sudbury Series those rocks exposed between the Beaver Pond and the Murray Faults.

Thus Collins did not recognize any Bruce Formation within the present map-area apart from the locality at Algoma referred to previously in this report. Rice (1940) changed the designation of the main branch of the Murray Fault and identified the Bruce Formation in this map-area. However, Rice also included the conglomerate unit, traceable west from Norway Point near the east end of Lauzon Lake, and the overlying quartzite of the Upper Mississagi Formation as the basal members of the Bruce Formation. In this report only the upper member of Rice's Bruce Formation has been placed in the Bruce (Conglomerate) Formation as it is the only one which can be traced laterally into the Bruce Formation as defined (but not in this area recognized) by Collins (1925).

Recent mapping has confirmed the pre-Cobalt age of these controversial rocks and their continuity with the Bruce Conglomerate of the Quirke Syncline (Robertson 1960 *et seq.*). The lack of continuity between the two exposures in the map-area is due to geological structure; the lack of exposure east of Spragge is partly due to the unconformity at the base of the Gowganda Formation and partly to structure. Within the map-area there is only one possible outcrop area of Bruce

Formation south of the Murray Fault. Collins (1925) shows Bruce Conglomerate at the mouth of Lauzon Creek. Samples from this locality contain red granite pebbles in a greywacke matrix and it is not clear therefore whether the exposures represent the Bruce Conglomerate or a conglomerate locally developed near the top of the Upper Mississagi Formation; tentatively it has been correlated with the Bruce Conglomerate. The conglomerate of the Bruce Formation has been recognized at one locality southwest of Blind River (Robertson 1964) west of the map-area, and it also occurs locally on the south shore of Aird Island, southeast of the map-area (Robertson 1965b and c).

The typical conglomerate of the Bruce Formation consists of a moderately-sorted aggregate of sub-angular to sub-rounded boulders and cobbles of granite, gneiss, diabase, and "greenstone", and angular to rounded pebbles and fragments of the same materials and quartz, feldspar, chert, and rarely jasper, set in a highly siliceous gritty greywacke to quartzite matrix. The matrix is characterized by well-rounded grains of glassy smoky quartz; blue quartz grains may also be recognized. Pyrite and pyrrhotite are disseminated throughout the matrix and are often found between the pebbles and the matrix, rarely replacing the quartz and feldspar fragments. On the weathered surface of the rock this pyrite gives rise to irregular rusty patches. The outer quarter inch of the rocks is generally lighter grey in colour owing to leaching during weathering.

Regionally there is wide variation in the packing of the conglomerate but this is not characteristic of the present area where a moderately sparse distribution of fragments is typical. The granitic boulders may be white, pink, or red, but white granite predominates over all other rock types. Pink or red granitic boulders are most common near the base of the formation. The mineralogical and textural features of the granites are similar to those of the Algoman granites. The diabase boulders weather rapidly at the edges and the centres, giving the effect of an upturned saucer. Since the matrix is harder than the boulders the latter tend to weather more rapidly, giving the rock a pitted surface. Where the matrix is less siliceous, or where the outcrop surface has been protected from weathering, there is no such differential weathering between the pebbles and the matrix. Locally, and particularly towards the top of the formation, the matrix of the conglomerate is a fine- to medium-grained, dark green to black greywacke; and pebbles are fewer in number, and tend to weather up, that is, the pebbles weather more slowly than the matrix and are left as prominences on the surface of the rock. In greywacke or greywacke conglomerate a poorly- to well-developed lamination may be found, usually showing graded bedding. The relationship of the pebbles to the laminae suggests that they were dropped into partially consolidated sediment, possibly from floating ice. Such laminated conglomerates are characteristic of the Gowganda Formation of the Cobalt Group and it is possible, *inter alia*, that the occurrence of this rock-type led Collins (1925) to relate this unit to the Gowganda Formation instead of to the Bruce Formation.

Coleman (1908; 1914) suggested that the rocks of the Bruce Formation as well as the conglomerates of the Gowganda Formation were tillite. Rice (1940) extracted and illustrated striated boulders from the Bruce Conglomerate. However, Rice did not commit himself to a glacial origin but only to some form of mass transportation. McDowell (1957) suggested a mud-flow deposit. It is clear that the unit was deposited in water and that some sorting and winnowing took place.

Rarely lenses of quartzite may be present in the Bruce Conglomerate; these are well-washed, rusty-weathering, white, feldspathic quartzite. Where the lenses are found in the western exposure, near the Long-Striker township boundary, these may show micro-crossbedding; the quartzite is slightly calcareous and is more characteristic of the lower part of the formation. These lenses cannot be traced for more than a few tens of feet. In the eastern exposure, near Pronto's Beaver Pond, quartzite forms a greater part of the sequence. The basal contact with the Upper Mississagi Formation is poorly defined and is gradational in nature; transition from a laminated quartzite sequence to a dominantly conglomeratic sequence taking place in about 10 feet. Ribs of impure quartzite persist through that part of the sequence exposed in this area. The contact with the overlying Gowganda Formation is poorly exposed. Bruce Conglomerate (possibly only partially consolidated) may have been reworked and incorporated in the basal beds of the Gowganda Formation. Rice (1940) did not recognize the Bruce Formation in this area and showed the entire sequence above the Mississagi Formation as being Gowganda Formation.

In the western exposure about 200 to 300 feet of the formation is exposed near the Long-Striker township boundary and as the upper limit is defined in eastern Striker Township it is probable that this is close to the true thickness of the formation. The eastward thinning along Lauzon Lake may be partly original and partly due to the encroachment of the Gowganda Formation. The critical areas are not exposed.

Espanola Formation

Throughout the North Shore of Lake Huron a series of limestones, mudstones, and dolomites overlies the Bruce Conglomerate Formation conformably. Normally it is possible to map three units: a lower unit characterized by limestone, the Bruce Limestone; a middle unit characterized by mudstone and greywacke, the Espanola Greywacke; and an upper unit having a marked development of ferruginous dolomite, the Espanola Limestone. Collins (1925) regarded all three as variations of the one unit and grouped the three as the Espanola Formation. Quirke had previously (1917, p. 33-38) ascribed formational rank to each of the above units as exposed in the Espanola region and placed them in the Espanola Group.

Abraham (1957, p. 61) followed Collins in considering a limestone in the Chiblow Lake-Blind River area as lying in the Gowganda Formation though the writer (Robertson 1956) was not in agreement with this and considered the unit to be Bruce Limestone. The latter view was also held by Rice (1940) apparently with Collins' approval.

When mapping in the Quirke Syncline, Abraham (1956) removed the Bruce Limestone from the Espanola Formation and placed it in the Bruce Formation with the Bruce Conglomerate. This arrangement has the merit of emphasizing the cyclical nature of the Bruce Group, which can be divided into a number of units each characterized by an arenaceous or rudaceous basal member grading upward into an argillaceous or calcareous upper member. Nevertheless, most recent workers in the area have retained Collins' nomenclature in this respect (see Table 1).

Spragge Area

No member of the Espanola Formation has been identified within the map-area. In the Lauzon Lake area Bruce Limestone outcrops near the narrows in Striker Township north of Algoma but it is clear that the member dies out near the Striker-Long township boundary. The unit has been traced westward and like the underlying Bruce (Conglomerate) Formation there is no doubt as to its identity. The upper members of the Espanola Formation were either not deposited at all or were, more probably, removed by the pre-Gowganda erosion.

Members of the Espanola Formation were mapped by Collins (1925) and Rice (1940) on Aird Island (the island on the south side of Whalesback Channel east of John Island) and other islands east of the southeast corner of the present map-area. This was confirmed during mapping carried out in 1965 (Robertson 1965a and b). Probably this belt continues westward, beneath the water, near the south limit of the present map-area.

A small exposure of Bruce Limestone has been identified at one locality south of the Murray Fault near Blind River by Collins (1925), Rice (1940), and the author (Robertson 1964, Map 2028).

For detailed descriptions of the Bruce Limestone and the other members of the Espanola Formation the reader is referred to earlier reports by Collins (1917), Quirke (1917), and the writer (Robertson 1960, *et seq.*).

Cobalt Group

The Bruce Group is followed unconformably by the Cobalt Group. The Cobalt Group consists of the Gowganda Formation, the Lorrain Formation, banded cherty quartzite[1], and finally, the upper white quartzite[1] and cherty quartzite (Collins 1925, p. 63). Of these formations only the Gowganda Formation is exposed within the present map-area. The Gowganda Formation is a heterogeneous assemblage of conglomerates, greywackes, siltstones, arkoses, and quartzites. The Lorrain Formation is typically white orthoquartzite with or without quartz, chert, and jasper pebble bands. Boulders and large erratics of Lorrain quartzite are found in the drift and in the boulder beaches along the shore of Lake Huron.

Gowganda Formation

The Gowganda Formation is exposed in the southern parts of Long and Spragge Townships from Algoma to just east of the junction of Highways 17 and 108. It is bounded on the south side by the Murray Fault. The basal part of the formation is exposed northeast of Algoma, also south of Pronto Mine, and near Spragge village. Elsewhere the base is not seen owing to a fault along Lauzon Lake that extends eastward through Spragge village. The formation, due to structural relationships, is nowhere totally exposed in the map-area and by comparison with the rest of the Blind River-Elliot Lake area (Robertson 1960 *et seq.*) it is evident

[1]Banded cherty quartzite and upper white quartzite have been named Gordon Lake Formation and Bar River Formation respectively, by Frarey (1967).

that only a comparatively small proportion of the formation is present.

Within the map-area the formation consists essentially of: interbedded greywacke, which may or may not be conglomeratic; arkosic quartzite; and siltstone or shale. Regionally the basal part of the Gowganda Formation is normally more conglomeratic and less quartzitic than it is found in the map-area. This led Rice (1940) to postulate that the Lorrain Formation was present in the Lauzon Lake-Spragge sector. However, this contention is not supported by the lithology of the rock types present nor by the regional mapping which clearly shows continuity with the more typical sequence.

The contact of the Gowganda Formation and the underlying Bruce Limestone Member of the Espanola Formation is exposed in Striker Township west of the present map-area (Robertson 1964, p. 36). The contact is sharp, and fragments of Bruce Limestone are found in the basal members of the Gowganda Formation, indicating an unconformity. The basal contact of the Gowganda Formation is not exposed in the map-area except to the south of the Beaver Pond near Pronto Mine, and in exposures near Spragge. On the hillside south of the Beaver Pond it is possible to traverse from interbedded quartzite and conglomerate through greywacke conglomerate, apparently of Bruce-type, into a Gowganda-type greywacke with sparse conglomerate, with no clear-cut break. Near Spragge, Gowganda-type conglomerate rests directly on Upper Mississagi quartzite. Elsewhere in the Blind River-Iron Bridge sector (Robertson 1963b; 1964) where Gowganda Formation rests on or near Bruce Formation the basal members of the Gowganda Formation take on many of the characteristics of the Bruce Formation particularly in the predominance of white granite clasts. It is therefore thought by the writer that the sequence south of Pronto Mine presents an illusion of conformity and that the basal part of the Gowganda Formation contains much reworked Bruce Conglomerate.

The conglomerates, the best known rocks of the Gowganda Formation, show wide variations but typically consist of boulders, cobbles, and pebbles of red granite, gneiss, diabase, and greenstone; and pebbles of quartz, chert, and jasper scattered through a fine- to medium-grained matrix. The matrix may be: 1) greywacke, in which case it has been generally assumed that the rock is a tillite (see Photo 4); or 2) argillite or shale. The latter type is more common in the map-area than is usually the case. In addition to the transported rocks these conglomerates may contain fragments of the other Gowganda rock types; these are frequently torn and bent suggesting that they were disrupted and re-deposited in a partly consolidated state.

The granite boulders predominate; the majority have the same character as the red phase of the Algoman granite from which they were probably derived. With the exception noted above white granitic rocks are less abundant.

As Collins (1925, p. 63-67) has pointed out the conglomerates of the Gowganda Formation fall into three broad types: 1) dense boulder conglomerates; 2) sparse boulder conglomerate, with either a greywacke or a shale matrix; and 3) laminated greywacke conglomerate. Although types 1 and 3 do occur locally they do not form a significant part of the sequence in the map-area.

The dense boulder conglomerates are not well-developed within the map-area. Bedding is normally massive but well-defined; frequently the base is a definite erosion surface and a crude graded bedding is visible. Boulders may show considerable variation in size and shape, but normally there is some degree of

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Photo 4 – Gowganda Formation; conglomerate (tillite-type). North of Highway 17, Long Township.

sorting and some evidence of rounding, suggestive of water transportation. The matrix may be gritty quartzose greywacke or greywacke and it forms a small part of the total rock. Fragments of quartzite, greywacke, and conglomerate similar to those of the lower parts of the Gowganda Formation are also found in small quantities; locally fragments of contorted mudstone obviously transported in a partially consolidated state, may be observed.

The sparse boulder greywacke conglomerates are made up of the same materials as the boulder conglomerates, but the matrix here forms the greater part of the rock and is medium- to fine-grained, breaking with a splintery to sub-conchoidal fracture. Boulders and cobbles are scattered throughout the rock and are rarely in contact with each other. The matrix consists of poorly-sorted, angular to subangular, grains of quartz, plagioclase, and microcline in a groundmass of chlorite and finely comminuted rock and mineral fragments, with magnetite and other heavy minerals as accessories. Under the microscope the disrupted texture of greywacke is clearly seen. The feldspar grains are only slightly altered to clay minerals and sericite. Minor amounts of pyrite and, rarely, chalcopyrite may be present; these sulphide minerals may be scattered through the matrix, around grains or pebbles, or replacing quartz, feldspar, or chloritic fragments. Some pyrite may be detrital but the bulk is either authigenic or introduced. The matrix may show a slight lamination. Where the rock has a cleavage or is well-jointed (in the map-area this happens where the formation is bounded by major fault structures) the weathered matrix breaks up into flakes and "pencils" that lie scattered over the outcrop surface. In the sparse boulder greywacke conglomerate the boulders may be up to several feet across (Abraham's field notes mention one granite boulder 20 feet long) but are generally between 2 and 6 inches across. Shapes show considerable variation but are normally sub-rounded to sub-angular.

Boulders and cobbles with markedly flattened or "soled" sides are not uncommon. Striated boulders have been recognized in rock cuts in similar rocks near Elliot Lake. Striated and "soled" boulders; the contrast between the boulders and the matrix; the disrupted texture of the matrix; and other features of these rocks and associated members of the assemblage led Coleman (1914) and Collins (1925) to conclude that these rocks were tillites, that is conglomerates transported and deposited by ice. At present a growing school of opinion suggests that such features may be explained by other means of mass transportation such as mud-flows; but Ovenshine (1964) has recently re-emphasized the glacial origin of the Gowganda Formation in the Blind River district. In contrast to the typical Bruce Conglomerate the above rocks are greywacke rather than sorted quartzose greywacke, boulders are dominantly red granite rather than white and weather less rapidly rather than more rapidly than the matrix, and sulphide minerals are less conspicuous in the matrix.

The laminated greywacke conglomerates, which are not characteristic of the present map-area, are well-bedded greywackes with a few scattered rock fragments and pebbles with no characteristic shape or sorting. The matrix is finely-laminated, each layer showing graded bedding (grain gradation). It has been suggested that such rocks are varved deposits and that the fragments and pebbles have been dropped from floating ice.

The Gowganda Formation conglomerates may be traced for considerable distances but lens out laterally or pass into boulder-free greywacke. Massive greywacke beds 2 to 3 feet thick, showing micro-crossbedding, graded bedding, and other features characteristic of turbidites are well-exposed along Lauzon Lake.

After conglomerate-greywacke, the most common rock type in the Gowganda Formation is quartzite. Again there is considerable variation in lithology and composition.

The most common of the quartzites is a fine- to medium-grained, red-weathering, grey to pink, impure, feldspathic quartzite with conchoidal to sub-conchoidal fracture. The pink colour is due to hematite scattered through both the matrix and the feldspar grains. Close to the Murray Fault and the larger diabase intrusions this hematite has been removed from the quartzites and the weathered surface of the rocks at these places is almost white. Rarely the removed hematite appears as films along fractures and bedding. Throughout the map-area where dips are steep, ranging from 65 degrees to vertical, and quartzite is intimately interbedded with greywacke and shale, the quartzite beds, due to differential weathering, stand up as ribs. In thin section it is seen that plagioclase is the dominant feldspar in this quartzite and in several sections microcline is lacking; accessory minerals are zircon, magnetite, apatite, muscovite, and chlorite. Features such as crossbedding, graded bedding, ripple-marks, and mudcracks are rare. Generally beds dip steeply south and tops face south. Determinations in places along Lauzon Lake indicate local northerly dip with top facing south.

Fine- to medium-grained, white-weathering, white to grey, impure feldspathic quartzite is also found. Calcite or limonite patches may be present and pyrite grains are more common than in the normal pink quartzite. Otherwise the rock-types are generally similar.

Medium- to coarse-grained arkoses with large grains of potassic feldspar are not characteristic of the map-area although they have been found in the Gowganda Formation elsewhere.

Argillaceous quartzites and siltstones may be regarded as intermediate between the quartzite and the shales or greywacke.

Shales and argillites are well-developed in the map-area. In the field they may be difficult to distinguish from the fine-grained greywackes. All these rocks show a strong cleavage; the area is in a zone of severe deformation. The argillaceous rocks are interbedded with quartzite. Where both quartzite and shale are thin or the quartzite is thin relative to shale the quartzite beds may be distorted or disrupted. This distortion may be owing to the differing competencies of these rock types during tectonic stress but, as such features are also found in the Gowganda Formation away from the Murray Fault or other zones of dislocation, it may be owing to slumpage in partly consolidated sediments.

Shales and argillites may pass laterally into siltstones and quartzites or into greywackes and conglomerates.

From the foregoing it will be seen that the Gowganda Formation comprises many rock types: some of which are definitely waterlaid; some of which accumulated under cyclic conditions suggestive of seasonal freezing or thawing, flooding, or turbidity currents; and some may represent glacial deposits or possibly mud-flows. As compared with the rest of the Blind River-Elliot Lake area the basal part of the formation (the only part represented in the map-area) is better bedded, has less conglomerate, particularly dense conglomerate, and more quartzite and shale.

POST-HURONIAN MAFIC INTRUSIONS

Nipissing Diabase

Following the deposition of the Huronian sediments the area was subjected to considerable tectonic disturbance and the intrusion of igneous rocks. There were three such periods of intrusion:

1) Quartz diabase, gabbro differentiated to diorite, diabase, and possibly lamprophyre; generally correlated with the Nipissing-type diabase.
2) Granite, two-mica granite, and pegmatite; the Cutler Granite.
3) Olivine diabase; as northwest-trending dikes.

Collins (1925) considered that all three events were phases of the one cycle and correlated all three with the Keweenawan; consequently this term was used in the writer's earlier reports and in the preliminary maps for the Spragge area (Robertson 1960 *et seq.*).

Isotopic age determinations (see beginning of section on "General Geology") however, reveal a wide time gap between these events. The intrusion of the Nipissing-type diabase and that of the olivine diabase are separated by almost 1,000 million years. The Penokean orogeny, here represented by the Cutler Granite and the metamorphism of the adjacent rocks, took place in the interval between these two mafic intrusions.

The olivine diabase gives ages comparable to those obtained from gabbroic rocks at Duluth and accordingly, in this report Keweenawan has been restricted to the olivine diabase.

The rocks here correlated with the Nipissing diabase occur as large irregular sill-like bodies or as dikes characterized by west-northwesterly or northwesterly strike. The irregular bodies consist of gabbro differentiated to diorite; and lithologically and petrographically these are of Nipissing-type.

The dikes, which are especially numerous in the granitic core of the Chiblow Anticline (see Robertson 1963b, Map 2032), have many features in common with the irregular bodies discussed in the preceding paragraph but the age relationship is not clear. It is possible that they represent a slightly later phase of igneous activity. They are termed Nipissing with rather less confidence. It is, moreover, possible that several ages of diabase may have been included in this group. There has never been any clear-cut evidence in the Blind River area for pre-Huronian diabase dikes cutting the Algoman granite, but this possibility should not be excluded.

In the present map-area irregular sill-like bodies of gabbro-diorite are located as follows:

1) Between Esten and Nordic Lakes. This is the southwestern limit of a sill-like body which has been traced eastward through Townships 149, 143, and 137 to the nose of the Quirke Syncline; this body probably continues under Whiskey Lake and outcrops on the north limb of the syncline in Townships 138 and 144 (Robertson 1961a; 1962; 1968; see also Map 2185, back pocket.)

2) In northwest McGiverin Township in the vicinity of Esten, Rossmere, and McGiverin Lakes. If the linear nature of Esten Lake is due to east-striking faults this may be the faulted continuation of number 1. To the west this body can be traced through the townships of Mack, Scarfe, 167, and 161 (Robertson 1963a; 1964; see also Map 2185, back pocket).

3) In the Huronian belt north of the Rio Algom and Denison sidings, thickening westward and forming a prominent ridge to the south of Waugush Lake and north of Spragge village; swinging northwest along Spragge Creek to Long Lake; from there it turns west to the south shore of Hastie Lake; west and northwest of Hastie Lake it forms high ground known locally as Lauzon Heights. Much of the northwest corner of Long Township and adjacent parts of Striker Township are underlain by this portion of the intrusion. In Striker Township the outcrop is displaced by the Lake of the Mountains Fault and the body can be further traced across the southern parts of Mack and Scarfe Townships (Robertson 1964; Map 2186, back pocket).

4) Another body of diabase lies north of and strikes sub-parallel to number 3. It has only been mapped within basement rocks and contacts suggest that it may be a dike. This body is different in composition and texture, and follows a strong magnetic anomaly (Map 2186, back pocket).

The dikes are vertical or near vertical and are typically 20 to 150 feet in width, though both thicker and thinner portions are found. Several dikes are considerably wider. Generally on map-scale they are marked by rectilinearity (differing in this aspect to the irregular sill-like bodies) and a number have been traced for several miles. Dikes show a marked concentration in the granitic core of the Chiblow Anticline, an area also marked by numerous faults; both features are due to the high competency of granite, which can only yield to forces by fracture. The dikes, as throughout the Blind River-Elliot Lake district, show a marked concentration along west-northwest and northwest trends. North- and northeast-trending dikes do occur but are comparatively rare.

The west-northwesterly set of dikes, that is the set parallel to the fold axes of the Quirke and Chiblow folds and sub-parallel to the regional trend of the Murray Fault (though definitely oblique to the trend within the map-area) is rather better developed than the northwesterly set of dikes. Except that the wider dikes, which show some differentiation towards gabbro or diorite in the core, tend to occur in the westerly group, there is no great difference between the dikes of the different groups. Age relationships between the dikes of differing trend were rarely observed and these were conflicting. In some localities, dikes were observed to split, each branch following different trends. It is therefore concluded that the diabase dikes of Nipissing-type(?) were intruded simultaneously into a set of pre-existing fractures.

Both dike and sill rocks show chilled margins; generally these margins are sharp and unaltered but locally may be strongly sheared; chlorite and veinlets or dissemination of quartz, calcite, and occasional minor amounts of pyrite and chalcopyrite may develop at the margins. The fine-grained chilled marginal phases grade rapidly into medium- to coarse-grained diabase, then to gabbro with lath-like feldspar crystals, which in turn grades into coarse-grained gabbro. The diabase and gabbro are made up of calcic labradorite, diallagic augite with or without pigeonite, minor quartz and, in some sections, micropegmatite. The accessory minerals may include chlorite, red-brown biotite, zircon, apatite, and magnetite. Pyrite, pyrrhotite, and chalcopyrite may be disseminated through the rock. The pyroxenes may be fresh, particularly in the basal parts of the sill-like bodies, but are normally moderately to strongly uralitized. The plagioclase crystals, particularly the more calcic cores of these crystals, are partly altered to saussurite.

In the gabbroic rocks there is a gradual transition to diorite. The uralitized pyroxene is replaced by a blue-green pleochroic hornblende. Large plates of chlorite may be present. Red-brown biotite becomes a characteristic accessory mineral and may be visible in hand specimens. There is an increase in the free quartz and the micropegmatite present. The plagioclase is less calcic but more strongly zoned. In some patches in outcrops the diorite is characterized by inch-long hornblende crystals showing faces and twinning. These patches may be vuggy, with quartz and, rarely, calcite present, and they are generally lighter in colour than the adjacent rocks. Sphene and epidote are characteristic accessory minerals of the dioritic phase. The red-brown biotite may show intergrowth with skeletal, titaniferous magnetite.

No granophyre or "red rock", the normal end stage of differentiation of the Nipissing-type diabase or gabbro, has been identified within the map-area. It has, however, been recognized in the upper part of the sill-like body west of Hastie Lake in Striker Township (Robertson 1964, p. 42-43).

No surface exposures of lamprophyre have been found in the present map-area. Lamprophyre, identified by company geologists as alnöite, was found in the workings at Pronto Mine. This is characterized by red-brown phlogopite. Similar rocks have been found throughout the Blind River area, mostly in drill holes or mine workings. The writer has regarded these as related to the end stage fluids of the Nipissing diabase. Age determinations on lamprophyre give ages of about 1,400 million years which is similar to mica ages from the metasediments in the Penokean fold belt (Van Schmus 1964; 1965). It is not yet clear whether these ages should be regarded as indicating a Penokean age for the lamprophyre or whether the micas were reconstituted at that time.

Dikelets intruding the metamorphic rocks of the Spragge Group have been identified as a lamprophyre (probably minette). These consist of black to brown biotite in a carbonate-rich groundmass and nothing is known of their true age relationships.

Locally, near diabase or gabbro bodies, dikes, and many of the faults, the country rock takes on a bright-pink colour due to the introduction of hematitic albite. Quartz-albite-epidote, or quartz-carbonate-sulphide veins and stringers may be found in or near the border or marginal phases of gabbro or diabase. Albite stringers along joints in Lower Mississagi quartzite at the west end of the Pronto Mine were described as granite by Ginn (1960). Extensive albitization in the mine (discussed under "Pronto Mine") was considered by early workers to be radioactive quartzite (Holmes 1957) or intrusive granite (Joubin 1958, personal oral communication) but as mining progressed at Pronto and from experience gained in the other mines and in surface mapping the actual composition of the material became clear. In addition to albitic alteration, chloritic and carbonate-rich alteration materials were also recognized at Pronto (see Table 3). Originally these were described as radioactive grits (Holmes 1957); the terms radioactive quartzite and radioactive grit were retained in the mine terminology as a matter of convenience after the identity of the materials in question had been established. These types of alteration are discussed further under structural geology in the "Pronto Mine" section.

Throughout the Blind River-Elliot Lake area there is some indication that hydrothermal copper deposits are geometrically and genetically related to the large, irregular, differentiated bodies of Nipissing gabbro-diorite. A copper deposit associated with a shear plane in the southern part of Township 149 (Robertson 1968) may be related to the sill-like body between Nordic and Esten Lakes. Buckles Algoma Uranium Mines Limited (eventually incorporated into Rio Algom Mines Limited) was formed to carry out exploration in the vicinity of the showing (Robertson 1968; and section on Buckles property, this report). Mapping and trenching were carried out in northern Esten Township but no extensive copper mineralization was discovered. The copper showing at Christie Lake in Esten Township is associated with sheared Keewatin material in the granite and the relationship, if any, to post-Huronian diabase is unknown. The Pater Mine is located in the Spragge Group south of the Murray Fault. Possibly the mineralization was derived from a Nipissing intrusion and remobilized and concentrated during the Penokean orogeny.

The large west-northwest-trending diabase body in Spragge and Long Townships with the associated magnetic anomaly, referred to on page 37 as number 4, consistently shows signs of mineralization. Chalcopyrite, pyrite, and pyrrhotite coat fractures and are disseminated through the rock as exposed in rock cuts on Highway 108. Local inhabitants informed the writer that test pits had been sunk on this body in northern Spragge Township in the 1920s or 1930s but these were not found by the writer's field party.

Inclusions of the country rock in diabase or gabbro are not common; where these are present they are usually restricted to the marginal phases. The borders of some inclusions may be sharp and angular, and the inclusions show little change apart from albitization. Others, however, show blurred boundaries indicating some degree of assimilation; these inclusions may be surrounded by a thin rim of acicular amphibole crystals oriented perpendicular to the contact of the inclusion with the diabase. Some dikes near Blind River (Collins 1925, p. 80-82; Robertson 1964, p. 44) and the sill exposed in Lauzon Heights (page 37 number 3) have numerous large inclusions of quartzite (in the case of Lauzon Heights both granite and quartzite). The boundary relationships of these inclusions have been described by Collins (1925, p. 80-82) and Rice (1940). Although the boundaries may be locally sharp, they have usually been corroded and show the development of one or more surrounding amphibole rims. Collins (1925) and Rice (1940) suggested that there are all gradations between the unaltered inclusions and the leucocratic dioritic patches. As micropegmatite is characteristic of the selvages of the quartzite inclusions it was further suggested (Collins 1925) that the granophyre or "red rock" had formed by the assimilation and subsequent flotation of the quartzite. However, regional mapping (Robertson 1960 *et seq.*) has shown that extensive granophyre is found in bodies not characterized by many inclusions. Moreover, the dikes (or sills) at Blind River and the Spragge-Long Lake-Lauzon Heights body have been intruded into fault zones. The writer (Robertson 1964, p. 44) has suggested: that the faulting, previous to the diabasic intrusion, caused intense fracturing of the country rock; that the intrusive diabase was for this reason able to enclose large blocks of country rock; and that the energy which would normally have been required for intrusion was thus available for assimilation of the inclusions which, therefore, proceeded to a greater degree in those localities than is normally found in this region.

Within the present map-area there is no clear-cut relationship between the dikes and the "sills". Some dikes would appear to be connected to the sills possibly as feeders or as offshoots. Elsewhere in the Blind River-Elliot Lake district, notably in the Whiskey Lake sector (Robertson 1962, p. 45) there is some evidence that dikes tend to be later than sills.

The structural significance of the distribution of diabase is discussed under "Fractures Filled by Nipissing Diabase Intrusions".

Thus the greater part of the Nipissing (as used in this report) was a period of hypabyssal mafic intrusions. Some of these mafic intrusions formed large, irregular, transgressive, sill-like bodies. These sills or irregular bodies were strongly differentiated from gabbro to granophyre with possibly lamprophyric segregations; albitic, carbonatizing, and chloritic end-stage hydrothermal solutions invaded and altered the country rock (these end-stage alterations are of some economic significance because of the intensity of this alteration at Pronto Mine). Other bodies, possibly contemporaneous, possibly slightly later in age, were intruded as diabase to quartz diabase dikes showing marked structural control.

AREA CONTAINING HURONIAN(?) ROCKS

The map-area contains rocks of both the Superior Province and Penokean fold belt sub-province of the Southern Province (see Stockwell and Williams 1964, for structural divisions and orogenic history of the Canadian Precambrian Shield). The Algoman granites and Keewatin-type rocks of the basement belong to the Superior Province but these have been caught up in the Penokean (Hudsonian) tectonic disturbance. The rocks north of the Murray Fault show relatively moderate folding and dislocation and may be regarded as the foreland area. The rocks to the south of the Murray Fault are more strongly deformed, metamorphosed, and faulted and, moreover, are intruded by the post-Huronian granitic rocks of the Cutler batholith. Brief descriptions of the Cutler batholith and the associated rocks have been given by Collins (1925), Rice (1940), and the writer (Robertson 1960; 1965a and b).

Miller and Knight (1915) correlated all granitic rocks on the North Shore of Lake Huron with the granitic rocks exposed at Killarney. They used the term Killarney Granite but believed that all the rocks in question were of Laurentian, that is, pre-Huronian age. Collins and his associates (Collins 1917) initially followed this concept but as their work progressed it became clear that there were several ages of granitic intrusions and the term Killarney Granite was restricted to those bodies proven, or believed, to intrude the Huronian (Collins 1925, p. 85). These bodies included the Killarney, Birch Lake, Eagle Island[1], and Cutler Granites. The Cutler Granite was nowhere seen in contact with Huronian rocks but Eskola (Collins 1925) observed: 1) that Huronian rocks to the north of the batholith (and north of the Murray Fault) showed a higher degree of recrystallization at their closest proximity to the granite; 2) that the quartzites believed to be of Mississagi age, exposed in the island to the south of the Cutler Granite, showed a progressive increase in metamorphism in a northerly direction; and 3) that post-Huronian diabase was metamorphosed and included in the granite body.

Rice (1940) followed Collins' interpretation (Collins 1925) but found further proof of the post-Huronian age of the Cutler Granite in exposures showing granite and pegmatite cutting quartzite on Caroline and Laughlin Islands, which are on strike with, but west of, the islands south of the Cutler batholith. Later workers correlated many granites north of the Murray Fault with post-Huronian granite on the basis of a fresh appearance.

In the late 1950s (Ginn 1956; Robertson 1960) it became apparent that much so-called Killarney Granite (especially north of the Murray Fault) was in reality a potassic phase of the pre-Huronian granite. In view of this and: 1) as pre-Huronian granites also occur south of, and adjacent to, the Murray Fault in the vicinity of Blind River; 2) as there are large-scale faults and post-Huronian diabase intrusions, which could have caused the metamorphic effects described by Eskola; and 3) because of the supposed restriction of the Cutler Granite to rocks (of the Sudbury Group or Series) classically believed of Archean age; the writer (Robertson 1960; 1961c) suggested that the Cutler Granite might be a block of pre-Huronian granite thrust up on the south side of the Murray Fault. Using Thomson's (1960) criterion of radioactivity as a guide to the unconformity at the base of the Huronian (Robertson 1960 *et seq.*) it was further suggested by the writer that a zone of radioactive anomalies along Aird and adjacent islands (O.D.M. 1954b) could mark the base of the Huronian and that the metamorphosed quartzite on the north side of the islands was Archean. Ginn (1960) also doubted the post-Huronian age of the Cutler Granite.

The interpretation remained obscure until age determination data for the district revealed the pattern indicated on page 12. The earlier results showed no

[1]This body is now termed the Croker Island complex (see Card 1965a).

great age difference between undoubted pre-Huronian rocks and the Cutler Granite and had tended to confirm the previous hypothesis of a pre-Huronian age. After the younger age was accepted for the Cutler Granite, however, it was noted both by workers from the Massachusetts Institute of Technology (Fairbairn *et al.* 1960) and those from the Carnegie Institution of Washington (Tilton *et al.* 1959, p. 176) that pegmatites crosscutting the granites consistently gave ages older than the granite (approximately 1,750 million years and 1,350 million years respectively). This anomaly led G. W. Wetherill, one of the Carnegie workers, to resample the Cutler Granite with similar results (Wetherill *et al.* 1960). Wetherill's work on age determinations was taken up by W. R. Van Schmus (Van Schmus et al. 1963; Van Schmus 1964; 1965) who worked primarily on the mafic intrusions. The results of this work although not solving the pegmatite-granite problem, clearly showed that both were younger than the Nipissing diabase and were therefore post-Huronian. Age data from the Geological Survey of Canada (Lowdon 1960; 1961; Lowdon *et al.* 1963; Leech *et al.* 1963) confirmed this sequence of events. Van Schmus (1964, p. 18-21) found one locality on John Island where a Cutler-type pegmatite cuts the quartzite. Neither Van Schmus nor the writer found any sign of the postulated unconformity on John or Aird Islands (Robertson 1960 *et seq.*). In 1966 the writer found further evidence for Cutler-type pegmatites cutting intermediate grade metasediments on John and Rainboth Islands.

These results combined with: 1) the realization that the Huronian south of the Murray Fault, if continued eastward from Algoma, could give rise to the metasediments of the Spragge Group; and 2) the possibility that the Spragge metavolcanics could represent the eastward continuation of the Thessalon Greenstone, which Frarey (1961a and b; 1962) believed to occur near the base of the Huronian; have led to the proposition that the Cutler Granite is not only post-Huronian in age but is intruded into rocks of possible Huronian age. Owing to the lack of outcrop, and to the complicated structure of the area, this proposition cannot be proved by mapping alone within the Spragge map-area and for the purpose of this report the metamorphic rocks south of the Murray Fault have been termed the Spragge Group (see Table 1).

There are currently three major hypotheses regarding correlation south of the Murray Fault.

1) The classical concept of Collins and his associates (1925) which reports: definite Huronian rocks are found south of the fault; between the Huronian and the fault there is a series of more highly metamorphosed sedimentary rocks termed the Sudbury Series which are probably Archean in age. It was believed that the metamorphism of the Sudbury Series rocks was pre-Huronian in age but the predicted unconformity could not be identified.

2) The hypothesis that there is no unconformity in the metasediments south of the Murray Fault; that there is no good evidence of Huronian age of this sedimentary unit; and that there are no proven volcanic rocks in the Huronian sequence. Thomson (1952;1953) pointed out: a) that different conglomerates have similar lithological characteristics and that he did not agree with all of the previous correlations; moreover, b) that some of the quartzite units show greater variations within themselves than between each other and thus are also unsuitable for use as markers. In later works based on compilation of published data and assessment files, Thomson (1961; 1962) described the regional

geology in terms of the classical interpretation while noting that some geologists advocated the theory of Huronian rocks lying south of the Murray Fault. Thomson's work, therefore, has had the effect of codifying and clarifying classical concepts and emphasizing that correlation should be made from the original Huronian areas eastward towards Sudbury rather than conversely.

3) The hypothesis that there is no *major* unconformity in the rocks south of the Murray Fault; that only the Upper Mississagi Formation is represented in those rocks originally mapped as Mississagi Formation by Collins (1925); that the underlying rocks, the Sudbury Series of Coleman (1914) and Collins (1925), Sudbury Group of Robertson (1960; 1961c) and the Spragge Group of this report (and Robertson 1965a and b) can be correlated with part of the Lower Mississagi Formation (Nordic Formation of Roscoe 1957) and possibly part of the Middle Mississagi Formation. To correlate these rocks it is necessary to consider: the lateral variations in thickness and facies revealed by recent mapping in the Blind River-Elliot Lake-Spanish area (Robertson 1967); that volcanic rocks may occur locally near the base of the Huronian sequence; and that the metamorphism of the Spragge Group is post-Huronian in age and is a function of geographical and structural location and of the original rock composition, not of stratigraphic position.

SPRAGGE GROUP

The rocks of the Spragge Group are exposed mainly in a narrow strip bounded on the north by the Murray Fault and on the south by the waters of Lake Huron and the Serpent River. They are not exposed at the western limit of the map-area and the rocks found south of the Murray Fault at Algoma village are undoubtedly relatively unmetamorphosed Lower Huronian sedimentary rocks. From Chicora Island to just east of Pater Mine the main sequence consists of volcanic, pyroclastic, and minor sedimentary rocks, whereas to the south and east, these are overlain by pelitic and semipelitic schists and schistose quartzites. Diabase, intrusive into these volcanic and sedimentary rocks, was metamorphosed at the same time as they were and now outcrops as high ridges of epidiorite, amphibolite, or locally, hornblende schist. Inclusions of the metasediments and of the epidiorite are common in the Cutler batholith, particularly in the marginal phases. Lower grade schists and schistose quartzites are found on the north shore of John Island. More recent mapping (Robertson 1965b) has indicated that the metamorphic rocks on John Island pass laterally eastward into relatively unmetamorphosed rocks and pass southward up the stratigraphic sequence into quartzites, which are also relatively unmetamorphosed, and which have been correlated with the Upper Mississagi Formation (Collins 1925).

The more highly metamorphosed rocks were named Sudbury Series and were regarded as Archean by Coleman (1914) followed by Collins (1925). Collins (1925, p. 26) reported that it was impossible to define the unconformity separating the Sudbury Series and the Mississagi Formation as mapped by himself. In recent years regional mapping carried out by the writer (Robertson 1965a, b, and c; 1966) and the evidence of isotopic ages determined by several individuals and institutions (discussed earlier in this report) have indicated that the rocks of the

Sudbury Group (Sudbury Group, Robertson, is the same as Sudbury Series, Coleman 1914, and Collins 1925, Table 1) can be included in the Huronian.

As the rocks at Spragge are considerably removed from the type area of the Sudbury Series the writer suggests that they should be termed the Spragge Group. The type area for the Spragge Group is therefore the area of outcrop shown on the present map and the type section is at Pater Mine. The most complete study of these rocks at Pater copper mine has been made by various members of the staff of Rio Algom Mines Limited. The bulk of this work has been carried out by C. J. Knight, chief geologist to Rio Algom Mines (Pronto Division: Pater Mine) in 1960 and 1961 and subsequently graduate student at the University of Toronto. Company reports and university theses by Knight (1963; 1965; 1967) have been available to the author through the generosity of Mr. Knight and Rio Algom Mines Limited. Other graduate work was carried out in the Pater Mine area by R. M. Beger (1963) of the Michigan College of Mining and Technology.

The lowermost unit of the Spragge Group is about 1,250 feet thick and consists mainly of metavolcanics, pyroclastics, and minor metasediments. This unit, the Pater Volcanics, forms most of the north shore of Lake Huron and the Serpent River estuary from the vicinity of Chicora Island to just east of the Pater Mine at Spragge. Outcrops on a few islands south and west of Spragge also show rocks of this sequence. Collins noted the similarity of these rocks to the Thessalon Greenstone but these are shown as Keweenawan? on his map (Collins 1925, p. 76 and Map 1970).

The general sequence strikes slightly north of east and is truncated by the Murray Fault which strikes almost east-west in this area. Tops as determined by distribution of pillows, amygdules, graded bedding, and crossbedding are usually facing south. This south facing is also generally true for the overlying sedimentary unit but the simple picture is complicated by numerous small drag folds and the possibility of larger scale tight folds in these sedimentary rocks. A cleavage parallel to the bedding is superimposed on all but the most competent rocks. The latter, in areas of strong deformation, show boudinage structures.

Within the area mapped and drilled by Rio Algom Mines Limited (or predecessor companies including among others Pronto Uranium Mines Ltd., Pater Uranium Mines Ltd., Peach Uranium and Metal Mining Ltd., and Technical Mine Consultants), the sequence is as follows:

1) Metagreywacke 500 feet thick.

2) Schistose amygdaloidal lava (locally termed quartz-eye schist). Its thickness ranges from 0 to 100 feet.

3) Massive lavas with patches of schistose amygdaloidal lava and occasional pillowed sections particularly in the upper part. The massive lava unit reveals a maximum thickness of 600 feet, south of Spragge, but elsewhere is 200 to 400 feet thick.

4) To the south of the massive lava lies chloritic, garnetiferous, amphibolite schists with prominent shear zones. These shear zones show numerous thin quartz veins, small amounts of pyrrhotite-chalcopyrite-pyrite mineralization, and minor alteration. These rocks are believed to have been volcanic greywackes or possibly tuffs. At a number of localities stretched granitic, amphibolitic, and quartzitic pebbles were observed in these schists (see Photo 5); the original sediments in these places may have been conglomerates or possibly agglomerates. On Strong and the Fournier Islands these rocks have

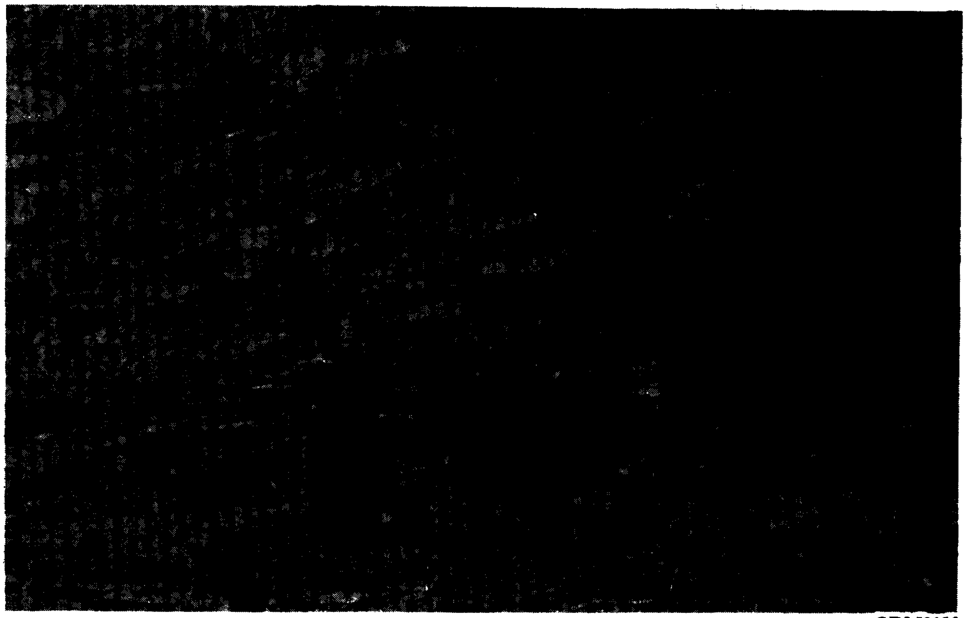

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Photo 5 — Spragge Group; stretched conglomerate. First rock cut on Canadian Pacific railway west of Denison siding, Spragge Township.

developed garnet and amphibole during metamorphism. This is also the case south of Pater Mine; but, farther west on the mainland south of Pronto East sub-division chlorite and hornblende are the metamorphic minerals developed.

5) Rare lenses of metaquartzite and feldspathic quartzite, and (or) sericite-biotite-quartz-feldspar schist may be interbedded with the volcanic sequence. These and related rock types form the sedimentary unit overlying the volcanic unit.

In thin section the metavolcanic greywackes are seen to consist of chlorite, sodic hornblende, albite, quartz, biotite, and epidote with minor amounts of magnetite, carbonate, sphene, sericite, and sulphide minerals. At lower metamorphic grades chlorite predominates over hornblende, and at higher metamorphic grades hornblende is the major mafic mineral. Typically in the chloritic rocks the plagioclase is calcic albite, with the albite in coarse angular grains showing twinning. Sorting is poor in the metavolcanic greywackes and occasional granitic fragments may be seen; the rock is regarded as a greywacke formed from the weathering of terrane rich in mafic volcanic rocks. Table 4 lists approximate compositions of metavolcanic greywackes from the Spragge Group at Pater Mine.

The metagreywackes (metavolcanic greywackes) lying near the southern limit of the volcanic belt (i.e. just south of Pater Mine buildings) are at a higher grade of metamorphism than the rocks examined for Table 4, as evidenced by more calcic plagioclase and almandine garnet. In these rocks the mineral assemblage is hornblende - plagiolase(An_{30}) - almandine - epidote - quartz - biotite; chlorite and carbonate have developed as the result of retrograde metamorphism.

Table 4 APPROXIMATE COMPOSITION OF METAGREYWACKE FORMING NORTHERN PART OF SPRAGGE GROUP METAVOLCANICS AT PATER MINE; AFTER C. J. KNIGHT (1965, P. 78).

SAMPLE NUMBER	MINERALOGICAL COMPOSITION IN PERCENT															
	HBD	PLAG[1]	QTZ	SER	CHL	BIO	EP	MAG	LEUC	PY	PYRR	CP	CARB	SPH	AP	ZR
PS-11C	20	55	M	...	M	22	2	M	...	...	...	...	M	...	...	...
PS-12C	6	50	6	m	6	30	1	M	...	...	...	...	M	m	...	...
PS-13C	...	50	4	M	35	M	...	2	M	...	...	...	4	...	...	...
PR-10-1C	2	22	48	...	...	24	2	...	...	...	...	...	M	...	...	Tr
PR-12-4C	...	34	6	...	...	36	1	1	M	1	...	...	18	M	...	...
PR-12-23C	...	12	20	...	5	50	5	...	...	...	...	M	8	M	...	...
PR-16-1C	...	62	4	m	5	20	m	M	M	...	2	...	16	...	m	...
PR-16-2C	...	62	4	...	19	7	...	1	...	...	...	...	3	...	...	...
PR-16-4C	30	22	8	...	1	11	...	1	...	...	...	...	M	...	...	...
PR-16-7C	18	8	50	M	2	18	M	2	...	...	...	...	2	...	m	...

Hbd—Amphibole (Hornblende)
Plag–Plagioclase
Qtz–Quartz
Ser–Sericite
Leuc–Leucoxene
Chl–Chlorite
Bio–Biotite
Ep–Epidote or epidote group mineral
Mag–Magnetite
Py–Pyrite
Pyrr–Pyrrhotite
Cp–Chalcopyrite
Carb–Carbonate
Sph–Sphene
Ap–Apatite
Zr–Zircon

M–Minor
m–very minor

NOTES
[1]Plagioclase mostly albite or albite-oligoclase in composition.
...Not detected.

Table 5 APPROXIMATE COMPOSITION OF MAFIC METAVOLCANICS, SPRAGGE GROUP, SPRAGGE TOWNSHIP; COMPILED BY J. A. ROBERTSON, MODIFIED FROM BEGER (1963) AND KNIGHT (1963; 1965). VALUES IN PERCENTAGES.

ROCK TYPE:	MASSIVE METAVOLCANICS		FLOW BRECCIA	BRECCIA	AMYGDALOIDAL LAVA		
METAMORPHIC FACIES:	Amphi-bolite Facies	Chlorite Facies	(Sheared)	Chlorite Facies	Chlorite Facies	Amphibolite Facies	
	No. 1	No. 2	No. 3	No. 3	No. 4	No. 3	No. 2
Hornblende	72	58	12	2	4	1	4
Plagioclase	16	18	28	50	48	60	minor
Composition	Andesine	Albite-Oligocl.		Andesine	Albite	Albite	Andesine
Quartz	4	16	36	tr	14	15	35
Biotite	2	2	...	tr	18	2	38
Chlorite	tr	2	16	42	12	16	5
Epidote	2	tr	2	tr	tr	...	7
Sphene	1	tr	tr	1	tr	tr	...
Apatite	tr	...	tr	...	tr	tr	...
"Ores"	2	tr	tr	4	tr	tr	tr
Carbonate	tr	...	1	...	tr	...	4

Location of Samples:
No. 1 — 5 samples, 2,000 feet WSW of Pater shaft.
No. 2 — Pater Mine (2 samples of massive metavolcanics)
No. 3 — Sprague Church
No. 4 — ½ mile east of Pronto East subdivisions

NOTES
tr—detected less than 1%.
...—not detected.

Similar to the metavolcanic greywackes the amygdaloidal mafic lavas lie partly in the greenschist (chlorite) facies and partly in the epidote-amphibolite facies. The petrographic composition of selected samples is indicated in Table 5.

In the greenschist facies the mineral assemblage is quartz-albite-chlorite-biotite with traces of hornblende and epidote. In the epidote-amphibolite facies the mineral assemblage is hornblende-quartz-albite-biotite-epidote with traces of chlorite and carbonate. Sulphide minerals, magnetite, leucoxene, sphene, apatite, and zircon may occur as accessory minerals. In thin sections many of the "quartz-eyes" show a zoned structure with epidote and albite in the cores and quartz at the margins; this suggests zoned amygdules rather than quartz grains as the original material of the quartz-eyes. Knight (1965, p. 114) noted spherulitic to subspherulitic structures in some "eyes" and this has been confirmed by the writer. Knight also noted that there was no significant difference in bulk composition between spherulitic and non-spherulitic lavas and suggested that differences in mineralogy were due to variations in metamorphic history. The similarity of bulk composition of the metagreywackes described above and of the quartz-eye schists has been taken to indicate that the greywackes formed from weathered lavas.

The more massive metavolcanic lavas (number 3 in the Rio Algom sequence, page 44 also show changes in metamorphism from greenschist to the epidote-amphibolite facies. The mineral assemblage in the amphibolite facies is hornblende-andesine (partially altered to epidote)-quartz, with minor biotite and chlorite. In the greenschist facies chlorite becomes the predominant mafic mineral and the composition of the plagioclase is albite. The rare spots visible on the weathered surface of the rock are scattered amygdules of quartz and plagioclase, often with epidote and carbonate. Samples from the vicinity of Pater Mine show amphibole partly changed to chlorite; in these samples carbonate is abundant near fractures. This indicates retrograde metamorphism possibly associated with the ore-forming process.

Fragmented or disrupted amphibole layers occur at places within the number 3 volcanic sequence; these have been variously interpreted as flow breccia, post-consolidation breccias, and pillow lavas. It is probable that these three types all occur but that the original nature of the rock has been obscured by shearing and metamorphism. The mineralogy of these fragmented rocks (flow breccia and breccia in Table 5) is consistent with that of the adjacent unfragmented rocks (not represented in the table) except that chlorite and carbonate are developed to a greater extent in the margins of the fragments and in the intervening material.

The uppermost sedimentary unit of the Spragge Group may be up to 2,000 feet thick between the volcanic unit and the Cutler batholith. However, within the present map-area it is not possible to make reliable thickness estimates. Investigations during mapping at the east end of the Cutler batholith (Robertson

Table 6 APPROXIMATE COMPOSITION OF THE METASEDIMENTS OF THE SPRAGGE GROUP, SPRAGGE AND LONG TOWNSHIPS, VALUES IN PERCENTAGES (COMPILED FROM KNIGHT 1963; 1965)

MINERALS PRESENT	SAMPLES*							
	1	2	3	4	5	6	7	8
Plagioclase						...	58	27
Composition	4	8	8	50	tr			
(percent An)	25-40	25-40	5	30	30	...	8	5
Potassic feldspar	...	...	...	...	...	8	...	...
Quartz	80	36	66	10	92	88	14	17
Muscovite	3	32	15	12	...	3	...	...
Chlorite	8	17	tr	15	1	1	23	15
Biotite	1	tr	9	6	5	...	4	22
Epidote	tr	...	tr	tr	tr	tr	1	tr
Magnetite	tr	tr	...	3	tr	...	...	1
Leucoxene	...	...	tr	2	...	tr	tr	3
Pyrite	tr	tr	...	...	...	...	tr	...
Chalcopyrite	tr	tr	...	tr	...	...	...	...
Carbonate	...	...	...	...	...	tr	tr	20
Apatite	tr	tr	...	...	tr	tr	tr	...
Zircon	tr	tr	...	...	tr	tr	tr	...
Garnet	tr	tr	...	...	tr	...	...	...
Staurolite	...	6	...	...	...	...	...	...

*DESCRIPTION AND LOCATION
1–Quartzite, average of 3 analyses; shore south of metavolcanics.
2–Sericite schist, average of 4 analyses; shore south of metavolcanics.
3–Quartzite, average of 2 analyses; interbedded with metavolcanics and greywacke.
4–Sericite schist, 1 analysis; interbedded with metavolcanics and greywacke.
5–Quartzite, average of 3 analyses; interbedded with quartz-eye schist.
6–Quartzite, average of 3 analyses; interbedded with metavolcanics and greywacke, west end of Spragge Group.
7–Metaconglomerate, average of 3 analyses; location unknown.
8–Metaconglomerate, 1 analysis; location unknown.

1965b) have shown that the batholith was intruded after the sedimentary rocks had been folded and metamorphosed. Many inclusions, particularly of the more resistant materials and of the sill-like units of diabase, later metamorphosed, define the structures prior to the intrusion of the granite.

The metasediments are an intimate mixture of quartzites, feldspathic quartzites, and biotite-sericite-feldspar-quartz schists. In areas of higher metamorphism the schists may have numerous garnet and (or) staurolite crystals, the latter frequently show twinning and their form may be recognized even where the staurolite has itself been partly or totally altered. Table 6 lists approximate compositions of metasedimentary rocks of the Spragge Group from Spragge and Long Townships; both the metasediments interbedded with the metavolcanics and the metasediments overlying the metavolcanic sequence are included.

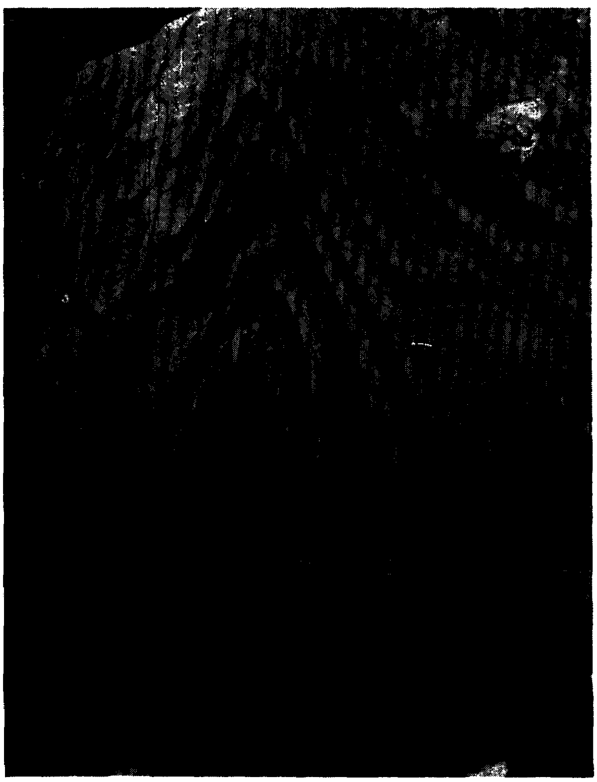

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Photo 6 – Spragge Group; isoclinally-folded staurolite schist, note cleavage, minor drags, reversed graded bedding. East end Nobles Island, Serpent Harbour, Spragge Township.

Drill cores indicate that, in the vicinity of the Pater Mine, the garnet isograd lies just south of the boundary between the metasedimentary and the metavolcanic units. The islands in Serpent Harbour lie to the south of the staurolite isograd. Graded staurolite schists are well-exposed on Nobles Island (see Photo 6).

A crude streaking in the quartzitic member, as exposed in the lower metamorphic grade sector at the western limit of outcrop of the Spragge Group near Chicora Island, is suggestive of crossbedding; using this crossbedding as evidence, tops are generally considered to face south in the quartzitic member; these determinations are consistent with top determinations in other parts of the Spragge Group using grain gradation and pillow structures as criteria. The quartzite beds are grey in colour and are generally a few inches to a few feet in thickness. Fresh surfaces are silvery due to sericite (finely divided muscovite) developed on cleavage surfaces. Cleavage and sericite are both more strongly developed at the tops of the beds.

The schists of the metasediments may be sericite-feldspar-quartz schists ("silver" schists), uniform in character; or well-bedded quartzitic silver schists; or quartzitic silver schist grading to sericite-biotite-feldspar-quartz schist with or without cordierite, staurolite, and (or) almandine garnet (see Table 6). In some schists reversed graded bedding (grain gradation) may be well-developed (see Photos 6 and 7) and top determinations, away from drag folds, are consistent and reliable; typically, tops face south in the schists. In the schists showing grain gradation original bedding ranges from a fraction of an inch to a few inches in thickness.

ODM8192

Photo 7 – Cutler Granite; slightly foliated granite with inclusions of graded mica schist and epidiorite, cut by zoned pegmatite. Cutler batholith, I.R. No. 7, Whalesback Channel.

The original rocks, most types with graded bedding, were massive quartzite, quartzites, semipelitic rocks, and varied greywackes and shales (see Table 6). These rock types are characteristic of the rocks of the Middle Mississagi Formation and adjacent parts of the Lower and Upper Mississagi Formations as mapped within the map-area north of the Murray Fault, and as found south of the Murray Fault west of Algoma village (Robertson 1964) and east of the Cutler batholith (Robertson 1965a, b, and c).

In correlating the Spragge Group with the Mississagi Formations two problems arise; the first is that to the east, west, and south of the Cutler batholith the crucial areas are covered by water with only a few rocky islands available for investigation; and the second is that within the Blind River-Elliot Lake district no volcanic rocks are found in "undoubted" Huronian rocks.

However, in the area around Cutler and the Spanish River estuary, where open water is at a maximum, almost invariably the underlying rock can be correlated with the most argillaceous sections of the Mississagi sequence, the upper Middle Mississagi and upper Lower Mississagi or the Pecors and Nordic argillites of the Blind River-Elliot Lake sequence, or the lower Mississagi and the McKim Greywacke of the area to the east of Spanish (see Table 1). There is insufficient evidence to justify correlating the conglomeratic zone separating the volcanic and sedimentary sequences of the Spragge Group with the Middle Mississagi Conglomerate of the Blind River-Elliot Lake area or the Ramsay Lake Conglomerate of the Spanish River area, although the possibility cannot be ruled out.

MAFIC INTRUSIONS
(Epidiorite Believed Equivalent to Nipissing Diabase)

Diabase was intruded as sill-like sheets into the rocks of the Spragge Group prior to the regional tectonic disturbances responsible for the metamorphism (the grades of this metamorphism were described in the section on the "Spragge Group"). These sheets vary in thickness from a few inches to over 1,000 feet; the thin bodies are local in extent but the large, thick sills can be traced for several miles. The metadiabase, which was termed epidiorite by early workers, consists mainly of hornblende and plagioclase with varying amounts of epidote, quartz, and biotite. Locally, and particularly in marginal zones in the metadiabase, garnet has developed. Garnet has been observed in many epidiorite (metadiabase) inclusions in the western half of the Cutler batholith (on the Serpent River Indian Reserve). However, garnet has not been commonly observed in inclusions in the extreme western or southern marginal zones of the batholith.

The distribution pattern of garnet in epidiorite, and garnet and staurolite in pelitic and semipelitic schists, and the extent of recrystallization of feldspathic quartzites, suggest that the local node of metamorphism lay somewhat north of the axis of the Cutler batholith (for detailed discussion of nodes of metamorphism see Card 1964). Cutting relationships between the granite and the metamorphism was well advanced before the granite and pegmatite were intruded to the level now exposed.

Outside the Cutler batholith the larger sheet-like bodies of metadiabase or epidiorite form high ridges separated by valleys eroded over the schists. This valley and ridge topography is well-developed near the Serpent River at the eastern limit of the map-area. The metadiabase is generally massive and in places relict diabasic texture can be observed. Elsewhere, and particularly in the trains of inclusions within the Cutler batholith, a foliation has been developed. This foliation is usually a schistosity parallel to that developed in the schists but locally there may be a metamorphic segregation of the mafic and felsic minerals (see Photo 8). Rarely the amphibole crystals show a marked lineation. At the east end of the Cutler batholith (Robertson 1965b) it was shown that there was a parallelism between this lineation, the plunge of minor drag folds in the metasedimentary rocks, and the plunge of the mappable fold structures. Detailed and time-consuming work would be needed to systematize these structural elements in the present map-area. Several graduate students at various universities, including Syracuse University, Syracuse, New York, and the University of Western Ontario, London, Ontario, have been making investigations based on these observations and it is hoped that further clarification of the structural and metamorphic history of the area will result from their studies.

Within the outcrop area of the volcanic unit of the Spragge Group there are bodies of amphibolite or epidiorite which may represent metamorphosed intruded diabase. However, as massive basaltic lavas would have similar composition to the

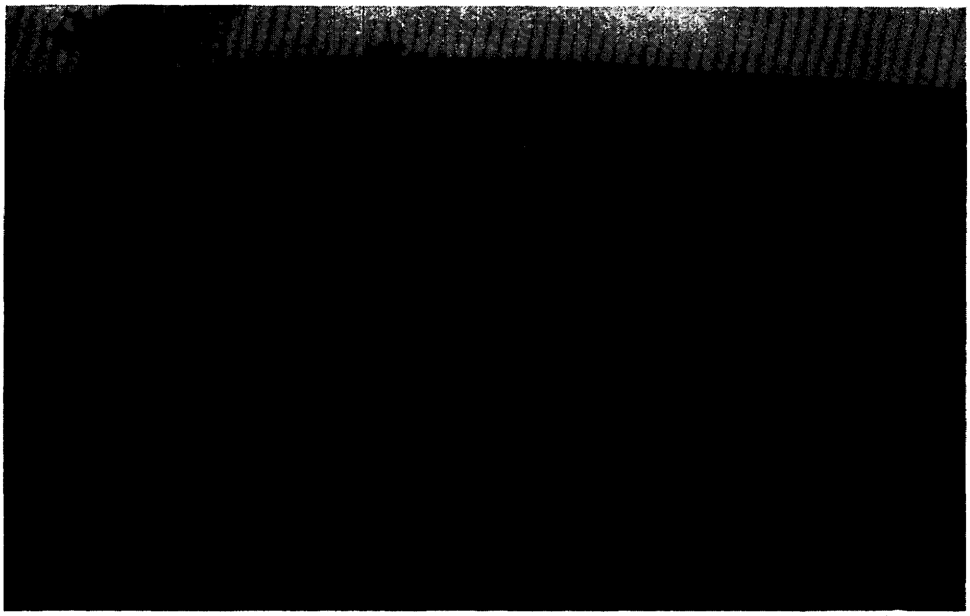

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Photo 8 – Epidiorite; gneissic epidiorite (metadiabase) associated with Spragge Group. Outcrop north of the mouth of the Serpent River, south of Denison siding, Spragge Township.

diabase and would develop similar mineralogy and texture under the metamorphic conditions envisaged for this area, there is a practical problem involved in separating rocks originally intrusive from those originally extrusive. In field study, both company and government personnel considered that the bulk of the amphibolite in this area showed gradational boundaries to either pillowed, brecciated, or amygdaloidal zones and could therefore be regarded as extrusive in origin.

Some of the more amphibolitic zones known to occur in the belt mapped by Knight (1963; 1965) and named by him volcanic metagreywacke, may represent small lenses of basalt intercalated with the sedimentary and pyroclastic rocks. South of Spragge village, Beger (1963) mapped much of the chloritic amphibolite as volcanic rock. This difference in mapping stresses the occurrence of amphibole as an indicator of volcanic rock and restricts the sedimentary origin to only those rocks showing evidence of bedding; these controversial rocks by their physical nature have tended to shear either during the original metamorphism or during subsequent events and are now represented by the more chloritic schists. This latter interpretation (Beger's) is perhaps more consistent with the development of numerous lenses of schistose amygdaloidal lava in the metagreywacke unit east of Pronto East subdivision.

The metadiabase bodies show changes in composition and texture (see Table 7); both margins tend to be mafic and fine- to medium-grained (coarser if garnet is developed) whereas the cores are coarse-grained and close to diorite in composition, with occasional quartz segregations. Traces of sulphide and carbonate minerals may be observed. These bodies are believed to be the metamorphic equivalent of the Nipissing diabase and gabbro-diorite bodies found in the relatively unmetamorphosed Huronian north of the Murray Fault. In the area east of Cutler (Robertson 1965a, b, and c) it was found that these metadiabasic bodies, as they were traced farther away from the zones of greatest metamorphism, more closely resembled the Nipissing diabase.

Table 7 MODAL ANALYSES OF "EPIDIORITE" ASSOCIATED WITH THE SPRAGGE GROUP ROCKS, SPRAGGE TOWNSHIP. SAMPLES COLLECTED BY J. A. ROBERTSON FROM ROCKS BELIEVED TO BE METADIABASE (NIPISSING DIABASE) (AFTER R. M. BEGER 1963, P. 29, SAMPLES 7 AND 8)

Location	1 Ridge north side of Hwy 17 at Spragge-Lewis boundary	2 Ridge north side of Hwy 17 at former acid plant. I.R.7 Cutler
Hornblende	67.87	77.31
Plagioclase (andesine)	28.34	18.70
Quartz	2.19	1.18
Biotite	0.23	...
Chlorite	...	...
Epidote	...	...
Sphene	0.17	0.28
Apatite	0.50	0.53
'Ores'	0.68	2.00
Carbonate	...	...
Total	99.99	100.00

CUTLER GRANITE

The Cutler batholith forms the rugged area lying between the Serpent River and the Whalesback Channel of Lake Huron between the mouth of the Serpent estuary and Aird Bay. About two-thirds of this batholith lies within the present map-area to the south of Spragge Township. The total surface of granitic outcrop is rather less than 40 square miles (the normally accepted definition of a batholith) but the term has been entrenched in the literature and will be retained here. As indicated (in "Area Containing Huronian (?) Rocks" section), at the time the field work was undertaken it was thought that the age of the Cutler batholith had not been established beyond a reasonable doubt. But owing to age-dating and more recent mapping Wetherill *et al.* (1960), Van Schmus *et al.* (1963), Van Schmus (1964; 1965), and Robertson (1965a) the post-Huronian age of the granite has been confirmed.

Numerous inclusions of metamorphosed sediments and of epidiorites similar to those found in the Spragge Group and the associated metamorphosed Nipissing diabase are present throughout the batholith, particularly in the marginal areas (see Photo 7). These inclusions have generally uniform strike and dip and show little indication of disturbance by the granite which has been intruded along the bedding and jointing of the older rocks. Where sedimentary inclusions are particularly abundant valleys have developed; these valleys contribute to a rough topography within the batholith and to a fiord-type of shoreline, with finger-like headlands and elongate islands, at the western limit of the batholith. The trains of epidiorite inclusions, with their distinctive lithology, can be used to map the pre-granite structures; this possibility was first recognized in the Taschereau Bay area of I.R. No. 7, (Robertson 1961c; and Map 2186, back pocket) but was most effectively used in the eastern part of the batholith (Robertson 1965b).

In addition to the structural properties of the inclusions the granite has a foliation, the trend of which is congruent with that of the inclusions; this foliation is possibly partly primary but mainly of metamorphic origin. Pegmatite is a characteristic feature of the batholith. The pegmatite is largely quartz, microcline, and muscovite, but plagioclase, garnet, pyrite, and traces of apatite, and molybdenite have also been observed. Some pegmatite bodies have no sharp boundary with the country rock and large feldspar porphyroblasts (*dents de cheval*) may be found in adjacent rocks; whereas other pegmatite bodies, particularly in the marginal zone of the batholith and in the Spragge Group country rocks, have sharp contacts and are obviously intrusive. Zoning of the pegmatites is common; feldspar, feldspar-muscovite (with the muscovite sometimes containing chromium) and quartz being the common sequence from margin to core. Some pegmatite bodies show development of a foliation parallel to that of the granite although others post-date the foliation. Smaller, less persistent bodies of white-weathering pegmatite consisting of quartz, albite, muscovite, and apatite are found in many rocks. These albitic pegmatite dikes are folded and foliated with the sedimentary rocks.

The rocks of the Cutler batholith are mainly grey to pink, two-mica granites; at a distance the granite looks white. The beauty of the Whalesback Channel owes much to the scattered tree-covered islands formed by the granite. Throughout the batholith the grey granite predominates over pink and porphyritic varieties are not found. Samples selected from the batholith have a fairly uniform mineralogical composition consisting of: 35 to 40 percent quartz; 18 to 30 percent sodic plagioclase; 15 to 20 percent microcline; 4 to 9 percent biotite; and 2 to 8 percent muscovite. In thin section the following accessory minerals were identified: zircon (malacon), apatite, magnetite, hematite, sphene, allanite, monazite, and sulphide minerals.

Collins (1925, p. 88) and others remarked on the presence of radioactive minerals among the accessory minerals of the Cutler Granite (Killarney Granite). The core of the batholith is marked by a zone of radioactive anomalies (O.D.M. 1954e); these anomalies are probably the result of a mass effect influenced by the potassium content of the rocks. In hand specimens the presence of fresh micas, especially muscovite, and the high proportion of quartz serve to distinguish the Cutler Granite from both the Algoman granites of the North Shore district and from those granitic bodies between Espanola and Sudbury for which a post-Huronian age has been postulated (Collins 1925; Robertson 1960).

The high quartz content, the two micas, the abundance of simple pegmatite, and the quiescent intrusion along the structural weaknesses of the metasediments, may be taken as evidence that the Cutler Granite was formed at no great depth below the present surface by the plutonic metamorphosis and regeneration of a sequence of semipelitic and quartzose Huronian(?) sedimentary rocks. In many places away from water-worn surfaces it becomes very difficult to distinguish strongly altered sedimentary material from granite, and contact relationships may be blurred, suggesting extensive metasomatism.

Thin section studies indicate that there is little variation in the Cutler Granite (Robertson 1960). The pinker phases tend to be higher in hematite and biotite than the grey phases.

The quartz grains are elongate and are strongly strained, and show interlocking boundaries and biaxial interference figures. Inclusions of biotite, plagioclase, microcline, and the accessory minerals are common in the quartz grains. Trains of fluid and dust inclusions are also present but the fine hematitic dust characteristic of the Algoman red-phase granites (see "Algoman" section) is generally absent. Quartz corrodes adjacent microcline and plagioclase.

The microcline is subeuhedral and generally fresh and unaltered. Perthitic intergrowths with sodic plagioclase parallel to the cleavage in the microcline are common. Many inclusions of euhedral plagioclase are present; other inclusions found in the microcline grains are quartz, biotite, and the accessory minerals. The plagioclase is oligoclase showing normal zoning but some larger crystals show oscillatory zoning. The cores of the plagioclase grains are altered to sericite and minor clinozoisite. The microcline and plagioclase grains show straining, bending of the twinning, and gaping of the cleavages. Marginal areas of some of the plagioclase grains show myrmekitic intergrowths with quartz.

Biotite is the dominant ferromagnesian mineral in all samples and the orientation of the flakes defines the foliation of the rock. Zircon and allanite with pleochroic haloes are common inclusions in the biotite grains. Muscovite may be interleaved with the biotite. Alteration to penninite (pennine) is seen only at the margins of biotite grains and along some cleavages. The biotite shows little sign of cataclastic deformation.

Muscovite occurs as large warped plates; similar to the biotite grains the plates are oriented parallel to the foliation. The muscovite has inclusions of biotite.

Rare flakes of primary chlorite are found in the Cutler Granite. The accessory minerals observed in thin-section are similar to those found in the Algoman granites but there is more magnetite; the radioactive minerals, zircon, monazite, and allanite are more frequent. In a heavy mineral concentrate fluorite and epidote were identified in addition to the minerals identified in thin section (Robertson 1960).

While a graduate student, the writer made a zircon concentrate from the Cutler Granite for comparison with zircons from other granitic rocks in the district. The zircons[1] were identified (on the basis of refractive index and birefringence) as slightly metamict malacon of simple crystallography, but high elongation, and in these properties they showed important differences from the zircons of the red, grey, and hybrid phases of the Algoman granites. A further statistical study of length-breadth ratios on lines pioneered by Poldervaart (1956) and Larsen and Poldervaart (1957) indicated that the zircons of the Cutler batholith were self-nucleated (that is, magmatic in origin) and that their growth trend was significantly different to the growth trend of zircons from the Algoman granite bodies with which earlier writers had suggested the Cutler Granite should be correlated (Robertson 1960, p. 309-322, Table 16 and Figure 18).

Table 3 lists the chemical analyses of samples collected by the writer from the Cutler Granite. Trace element studies were also carried out (Robertson 1960) but neither major elements nor trace elements had sufficiently diagnostic properties to confirm a primary magmatic source but indicate the possibility of a metamorphic origin.

The Cutler Granite is therefore a post-Huronian granite, possibly formed as the result of transformation of Huronian(?) sedimentary rocks and intruded into metamorphosed Huronian(?) and intrusive post-Huronian mafic rocks shortly after the metamorphism of these rocks. The batholith itself was subjected to a tectonic metamorphism possibly at about 1,300 to 1,400 million years ago at which time the micas were either formed or regenerated.

The relationship of the batholith to the copper deposit at Spragge and to the deposits west of Massey is not known. It has been suggested (Knight 1963) that fluids migrating from the batholith were able to rework and concentrate sulphide minerals that had originally been deposited in favourable structures from hydrothermal fluids derived from the Nipissing diabase. The proximity of the Murray Fault suggests that the forces related to movements on that fault had created the favourable structures.

KEWEENAWAN

As indicated in the section on the "Nipissing Diabase" the term Keweenawan was originally used for all post-Huronian igneous rocks in the North Shore area of Lake Huron. Recent age determination data and regional mapping indicate that the term should only be applied to the olivine diabase dikes. A northwest-striking swarm of olivine diabase dikes occurs in the vicinity of Sudbury. The number of

[1]The author published a paper on "Zircon correlation with special reference to the granite rocks of the North Shore of Lake Huron" in 1968, Ontario Dept. Mines, Misc. Paper 21. Ed.

these dikes diminishes westward and there are few in the Blind River-Elliot Lake area.

The weathered surface of these dikes is reddish-brown and friable but, where water-washed the rock is solid and black. There is a marked tendency to spheroidal weathering and the joint surfaces are deeply eroded. An excellent diabasic texture is visible. The chief minerals are labradorite, pigeonite, augite, magnesium-rich olivine partly altered to serpentine, and minor amounts of biotite. The chief accessory mineral is magnetite although apatite and zircon were observed, particularly in the biotite.

No strong alteration effects related to the olivine diabase were observed in the Cutler batholith. At one locality Van Schmus (1965, p. 767) noted that no biotite remained within 8 metres of the diabase-granite contact. Biotite 8 metres within the granite gave an age identical (within experimental error) to that obtained on biotite in the olivine diabase. Van Schmus (1965, p. 768) gives 1,225 plus or minus 25 million years as the age of the Keweenawan olivine diabase. In addition to the alteration effects noted by Van Schmus in the Cutler Granite, alteration has been observed in the mafic rocks of the Spragge Group within a few feet of supposed olivine diabase dikes at two places, south of Spragge station and southeast of Pronto East subdivision. In the field this alteration is seen as a development of a light green chlorite at the expense of the amphibole or the dark green to black chlorite normally present. To the writer's knowledge no analytical work has been done on this chloritic alteration.

Few Keweenawan dikes of mappable dimensions occur within the map-area; the largest crosses Nobles Island in Serpent Harbour and can be traced southeastward across the Cutler batholith and Mulock and Parsons Islands in the Whalesback Channel. In 1965 the dike was further traced southeast across the relatively unmetamorphosed Huronian rocks of Aird and associated islands (Robertson 1965b). There was insufficient exposure to determine the relationship of this dike to the supposed westward extension of the Espanola Fault which passes along the Whalesback Channel. The dike was also identified in Spragge Township north of Nobles Island but was apparently terminated against the Murray Fault (see Map 2186, back pocket). A second narrow dike was traced across the headlands and islands at the west end of the Serpent River Indian Reserve (I.R. No. 7); this may continue to the Murray Fault in the vicinity of the Pronto siding. Detailed mapping by Knight and associates (Knight 1965) indicated that a number of thin northwest-striking dikes (probably olivine diabase) cut the Sudbury Group rocks (Spragge Group in this report) between Pater Mine and the Pronto East subdivision. None of these dikes has been traced beyond the Murray Fault.

The two larger dikes mentioned in the previous paragraph are associated with prominent magnetic anomalies (O.D.M. 1954b). Sands in the vicinity of the large dike on the north shore of the Whalesback Channel have a high proportion of magnetite left as a residue from the weathering of the olivine diabase. Both anomalies can be matched in shape, intensity, and strike with anomalies on the north side of the Murray Fault in Spragge Township. These anomalies are displaced approximately 6,000 feet north side east. In Spragge Township no olivine diabase has been identified at surface north of the Murray Fault. These observations have been interpreted by the writer as meaning that (1) movements on the Murray Fault subsequent to the intrusion of the olivine diabase resulted in a net horizontal component of movement of 6,000 feet, north side east and (2) that to the north of the fault the present erosion surface is too high to intersect the top of the dikes.

A thin northwest-striking olivine diabase dike was observed associated with a possible fault between McFadden Lake in northwest Long Township and Magog Lake in Mack Township (Robertson 1964, p. 45 and Map 2028). This dike may be the continuation of the dike mapped in the vicinity of Taschereau Bay (Map 2186, back pocket). A wider northwest-striking olivine diabase dike mapped in the Matinenda Lake area (Robertson 1963a, Map 2026) is probably the same dike as exposed on Nobles Island (Map 2186, back pocket). The regional magnetic maps (O.D.M.-G.S.C. 1963; 1964), as well as supplying evidence for the above correlation, indicate that to the southeast of the present map-area the Nobles Island diabase dike swings east-southeasterly and cuts through the Croker Island Complex; this dike is not exposed in that area (Card 1965a) and it continues eastward beneath the Paleozoic cover.

In addition to the olivine diabase dikes, which are Keweenawan in age, a number of thin, highly altered, biotite-carbonate-rich dikes, which have been termed lamprophyre, are present in the map-area. Because of their erosional susceptibility these lamprophyre dikes do not normally outcrop, but examples can be seen cutting Spragge Group schists and quartzites in the banks of the Serpent River at the east margin of the map-area. These lamprophyre dikes are best known from underground workings at Pronto and Pater Mines.

S. W. Holmes (formerly chief geologist at Pronto Mine) informed the writer (personal communication 1954) that alnöite dikes had been encountered and showed the writer samples similar to the alnöite found at a number of localities throughout the Blind River-Elliott Lake district (Robertson 1960 *et seq.*) The writer (1960 *et seq.*) had regarded these alnöitic lamprophyres as a femic (mafic) differentiate from the end stage fluids associated with the Nipissing diabase; this decision was made largely on the basis of what little was known of the distribution of the dikes. However, age dates by Van Schmus (1,530 million years) on a sample from Ironbridge (Van Schmus 1965, p. 768) and the Geological Survey of Canada (Lowden *et al.* 1963, p. 86-87) on a sample from Rangers Lake, Township 138 (1,395 plus or minus 85 million years) give ages much younger than those associated with the Nipissing diabase. Whether these ages are to be regarded as representing the primary crystallization of the biotite, which would require emplacement at approximately the same time as the Croker Island Complex (Card 1965), or whether they are to be regarded as a result of the reworking of biotite during the regional metamorphism, has not been established.

Knight (1965) briefly described dikes at Pater Mine. These are less than 2 feet wide and are extensively fractured and decomposed with patches of carbonate. One was found to be "dominantly carbonate and serpentine with talc apparently pseudomorphous after pyroxene and olivine with interstitial biotite" (Knight 1965, p. 148-149). In a second sample "the rounded carbonate patches contain small rosettes of phlogopite, the background contains biotite, phlogopite, and minor plagioclase. Clinopyroxene is relatively abundant in the groundmass, and talc is present in euhedral pseudomorphous aggregates evidently after olivine. Apatite is unusually abundant in relatively large grains" (Knight 1965, p. 149). As no melilite was identified the term alnöite cannot be used and the possibility that the rocks described by Knight are altered Nipissing or Keweenawan diabase cannot be excluded.

POST-PRECAMBRIAN

After the close of the Proterozoic, the area was eroded and reduced to a peneplane. In early Paleozoic time shelf-sea deposits, now preserved on Manitoulin Island to the south and in the Hudson Bay depression to the north, probably extended over the area. Exposures on various islands in the North Channel and Lake Huron suggest that the local northward limit of Paleozoic rocks lies not far south of John Island. Occasional slabs of flaggy, fossiliferous limestone are found on the beaches of Lake Huron (particularly to the west of Pronto East subdivision); it is assumed that these have been ice-rafted from the south, probably in recent times.

The region was exposed and eroded throughout the greater part of the post-Devonian time, with intermittent rejuvenation. The present topography was probably developed essentially between the Laramide revolution and the dawn of the Pleistocene.

During the Pleistocene Epoch the area was glaciated; the soil which had formed was removed. Outcrops were scoured and polished. Striae and chatter-marks indicate that the regional direction of ice-flow was S15°W. In the Serpent River valley and near Lake Huron the flow direction was closer to southwest. As the ice-sheet retreated, till, glaciofluvial sands, clays, gravels, and occasional large erratics were deposited within the area. This material occupies the low ground between the outcrops; generally it is partly concealed by Recent talus and swamp deposits. In addition to rock types found within the map-area there are large numbers of boulders derived from the Cobalt Group (Gowganda and Lorrain Formations). Porphyritic diabase, with large yellow plagioclase phenocrysts, and gneiss boulders are also common in the Pleistocene deposits.

Sand and gravel deposits are not common in the map-area; they are restricted to beach deposits along Lake Huron and to old lake deposits in the valley eroded along the Murray Fault. Clay soils are developed in flats adjacent to the Serpent River and this is the only part of the map-area suitable for cultivation. An abandoned farm east of the Pronto East subdivision comprised a few fields of grass. Varved clays were formerly visible in a pit by the main road to Pronto Mine just north of the Beaver Pond Fault. The stratified sand, gravel, and clay deposits represent material accumulated in post-glacial Lake Huron and (or) adjacent ice-dammed lakes.

Along the present shores of the North Channel of Lake Huron and of the Whalesback Channel, raised beaches, filled-in lagoons, and progressive bars, all characteristic of an emergent coast can be identified on the ground as well as from air-photographs. A conspicuous strand line can be traced from just north of Chicora Island to the old mill site at Spragge. This strand line was obviously controlled by the boundary between the volcanic and sedimentary members of the Spragge Group; the more massive volcanic rocks being more resistant to mechanical erosion.

There is sufficient sand and gravel within the map-area to meet current local needs.

STRUCTURAL GEOLOGY

In addition to the main post-Huronian disturbances of the area there is stratigraphic evidence to indicate earlier periods of tectonic disturbance; these may have taken place prior to and during Huronian time. Although it is possible to recognize locally small folds or faults as belonging to one of these earlier disturbances, observations are too limited to permit a guess at the causative regional forces. The discussion here is therefore limited to the post-Huronian structural elements.

The main structural feature of the map-area is the Murray Fault which cuts the southern limb of the Chiblow Anticline. The fracture pattern, infilled with diabase dikes (Nipissing and Nipissing(?) dikes), and the greater part of post-diabase fault system to the north of the Murray Fault are regarded as separate conjugate fracture systems formed by similar forces operating at different times; these forces are possibly related to the prolonged compression forming the regional fold pattern. The intensity of the fold and fracture pattern increases to the south and markedly so across the gap represented by the Murray Fault.

The relatively intense folding and the first metamorphism of the Spragge Group, in this area and to the east, belong to this period of compression. The primary schistosity of the rocks formed at this time, as did some of the drag folds. In places the epidiorite (metadiabase) can be seen cutting across the cleavage of the metasediments of the Spragge Group; but generally the epidioritic rocks themselves possess a cleavage or foliation. The schists generally show: a linear crenulation of the mica, defining the primary cleavage; numerous drag folds, the plunge of which is parallel to the crenulation of the micas; lineation of the hornblendes in the epidiorites which is also congruent. Boudinage of thinner epidiorite bodies is common. A second period of major deformation post-dating the formation of the diabase is postulated.

Thus both phases of the post-Huronian deformation, expressed largely as fracturing and faulting north of the Murray Fault, are represented by intermediate grade mechanical metamorphism to the south of the fault. The next major event was the intrusion of the Cutler Granite which was intruded along the structural weaknesses of the Spragge Group rocks. The invasion of the Cutler Granite was quiescent with little or no structural deformation, beyond dilational effects; but there are indications of minor thermal effects in the country rock. The Cutler batholith (and by implication, the country rock) was cataclastically deformed and a foliation developed essentially parallel to that of the earlier rocks and was possibly influenced by it. Some pegmatite bodies show a foliation and some do not.

Subsequent northwest fractures, some later filled with Keweenawan olivine diabase, post-date this third phase of regional metamorphism. To the east of the present map-area (Robertson 1965a, b, and c) north-striking faults are common.

The major movement, or at least the final lateral movement on the Murray Fault took place after the intrusion of the Keweenawan olivine diabase. Abraham (1953), later confirmed by the writer, mapped both S and Z drag folds in the sedimentary rocks north of the Murray Fault indicating that both right-hand and left-hand movements took place. The evidence of the olivine diabase dikes and the associated aeromagnetic anomalies suggests a net right-hand strike-slip of about 6,000 feet on the Murray Fault. Chlorite schist along the fault, and possibly some of that developed locally in the volcanic rocks found near Pater Mine, can be regarded as a retrograde (dislocation) metamorphism associated with the movements along the fault.

The Lake of the Mountains Fault, which passes through McGiverin Township, is known to post-date the Murray Fault (Robertson 1964). This is also true of the Webbwood Fault (Thomson 1961; Giblin and Leahy 1967b) and is probably true of the postulated major faults lying between these two faults (the Lake of the Mountain and the Webbwood Faults) and which are believed to control the main drainage of Esten, Proctor, and Deagle Townships.

CHIBLOW ANTICLINE

Only part of the Huronian sequence, as exposed on the south limb of the Chiblow Anticline, is found in the map-area; it is present as a narrow belt along the north side of the Murray Fault swinging northward along the western margin of the map-area. The downfaulted block of Huronian rocks northwest of Rossmere Lake in the northwest corner of McGiverin Township lies just north of the presumed axial zone of the anticline. Extrapolating the structure from adjacent areas and using the frequency of west-northwest striking dikes as a further guide, it is probable that the axial zone of the Chiblow Anticline strikes across north-central McGiverin Township reaching the Lake of the Mountains Fault system near the northeast end of McGiverin Lake. To the southeast of the Lake of the Mountains Fault system the axial zone probably crosses the southwest corner of Esten Township and the northeast corner of Spragge Township. Judging from the configuration of the Chiblow Anticline west of the present map-area and of the Quirke Syncline to the north of the map-area, the axis of the anticline plunges gently west (1° to 8°). (See Robertson 1964, Map 2032.)

Three possible modes of origin for the major fold pattern of the Blind River region have been suggested. These are:

Compaction folding over pre-existing Archean topography (D. S. Robertson and N. C. Steenland 1960).

A northwest-southeast right hand shear couple associated with north side east movement on the Murray Fault (Rice 1959).

A compression normal to the axial planes of the folds (Robertson 1960 *et seq.*)

The compaction hypothesis of Robertson and Steenland (1960) was developed prior to the intensive exploration of the district. Although it has been shown (Robertson 1967) that basement relief is of the order of several hundred feet it is insufficient to have caused the folding observed. Furthermore, it is now known (from mapping and drill hole data) that Huronian fold structures are transverse to the principal basement surface features. Locally compaction may have been significant but the regional structures were not formed by compaction.

Field evidence clearly shows that there was north side east movement on the Murray Fault. Many of the later faults (post-Huronian) were formed at this time and the existence of a right hand shear couple can be accepted. However, it is also clear that these forces (right hand shear couple) acted late in the tectonic history of the region and long after the major fold pattern had been established.

From a regional study of bedding plane lineations, small scale folds, drag folds, jointing, cleavage, faulting, and the distribution of fractures filled by the Nipissing-type diabase sills and dikes, the author (Robertson 1960 *et seq.*) has concluded that the regional fold pattern formed as a result of compression perpendicular to the axial planes of the folds. The regional compressive forces acted with varying intensity over a prolonged period of time. Evidence from the present area and that to the east (Robertson 1965a, b, and c) suggests that the intensity of the compression reached a maximum in the zone south of the Murray Fault.

MINOR FOLDS

Minor folds are common throughout the area, particularly in the belt of Huronian rocks adjacent to the Murray Fault and in the rocks of the Spragge Group. These minor folds have been formed in many different ways. The following discussion lists the different types of minor folds and suggests ways in which they may have formed:

1. Compaction folds related to the Huronian-Archean contact. The fold structures on the headland at the east end of Lauzon Lake may be due to Huronian sedimentary rocks draping around the west end of a basement ridge.
2. Minor folds and drag folds in the Huronian sequence congruent with the main Chiblow Anticline and formed by the same forces.
3. Drag folds formed in association with the various faults. Some of these faults may be part of the immediate post-Huronian structure but many are later and some, such as the Murray and Lake of the Mountains Faults, are much later. Adjacent to the Lake of the Mountains Fault, strikes of the Huronian beds curve towards the fault and confirm the northwest side northeast movement calculated from the displacement of marker beds and diabase dikes (Robertson 1964). Adjacent to the Murray Fault both S and Z drag folds with near vertical axes are found in the interbedded argillites and quartzites of the Gowganda Formation. Near-vertical lineations are found on bedding planes of the Gowganda, Mississagi, and Spragge rocks both north and south of the fault.

East of Spragge, Collins (1925, Map 1970) shows the post-Huronian diabase cutting across the Murray Fault but this was not confirmed by the present work. West of Blind River (Robertson 1960; 1963b) the pattern of diabase intrusions was controlled by fractures striking parallel to the Murray Fault.

This suggests that movement on the Murray Fault may have begun early in the tectonic history of the area. The fault is at least 200 miles long and has been traced along strike from Sudbury to Sault Ste. Marie (Collins 1935; Thomson 1961; Giblin and Leahy 1967b). Within this regional belt the strike of the fault is parallel, to subparallel, to the strike of the folding of the Huronian rocks. In many places (for example near the Pronto Mine) faults adjacent to the Murray Fault are thrust faults (the Pronto Thrust Fault and minor faults nearby). It is therefore probable that the early movement on the Murray Fault was from the south in response to the same forces which caused the regional fold pattern and the metamorphism of the Spragge Group. If the writer is correct in suggesting that the Murray Fault is a regional thrust fault occurring at the margin of a fold belt, as for example the Moine Thrust in Scotland (Phemister 1960) the fault may well flatten with depth and gradually assume a southerly dip rather than the near vertical (locally reversed) dip observed at surface. Underground workings at Pater Mine (as seen by the author) and dips calculated from drill holes (company records) suggest that in fact the fault is flattening to the south.

The S and Z drag folds observed, particularly in the Gowganda Formation north of the Murray Fault, to a lesser extent in the Spragge Group to the south of the Murray Fault, and including the fold structure apparently controlling the Pater orebody, are caused by late movements along the Murray Fault. These late movements were dominantly north side east and the total net slip was about one mile.

JOINTS

During the original field work, by both Abraham and the writer, no quantitative data on joints were collected. However, the following generalizations can be made.

1. In the sedimentary rocks there are systems of joints developed parallel to and perpendicular to the bedding. In the Spragge Group these joints have largely controlled the distribution of the intrusive Cutler Granite and pegmatite. In the more argillaceous rocks, joints are inclined at moderate angles to the bedding. These inclined joints may be so numerous as to constitute a strain slip cleavage. This pattern of jointing and cleavage confirms a north-south compression.

2. In diabase dikes and sills the best developed joints are perpendicular to and parallel to the walls and are probably cooling fractures. Those joints perpendicular to the walls often form a polygonal or hexagonal pattern. However, within the present map-area tectonic joints are commonly found in the diabase, indicating that the diabase was stressed after consolidation.

3. Joints and small-scale faults are well-developed, particularly in more competent rocks such as granite or quartzite, close to contacts with diabase or adjacent to faults.

4. The whole area is characterized by vertical or near-vertical joints and small-scale faults which often show as lineaments on air photographs. These fractures may be grouped by strikes as follows: a) slightly east of north, b) northeast, c) in an arc from west to west-northwest, and d) northwest. Although it is clear that the area has had a long and complicated structural history the dominant influence was a north-south compression.

FAULTS

Numerous faults enter or are entirely contained within the map-area. Faults were mapped largely on the basis of lineaments visible on the air photographs, together with evidence found in the field, such as, apparent displacement of outcrop, shearing and shattering of the adjacent rocks, or small-scale faults and drag folds in the adjacent rock. Normally, owing to the similarity of the rock types on opposite sides of a suspected fault, it is not possible to define the nature of the suspected fault; this is particularly true of the granitic terrane which forms the greater part of the map-area.

As indicated in previous sections of this report the structural history involves several periods of compression occurring over a long time interval. Throughout the greater part of the map-area it is not possible to date individual faults with any great precision (it is only possible to get a date for the Nipissing-type diabase) as neither the Cutler Granite nor the Keweenawan olivine diabase is present to provide a standard of reference.

The majority of faults within the map-area are steeply dipping. However, in the southern part of Spragge and Long Townships there are a number of westerly-striking shallow to intermediate dipping thrust faults (Figure 3 in section on "Pronto Mine"). These have been regarded by some workers as a footwall imbrication related to the Murray Fault.

The postulated near-vertical faults fall into the following groups on the basis of strike-direction: a) north, b) northeast, c) west to west-northwest, and d) northwest.

Thrust Faults

Thrust faults of shallow to intermediate dip have only been observed in the Huronian north of the Murray Fault. Two major faults have been observed at surface; these are the Spragge Creek Fault and the Pronto Thrust Fault. Many bedding plane slips and thrust faults with relatively minor movements were encountered in the underground workings at Pronto Mine; some of these displaced Nipissing diabase dikes but generally the relationship to the Nipissing diabase was unknown (Figures 3 and 4 in the section on "Pronto Mine").

Spragge Creek Fault

The Spragge Creek Fault is considered to be the edge of the outcrop of the Spragge-Long Lake-Lauzon Heights diabase body. Along Spragge Creek in the vicinity of the Long-Spragge township boundary the sequence of rocks from north to south is granite basement, regolith, Lower Mississagi arkose and minor uraniferous conglomerate, diabase, granite basement, regolith, Lower Mississagi arkose and the Pronto conglomerate bed, Pronto Thrust Fault, and basement granite.

In the Hastie Lake-McFadden Lake (Lauzon Heights) area bodies of granite and granite plus regolith are found in the Spragge-Long Lake-Lauzon Heights diabase body with Lower Mississagi arkose on both the footwall and the hanging wall; it is therefore probable that the diabase was intruded along the fault.

Diamond drilling was carried out by Pronto Uranium Mines Limited to test the conglomeratic horizon along Spragge Creek; those drill holes collared on the hanging wall of the diabase body, which dips south at an intermediate angle, passed through a normal sharp hanging wall contact. Thus the hanging wall contact had not localized later fault movement as had sill-like diabase bodies in the Quirke Syncline (Robertson 1961; 1962) and to the north of Iron Bridge (Robertson 1963b).

The diabase body can be traced: from the southeast corner of Spragge Township westward to the north of Spragge village where it is steeply dipping; swinging north along Spragge Creek to Long Lake where it has a moderate south dip; west to Hastie Lake where it again swings north with a decrease in dip; to McFadden Lake. It can also be traced farther west to the Lake of the Mountains Fault (see Robertson 1964, Map 2028). Northwest of the Lake of the Mountains Fault the diabase body forms the "Mountains" from which the lake takes its name and can be traced westward as a steeply south dipping, west-striking diabase sheet across Mack and Scarfe Townships (Robertson 1964, Map 2028). Throughout this length (at least 27 miles) the country rock on the southern side of the intrusion has been thrust up relative to that on the northern side.

Pronto Thrust Fault

The Pronto Thrust Fault has been traced on the surface from just east of the Spragge-Long township boundary westward along the south side of the gully south of the Pronto surface buildings, along the foot of the ridge on the south of the Pronto access road swinging south and cut off by a later fault at the Pronto townsite. The Pronto Thrust Fault seems to form the northern and western edge of the Algoman granite body south of, and adjacent to, the Pronto mine. Diamond drilling (see Figure 3 in the section on "Pronto Mine") indicates a uniform southward dip of about 40° for the fault plane. The fault surface is tight, with only slight indication of mylonitization. At an early stage in the uranium exploration it was thought that the granitic ridge south of Pronto Mine was an offshoot from the Cutler batholith and, on the basis of a hydrothermal theory of origin, a possible source for the ore (Joubin 1954). The relationships revealed in drilling and the identical lithology and petrology of the granitic rocks exposed in the ridge and the basement rocks intersected below the ore zone disproved this hypothesis. P. C. Masterman (formerly chief geologist at Pronto Mine) estimated "the vertical displacement in the order of 2,500 feet and a lateral movement exceeding 4,000 feet in the mine area" (Masterman 1960, p. 6).

The Pronto Thrust Fault cuts the Pronto orebody at depth and the intersection forms the southern boundary of the orebody (see cross-section, Figure 3, in section on "Pronto Mine" and structural map of Pronto orebody Figure 4, facing page 100).

The south side of the granite ridge is bounded by the Beaver Pond Fault, a steeply south-dipping normal fault (see Figure 3). At the surface the Beaver Pond Fault lies near the upper contact of the Upper Mississagi Formation. As diamond drilling to the south of the Beaver Pond Fault failed to reveal any Lower Mississagi Formation, and as the intersection of the Beaver Pond Fault and the Pronto Thrust Fault was not encountered underground, the relationships of the two faults are not fully known, but Pronto officials indicate that the Beaver Pond Fault cuts the Pronto Thrust Fault (Knight 1960, personal communication).

North-Striking Faults

North- to north-northeast-striking faults are poorly developed, but are rather more frequent in the map-area than elsewhere in the Blind River-Elliot Lake region. The strike is approximately at right angles to the Murray Fault and to the regional fold pattern. The faults recognized are generally small, and are terminated at both ends by faults of the other groups and probably represent minor adjustments caused by movements along the major faults. The faults identified with northerly trends are post-Nipissing diabase in age. Several north-striking faults in north-central Long Township are displaced by west-northwest striking, right-hand strike-slip faults.

Northeast-Striking Faults

Northeast-striking faults comprise those faults which are definitely oblique to the regional fold pattern. As with the north-striking faults those mapped are found throughout the map-area and are generally post-Nipissing diabase in age. Northeast faults were encountered underground at Pronto Mine (Masterman 1960). Both normal and reverse faults of intermediate to steep dip were encountered, particularly in the southwestern part of the mine, as the Pronto Thrust and Beaver Pond Faults were approached. In southwestern McGiverin Township and the adjacent parts of Long Township there are a series of northeast-striking right-hand strike-slip faults of post-Keweenawan age.

Two northeast-striking faults of interest occur in the southeast corner of Spragge Township. One defines the break in the ridge north of the Murray Fault used to take Highway 108 out of the valley and the second lies a short distance to the northwest of this. The first has no great displacement and nothing is known of its age relationships. The second has a considerable displacement but this may be only apparent as in this area there is a marked basement high (see "Bruce Group" section). The second fault is younger than the eastward extension of the Beaver Pond Fault but is cut off by the Murray Fault. Drag folding in Huronian beds, and the similar displacement of the intermediate- to steep-dipping Huronian rocks and the near vertical Beaver Pond Fault suggests that the movement on this fault was right-hand strike-slip.

Lake of the Mountains Fault

The most important of the northeast-striking faults is the Lake of the Mountains Fault which has been traced from Mississagi Bay on Lake Huron (in which vicinity it displaces the Murray Fault) to the present area (Robertson 1963b, Map 2012; 1964, Map 2028; and Map 2185, back pocket). The fault system swings eastward from McGiverin Lake to meet the valley containing Marshland and Trout Lakes. To the southwest of McGiverin Lake in Mack and Striker Townships the Lake of the Mountains Fault has a right-hand strike displacement of approximately three-quarters of a mile (Robertson 1964, Map 2028). Neither the subsidiary faults in McGiverin and Long Townships nor the fault system east of McGiverin Lake have any great displacement.

West- to West-Northwest-Striking Faults

The west- to west-northwest-striking faults are the most numerous and the best developed within the map-area. The Murray Fault is the most important of this group; within the map-area it defines the southeast arm of Lauzon Lake in the vicinity of Algoma village, the north shore of Lake Huron west of Chicora Island, and the general valley followed by Highway 17 in eastern Long and Spragge Townships.

The Beaver Pond Fault lies up to half a mile north of the Murray Fault and like the Murray Fault it can be traced across Long and Spragge Townships.

The next major grouping of west-striking faults lies in the northern half of Esten and northwestern McGiverin Townships. Of these west-striking faults the most significant is that forming the Marshland Lake-Grandeur Lake lineament which strikes slightly north of east (south of west) and forms the eastward continuation of the Lake of the Mountains Fault system. The other subparallel lineaments define the major drainage pattern of the area. The faults forming these lineaments post-date the Nipissing diabase intrusion but little is known about the actual movements of these faults, or of the relationship of these faults to the Lake of the Mountains Fault.

One west-northwest-striking fault in north-central Long Township is a right-hand strike-slip fault with movement of up to 700 feet; this fault post-dates the Nipissing diabase dikes and the local north-striking faults.

Faults of this group were not common in the workings at Pronto Mine (Masterman 1960). Those encountered in the mine were apparently normal faults with a steep southerly dip and displacements of up to 15 feet.

No west-striking faults were identified within the Cutler batholith.

Murray Fault

Within the map-area the Murray Fault can be traced eastward: through the southeasterly bay of Lauzon Lake near Algoma village; through a drift-filled valley to East Bay in Lake Huron; along the north shore of Lake Huron; swinging northward near Chicora Island; and thereafter following the low ground used as the route for Highway 17. In the western part of the map-area Collins (1925) identified the Beaver Pond Fault as the Murray Fault, and those rocks lying between his position for the Murray Fault and the Canadian Pacific Railway as Sudbury Series. Lawson (1929) pointed out the apparent eclipsing of the Gowganda Formation by the Sudbury Series in this area and suggested they were really the same unit. Rice (1940), with Collins' knowledge, re-identified the Murray Fault and the controversial rocks were named the Gowganda Formation. Rice's conclusions were independently confirmed by Abraham (1953; 1957) and the writer (Robertson 1956; 1960).

In road cuts and outcrops adjacent to Highway 17, between the east end of Spragge village and the Denison siding, the rocks of the Gowganda Formation near the Murray Fault are seen to be: strongly shattered (Photo 9); partly recrystallized; to have numerous small scale drag folds; and to show incipient boudinage of the more competent beds. Similar results are seen in the rocks of the

ODM8194

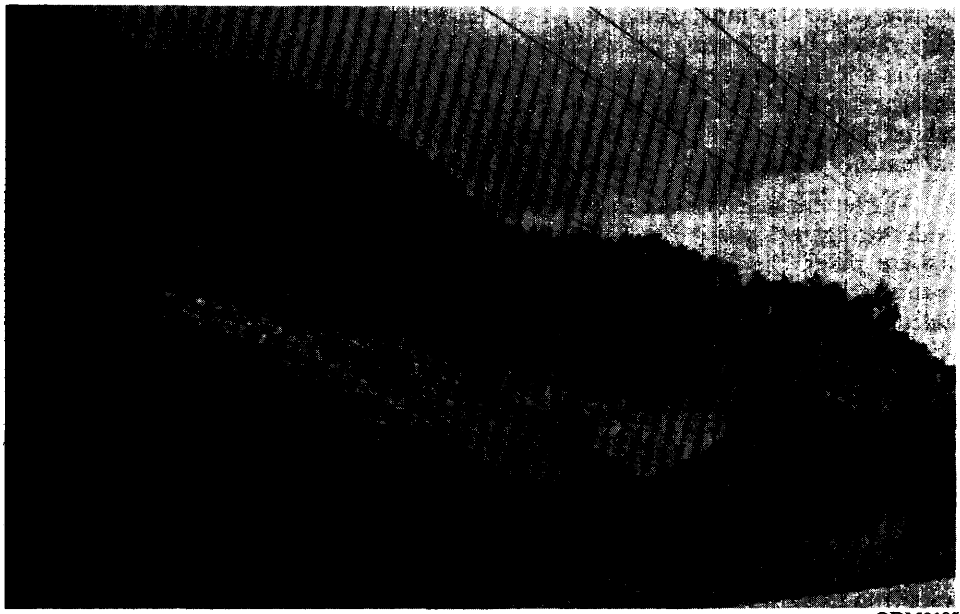
Figure 9 – Murray Fault; shattered interbedded quartzite and conglomeratic greywacke, Gowganda Formation. Highway 17 between Spragge village and Denison siding, east of Spragge Separate School, Spragge Township.

Spragge Group but these results are difficult to distinguish from the metamorphic effects normal in the Spragge Group rocks.

In the vicinity of Spragge separate school and in one road cut where the hydro-electric transmission line crosses Highway 17 the actual fault zone is marked by a zone, up to 80 feet wide, of highly sheared, chlorite schist (Photo 10). Thin sheet-like films of quartz and (or) calcite are scattered throughout the schist. There is no marked concentration of sulphide minerals in this area, but at least one exploration pit was found. Near the fault zone the drag folds in the Gowganda Formation show S- and Z-shapes with near vertical plunge. Lineations on bedding planes in the Spragge Group rocks also show vertical plunge and indicate south side up movement for the fault.

The Murray Fault has been traced westward from the present map-area to Iron Bridge (Robertson 1963b; 1964) and on to the vicinity of Sault Ste. Marie (Frarey 1961a and b; 1962). To the east it has been traced as far as Spanish (Robertson 1965a and b) and on to the vicinity of Sudbury (Thomson 1961; 1962; and Giblin and Leahy 1967b).

Both to the east and the west of the Blind River area the Murray Fault is one of a system of faults striking parallel to the Penokean fold-structures that are preserved in the Huronian rocks. These faults are generally believed to be reverse or thrust faults and to have formed in response to the same forces that initiated the Murray Fault. There is some evidence for believing that early movement on the Murray and parallel faults preceded the intrusion of the Nipissing diabase. However, it is clear from field studies in the present map-area and in the area to the east (Robertson 1965a and b) that large movements took place on the Murray



ODM8195

Photo 10 – Murray Fault; chlorite schist with quartz and calcite segregations marking fault zone. Highway 17 between Spragge and Denison siding, east of Spragge Separate School, Spragge Township. (Note sub-glacial pot hole.)

Fault subsequent to the two Penokean metamorphic events; these events were the intrusion of the Cutler batholith, and, in the writer's opinion, the intrusion of the Keweenawan olivine diabase (for the age relationship of these events see the beginning of "General Geology" section). The available evidence suggests that the net post-Keweenawan movement was about 6,000 feet north side east (see "Keweenawan" section).

Near Blind River the stratigraphic displacement was estimated at 6,000 feet (Robertson 1960; 1964) but within the present area, if the correlation of the Spragge Group with the Middle and Lower Mississagi Formations is correct, the stratigraphic displacement is much less. Collins (1925) estimated the net displacement at 6,000 feet, south side up. Rice (1940) however suggested that the net displacement was much greater and considered 15,000 feet as a more realistic figure.

Ginn (1960; 1961), on the basis of lineations, suggested that the movement in the Espanola area had a horizontal component of 6,000 feet, north side east, and a similar vertical component of 6,000 feet, south side up.

However, in the light of observations in the Aird Bay area (Robertson 1965b), where lineations of differing ages can be related to the fold pattern in the Spragge Group rocks rather than being related to the postulated movements on either the Murray or Espanola Faults, it is found that calculations based on lineations alone must be treated with caution.

In the region between Espanola and Sudbury (Thomson 1952; 1953; Card 1965b; Ginn 1965) there is no evidence that the olivine diabase dikes are displaced by late strike-slip movements on either the Murray Fault or the associated faults. This raises the following possibilities: (1) that the olivine diabase in the Spragge area is not the exact equivalent of that of the Espanola-Sudbury area; (2) that the Spragge area olivine diabase was intruded after the movement of the fault had ceased and that locally it was intruded into the fault zone; or (3) that late movements were restricted to this section of the fault.

At present, age data are insufficient to permit an analysis of possibility 1. Some evidence against possibility 2 includes the following information: two individual diabase dikes can be correlated across the fault zone on the basis of magnetic anomalies; this suggests fault movement rather than post fault intrusion. Indeterminate information was gathered during exploration drilling by Rio Algom Mines Limited in 1964 in the area east of the Pronto East subdivision; one drill hole penetrated the Murray Fault zone, and company officials tentatively identified a mafic rock from the fault zone as olivine diabase; however, with lack of surface exposure and limited drilling, it cannot be established whether this rock represents material intruded along the fault or a pre-existing diabase caught up in the fault zone. Possibility 3 is not favoured as an explanation as the strike slip components of the movement are similar in the Spragge and Espanola-Sudbury areas and it is unlikely that they took place at markedly different times.

From the foregoing it is clear that if the writer's contentions are correct (a) the latest movements on the Murray Fault in the present map-area post-date the olivine diabase dikes and (b) that both the olivine diabase dikes at Spragge and those of the Sudbury-Espanola area are of Keweenawan age, then the dikes at Spragge must have been intruded relatively early and the movements on the fault have taken place later than the intrusion but still early in the Keweenawan period.

Beaver Pond Fault

A second major west-striking fault lies a short distance to the north of the Murray Fault. Within the map-area it has been traced from the southeast bay of Lauzon Lake, near Algoma village, to the south shore of the northeast arm of Lauzon Lake, and along the valley containing the Beaver Pond south of the Pronto mine-site. It probably continues eastward to the Lewis-Spragge township boundary, defining first the south face of the diabase ridge north of the village of Spragge and then the northern boundary of the Gowganda Formation. On Pronto mine-plans and publications by company geologists (Holmes 1957) this fault has been termed the Beaver Pond Fault; this name is used in this report and on Map 2186 (back pocket).

The Beaver Pond Fault was recognized by Collins (1925) but was identified as the Murray Fault. The fault dips more steeply to the south than the Murray Fault (Figure 3, in "Pronto Mine" section) and is apparently a normal fault. At the surface the Beaver Pond Fault generally brings the Gowganda Formation against the Upper Mississagi Formation; exceptions to this are in western Long Township where Gowganda rocks form both the hanging wall and the footwall, and in the Beaver Pond vicinity where Upper Mississagi rocks form the hanging wall and the Algoman granite of the Pronto thrust block forms the footwall (Figure 3). As the Beaver Pond Fault was not positively identified in underground workings at Pronto

Mine the relationship of the Pronto Thrust Fault and the Beaver Pond Fault have not been definitely established. Diamond-drilling on the hanging wall side of the Beaver Pond Fault failed to find any faulted continuation of the Lower Mississagi ore-bearing conglomerate horizon. It is considered probable, that the Beaver Pond Fault cuts the Pronto Thrust Fault at depth.

Northwest-Striking Faults

Northwest-striking faults are found throughout the entire map-area including several possible faults in the Cutler batholith. Apart from those postulated in the Cutler batholith little is known of their age relationships; probably several different ages are represented by these faults. In McGiverin Township and northwest Long Township northeast-striking faults of the Lake of the Mountains system displace northwest-striking faults.

The major northwest-striking faults are the North Rossmere Fault; the South Rossmere Fault, which is displaced by the Lake of the Mountains Fault at McGiverin Lake; the Turtle Lake Fault, defining the lineament occupied by Turtle Lake, Black Creek, and Laderoute Lake; and a fault, adjacent to the Keweenawan olivine diabase at the east end of Intersect Lake, that enters three townships, Long, McGiverin, and Mack, and is cut by or terminated at, the Lake of the Mountain Fault. Few northwest-striking faults were encountered in the workings at Pronto Mine. Those shown on the structural map of the mine (Figure 4, facing page 100) are normal faults with an intermediate dip to either the northeast or the southwest.

Rossmere Faults

The Rossmere faults have been traced in southwest Township 161 (Robertson 1963a) and northwest McGiverin Township (Map 2185, back pocket). Northwest from Rossmere Lake these two faults border a structural outlier of Lower Huronian sediments. The Lower, Middle, and Upper Mississagi Formations are present in a syncline which plunges gently west. Within the syncline the Middle Mississagi Formation shows a marked reduction in thickness. It is believed that both faults are essentially normal faults enclosing a down-faulted block. The South Rossmere Fault displaces Nipissing diabase and there may be a left-hand strike-separation as well as the vertical movement. The vertical component of movement on each of the Rossmere faults is at least 750 feet (Map 2185, back pocket).

Turtle Lake Fault

From McGiverin Lake to east-central Spragge Township there is a pronounced zone of shearing which defines the valley containing Turtle Lake, Black Creek, and Laderoute Lake. Fault-structures and Nipissing diabase dikes could not be traced or correlated with certainty across this zone. There is some indication near McGiverin Lake of a north side east strike-slip movement. This is the sense of movement found on the majority of northwest-striking faults of the Blind River-Elliot Lake region and is in accord with north-south regional compression.

Summary

The faults in this area fall into the same strike direction groups as have been observed throughout the Blind River-Elliott Lake area (Robertson 1960 *et seq.*). The west to west-northwest and the northwest groups are the best developed, but late northeast-striking faults are better developed in this area than elsewhere in the district. The regional pattern of faults and of the fractures filled by the Nipissing diabase suggests that both faults and filled fractures consist of several series of conjugate fracture systems formed to accommodate a pulsating compression oriented north-northeast to south-southwest (Robertson 1960). However, within the present area the structural history is clearly more complex. At least the later movements on the Murray Fault involved dextral shear and some of the later faults may have been caused by the associated regional stresses. The Lake of the Mountains and associated northeast-striking faults are dextral strike-slip faults indicative of an east-west compression of unknown post-Keweenawan age.

FRACTURES FILLED BY NIPISSING DIABASE INTRUSIONS

The petrology and distribution of the Nipissing diabase intrusions have already been discussed under "Post-Huronian Mafic Intrusions".

Large differentiated sill-like gabbroic bodies in the northern, western, and southern parts of the map-area conform in a general way to the Chiblow Anticline. Towards the crest, however, they pinch off or change their attitudes becoming dikes. These bodies are associated with thrust faults and, as with similar bodies throughout the North Shore, are intruded into dilatant areas formed during the initial folding.

The diabase dikes may be either: 1) feeders or apophyses of the sills; or 2) later in age than the sills. Within the map-area both types are known to occur but in general the relationship is not known.

The dikes trend either west to west-northwest or northwest. A few dikes trend north or northeasterly; these northerly trending dikes are more common in this area than elsewhere in the Elliot Lake district. There is no apparent lithological difference between the dikes of differing trends. Cutting relations are normally obscure and when visible are conflicting; forked dikes have been seen. In the absence of detailed age determination studies it is concluded that the dikes were intruded at essentially the same time, from the same magma, into a well-developed set of conjugate fractures. The best developed of these fractures were parallel to the principal regional structures, the Quirke Syncline and the Chidlow Anticline, and sub-parallel to the Murray Fault; they were probably axial plane fractures which gaped on relaxation of the compressive forces. The northwest and northeast fractures would define conjugate shears, the acute angle between which indicates the regional direction of compression. Within the map-area the northwest direction of shear was developed at the expense of the northeast direction.

ECONOMIC GEOLOGY

The map-area has been intensively prospected particularly for gold, sulphide minerals (copper), and, in the period from 1953 to 1956, for uranium. Following the discovery of the copper deposits at Bruce Mines in 1846 prospecting in the area was concentrated on sulphide minerals and gold; most known sulphide and quartz vein occurrences have been trenched and pitted, probably in the 1920s.

In the post World War II period prospecting led to the discovery and development of the Pronto Mine. Following this discovery the entire Blind River-Elliot Lake district was subjected to intensive exploration. Large deposits of uranium and thorium were found in the Quirke Lake and the Nordic Lake areas of the Quirke Syncline but no further deposits were found in the present map-area, although detailed mapping and diamond drilling were carried out on the Huronian rocks of Long and Spragge Townships. During the exploration for uranium, a sulphide showing east of the Spragge railway station was drilled for assessment purposes and a potential copper orebody was discovered. Further drilling, followed by underground exploration, outlined approximately one million tons of potential ore grading 2 percent copper; but following the drop in the copper price at the end of the Korean War exploration was stopped.

The Pronto Uranium Mines Limited mill went into production in August, 1955, and production was maintained until April, 1960, when all companies in the Rio Tinto group were merged to form Rio Algom Mines Limited (see "Pronto Mine" section). Exploration carried out by Pronto personnel failed to find the faulted extension to the original Pronto orebody. At the time of the merger, the uranium reserves had been almost exhausted[1] and Pronto Uranium Mines had acquired the Pater property with a view to mining the copper deposit and milling it with the equipment installed at Pronto Mine. Following the merger, Rio Algom decided that the Pronto Division should operate the Pater Mine as a make-work project to help relieve unemployment in the Elliot Lake-Blind River area; this unemployment situation was caused by the cut-back in uranium production. The operation, mining copper on the Pater property, went into production January 2, 1961, and has been in production, providing a moderate profit, since then. Underground experience and exploration have established potential ore to a depth of at least 5,000 feet and the Pater Mine (in 1965) is being developed to allow extraction of this ore. The modification of the Pronto mill to treat copper ores, and the willingness of the company to undertake custom milling, led to a revival of interest in copper showings throughout the North Shore area. Some test shipments were made from deposits near Iron Bridge (Robertson 1963b, p. 53; 1964, p. 65) but up to 1966 no significant custom milling has been performed.

In addition to explorations completed in the Blind River-Elliot Lake district by various interests, Rio Algom Mines Limited carried out an extensive exploration program in the present map-area, on those rocks designated Spragge Group in this report. Old prospectors' pits were re-examined, the area was mapped in detail, and diamond drilling was carried out to test the various gossans revealed by the pitting

[1]Ore reserves are 300,000 tons of ore-grade material, Rio Algom Mines Limited stated in prospectus for series A shares, March, 1966.

and mapping. The gossan zones (as sulphide mineralization), pits, and drill holes are indicated on Map 2186, (back pocket). No sulphide-bearing zones of potential economic significance were discovered in the exploration. Neither were any traditional ore shoots found on the lateral extensions of the Pater shear zone.

To December 31, 1964 total production from the Pater Mine was 32,185,184 lb. of copper, valued at $10,239,705, and derived from 1,011,851 tons of ore.[1]

In addition to exploration activities in the southern part of Long and Spragge Townships, by various companies, surface mapping carried out in the vicinity of the Buckles showing in Township 149 (Robertson 1968, p. 19, 21-22) was extended southward to Esten Lake in Esten Township. Farther south a showing in central Esten Township, northwest of Christie Lake was trenched and drilled in 1956 by the Federal Kirkland Mining Company Limited.[2] The results of the investigation indicated reserves of 76,900 tons of 1.73 percent copper, over an average width of 8.04 feet in a zone 380 feet long and tested to a depth of 400 feet (Thomson *et al.* 1957, p. 91).

Of the industrial materials, the only production has been gravel from a few small pits located near Highway 17, and no appreciable reserves of sand and gravel, which can easily be obtained, have been found elsewhere in the district.

URANIUM

PRONTO MINE

History of Development

Although the history of the discovery and development of the Blind River-Elliot Lake deposits has been extensively chronicled, notably by Roberts (1955); Lang, Griffith, and Steacy (1962, p. 127 *et seq.*); the annual reports of mining companies; the Western Miner (1956); and the regular news items of the Northern Miner and technical periodicals, as well as of the national daily and periodical press; a generalized discussion of the developments, taken freely from the above references, follows.

In 1948, Karl Gunterman, a prospector associated with Aime Breton of Sault Ste. Marie, ran a geiger counter over rock and mineral samples in the mining recorder's office in Sault Ste. Marie. A piece of pyritic conglomerate labelled "Long" was sufficiently radioactive to arouse Gunterman's curiosity. Gunterman and Breton traced this sample to the east end of Lauzon Lake in Long Township where a series of test pits was found in a bed of pyritic conglomerate; these pits had presumably been dug by a prospector looking for gold or copper. The ground was

[1]Statistical files, Ontario Department of Mines.

[2]September 1958, Federal Kirkland was amalgamated with other companies into Cadamet Mines Limited; August, 1966, Cadamet was reorganized and the company's name changed to Terrex Mining Company Limited.

staked by these two men and efforts were made to interest geologists and mining companies in the claims. Although appreciable radioactivity was recorded at the surface, assayed samples apparently contained little uranium, although some thorium was present in the samples. Among the geologists who examined the property at this time was Franc R. Joubin. Joubin believed that the belt of Huronian rocks between Sault Ste. Marie, Sudbury, and Cobalt, already known for copper, nickel, cobalt, and silver should also contain uranium of hydrothermal origin.

In 1949 during the re-routing of Highway 17 just east of Algoma village, a German immigrant employed on the construction job discovered radioactive material at the old mining location "Location X, south of highway, township of Long." Six samples of this material assayed from 0.025 to 0.15 percent U_3O_8 (Lang *et al.* 1962, p. 128). Before the exact location, from which the samples had been taken, could be ascertained, the German was drowned. The available information was published by Lang (1952) in the first edition of "Canadian Deposits of Uranium and Thorium". This further discovery of uranium in Long Township rekindled Joubin's interest in the Breton property; the claims had lapsed and it was again open ground. With the backing of J. H. Hirshhorn, a block of 36 claims was staked and held in the name of Peach Uranium Syndicate (renamed Peach Uranium and Metal Mining Limited). Joubin again found himself confronted with the problem of high radioactivity on the surface but little uranium in the assays. Assays also revealed insufficient thorium to cause the observed radioactivity.

Joubin noted the similarity of the Long conglomerate to the famous gold-uranium-bearing quartz-pebble conglomerate (banket) of the Rand in South Africa and in March, 1953, he visited the United Kingdom to obtain background information on these rocks and the process of extraction (acid leaching). Joubin then theorized that the weathering of the Long conglomerate could lead to the formation of sulphuric acid which in turn could dissolve the uranium from the surface showings of the uraniferous conglomerate. Hirshhorn provided the capital for diamond drilling which was begun in April, 1953. It was stated (Lang *et al.* 1962, p. 129) that the first three holes gave values comparable to surface sampling but the subsequent holes indicated a substantial tonnage grading 0.13 percent U_3O_8 over a mineable width. The commercial possibilities of the deposit were now apparent.

Subsequent mining experience indicated that there was no zone of secondary enrichment down dip from the surface outcrops, and that both the thickness and the grade of the conglomerate in the vicinity of the discovery area, being near the margin of the orebody, were below the average for the mine as a whole (C. J. Knight, geologist, Rio Algom Mines Limited, Pronto Division, personal communication 1960).

In June 1953, Peach Uranium and Metal Mining Limited formed a subsidiary, Pronto Uranium Mines Limited, to develop and operate the original discovery. An extensive diamond drilling program was initiated using 300-foot centres (Abraham 1953) and within a year of the discovery, Pronto had blocked out sufficient ore to merit a 55-million dollar contract with Eldorado Mining and Refining Limited. The ore zone outlined was 3,500 feet long, with an average thickness of 7½ feet, and it was traced to a depth of about 1,000 feet; at that depth it apparently terminated against the Pronto Thrust Fault. The ore zone was bounded on the north by surface outcrop, to the east and west by facies change, and to the south by the Pronto Thrust Fault. Subsequent exploration failed to reveal either other ore zones along strike, or the faulted continuation of the orebody.

On May 16, 1954, a three-compartment shaft was collared and it was completed to a depth of 592 feet by December 1, 1954. Five levels were established and the mine laid out for slusher stopes and track haulage; details are given in papers by Eric Holt, in the Western Miner (1956) and in the C.I.M.M. (1957). At the same time as exploration and mine development were being carried out, the mill and the surface plant were under construction. The mill, rated at 1,000 tons per day, went into production on October 15, 1955. In 1957 and 1958 the shaft was deepened to allow development to the 7th level and the plant was expanded to the rate of 1,500 tons per day. Table 8 lists the published data on the production at Pronto Mine.

Table 8 | PRODUCTION DATA FOR PRONTO URANIUM MINE[1]

Year	Tons milled	Value $	Tons milled per day	Calculated Millhead feed lb. U_3O_8 per ton	Recovery percent	Cost per ton mined and milled
PRONTO URANIUM MINES LTD.						
1955	75,289[2]	487,054	550	— tune up period —		
1956	405,799	7,281,100	1,109	2.15	84.4	$10.90
1957	507,122	11,021,741	1,389	2.44	87.1	11.37
1958	549,976	12,219,639	1,507	2.36	91.5	11.59
1959	576,690	16,639,541	1,580	2.29	93.3	10.83
RIO ALGOM MINES LTD. (PRONTO DIVISION)						
1960	149,528[3]	(other data not given)				

NOTES
[1]Data compiled from company annual reports.
[2]Mill started Aug. 24, 1955.
[3]Mill closed April, 1960.

In May 1956, the Rio Tinto Company Limited (of London, England) purchased all the Blind River-Elliot Lake interests of J. H. Hirshhorn, and the Rio Tinto Mining Company of Canada was formed to control the following companies: Algom Uranium Mines Limited, Northspan Uranium Mines Limited, and Pronto Uranium Mines Limited.

In May 1959, Pronto Uranium Mines Limited entered into an extension contract with Eldorado Mining and Refining Limited; this contract was for the delivery of 1,508,000 pounds of U_3O_8 at a price of $8.00 (U.S.) per pound between the date of completion of the original contract and March, 1962.

On November 6, 1959, Eldorado Mining and Refining Limited announced that the United States Atomic Energy Commission would not exercise its option for deliveries of uranium concentrates in the period subsequent to the termination on March 31, 1962, or March 31, 1963, of the then existing contracts.

In order to relieve hardship in the uranium mining communities the companies were allowed to sell the unfilled portions of their contracts to other producers, or to amalgamate, and stretch out delivery of their contracts.

In the Elliot Lake camp, the following arrangements were made by the Rio Tinto group:

Algom Uranium Mines Limited, Milliken Lake Uranium Mines Limited, Northspan Uranium Mines Limited, and Pronto Uranium Mines Limited, merged to form Rio Algom Mines Limited. The Pronto Mine was closed in April, 1960, and preparations were made to mine a copper prospect (originally Pater Uranium Mines Limited) at Spragge and to treat the ore in part of the Pronto mill.

Geology of Pronto Mine Area

Although the Pronto Mine was the discovery locality for the Blind River-Elliot Lake camp comparatively little has been published concerning its geology. Early papers include a brief preliminary report by Abraham (1953) and a paper by Holmes (1957), formerly chief geologist to Pronto Uranium Mines Limited. General references to the Pronto Mine and its geology are scattered through the geological literature of the area. Fuller accounts of the geology, mineralogy, and structures of the typical Blind River-Elliot Lake ores are given in "Geology of Townships 149 and 150" (Robertson 1968). The account given here is largely from unpublished data in company files made available through the courtesy of P. C. Masterman, chief geologist at the Pronto Uranium Mine prior to the shutdown, and Paul Young, manager of Pronto Division of Rio Algom Mines Limited.

A variety of rock types and structural units traverse the mine area in a series of east-west strips. From north to south there is found:

a) The Algoman basement complex.

b) The post-Algoman regolith; intermittently preserved.

c) The Lower Mississagi Formation. This formation dips 15 to 20 degrees south, and comprises pebbly arkosic quartzite, grading upward to feldspathic quartzite with "green" bands. At the base of this formation, in the immediate mine area, lies the pyritic, quartz-pebble conglomerate of the ore bed. Locally, in the mine, there are patches of polymictic basal conglomerate but this does not form a continuous horizon. A maximum thickness of 600 feet of Lower Mississagi rocks is preserved beneath the Pronto Thrust Fault. Near the top of the sequence, localized argillaceous lenses indicate the proximity of the boundary between the Lower and Middle Mississagi Formations.

d) The Pronto Thrust Fault.

e) The Algoman basement complex. A block of the Algoman basement complex overlays the Pronto Thrust Fault; at one time it was thought that this block was an intrusive offshoot from the Cutler batholith but this has been disproved.

f) The Beaver Pond Fault. The south boundary of the granite block is marked by the Beaver Pond Fault, south of which lies (g) the Upper Mississagi Formation. The relationship of the Beaver Pond Fault to the Pronto Thrust Fault is not fully known.

g) The Upper Mississagi Formation. This formation is overlain by either (h) or (i).

h) The Bruce Formation; conglomerate.

i) The Gowganda Formation.

j) The Murray Fault. Close to Highway 17 the Murray Fault is encountered; this fault forms the south boundary of the Gowganda Formation.

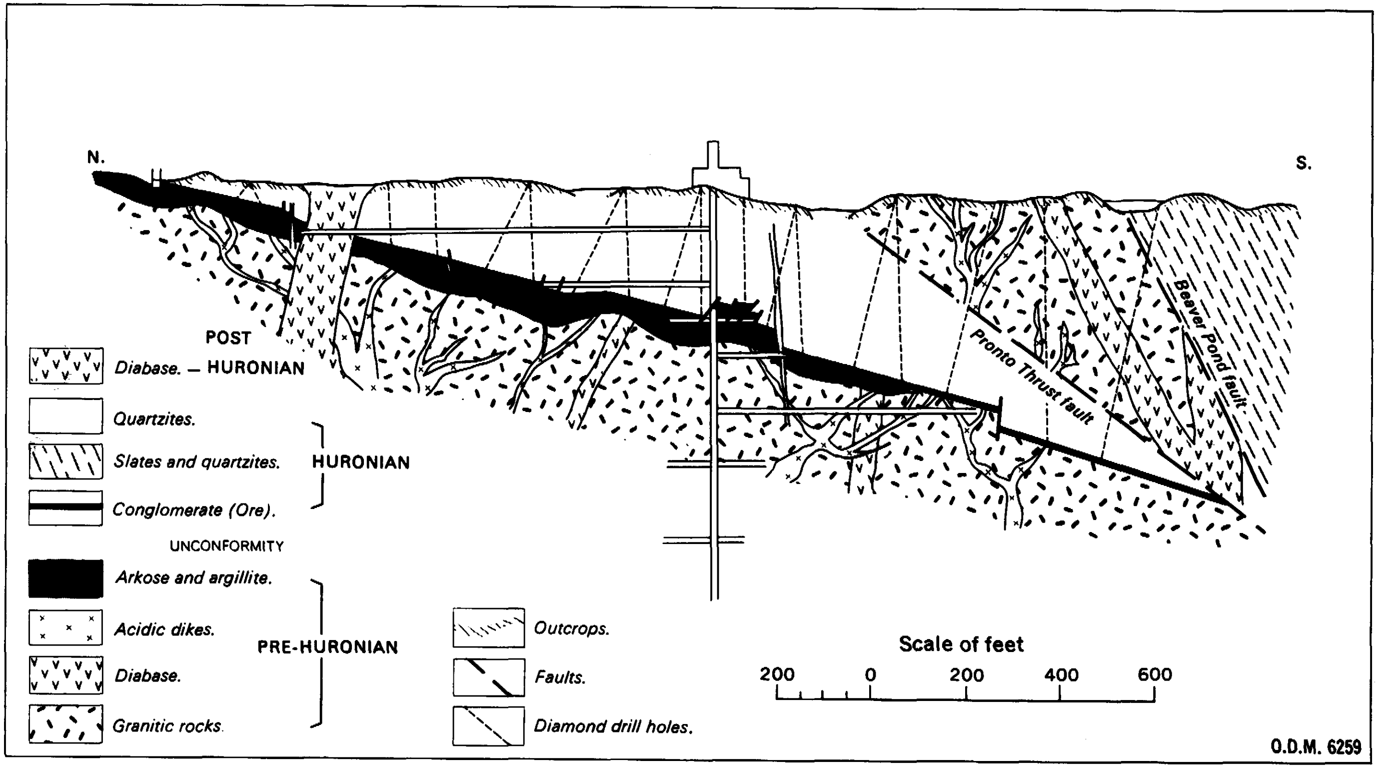
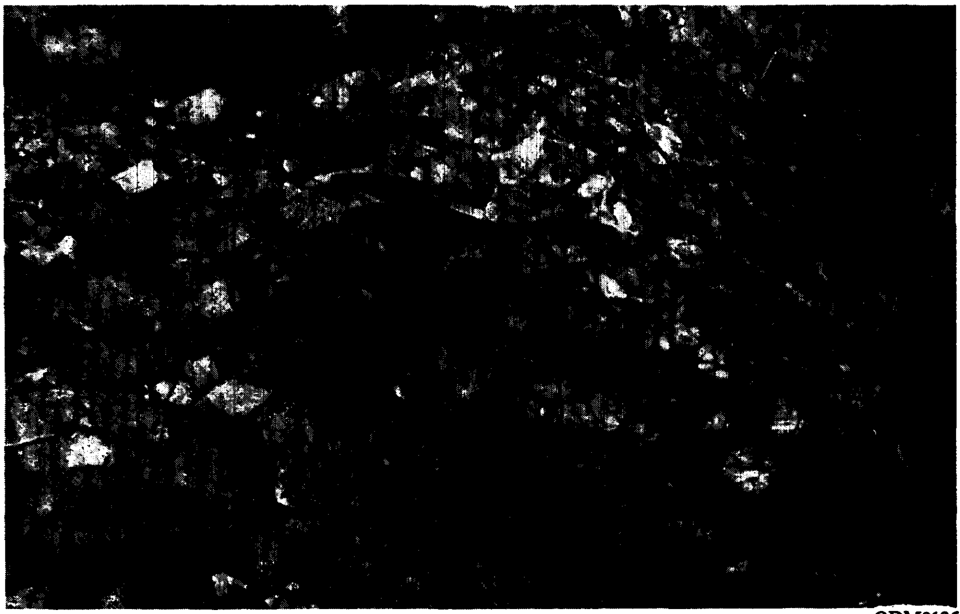


Figure 3 – Geological section through shaft looking east, Pronto Mine (Rio Algom Mines Limited, Pronto Division); after O.D.M. 1961, Chart B, map case.

k) The Spragge Group. To the south of the Murray Fault lies the Spragge Group, here represented by the Pater Volcanics (see Table 1).

The mine workings are chiefly in and below the ore bed; that is in Lower Mississagi Formation, Algoman basement complex, and acidic and diabasic dikes (see Figure 3). Over two-thirds of the ore has been mined out.



ODM8196

Photo 11 – Pronto Mine; uraniferous quartz-pebble conglomerate, surface showing of ore bed. West glory holes, Pronto Mine, Long Township.

Ore Deposit

The typical ore, and the only type seen at surface (see Photo 11) is pyritic, uraniferous, quartz-pebble conglomerate generally 6 to 10 feet thick but locally 15 to 20 feet thick. However, through much of the mine varying degrees of alteration are superimposed on the conglomerate and the associated quartzites. Three types of alteration have been distinguished: albitization, chloritization, and carbonatization. These types may occur separately or together (see Figure 4, facing page 100).

During early work (Holmes 1957) the albitized rock was mapped as radioactive quartzite and the chloritized rock as radioactive grit in the belief that they represented facies changes in the ore horizon. And, by the time the true nature of the rocks was realized, these terms had become entrenched in mine usage and have been retained by Pronto personnel. Lithologically, the conglomerate consists of well-rounded pebbles of quartz, quartzite, and occasionally chert embedded in a gritty matrix. The quartz pebbles are predominantly white and glassy, but bluish and banded grey ones are also present. The pebbles are remarkably uniform in size, and range from ½ inch to 2 inches in diameter. The ratio of pebbles to matrix was estimated to be about 65 to 35. The matrix of the conglomerate at the base of the series is pyritized with the concentration of pyrite varying considerably.

The rock in the ore zone is typically an oligomictic conglomerate characteristic of marine transgression over a surface of low relief. The term "oligomictic" applies to conglomerates noted, firstly, for their simple composition and, secondly, for the fact that the pebbles are of rock types that are resistant to erosion, such as quartz, quartzite, and chert; the pebbles are worn and well-rounded. No granite boulders have been observed in the ore-conglomerate; this phenomenon and the well-preserved regolith observed north of the "glory holes" and in the mine workings attest to the efficacy of the pre-Huronian weathering.

Although the pebbles are well-sorted, occasionally larger pebbles have been observed dispersed along one or more specific horizons. The conglomerate is essentially in lenses; this is quite apparent near the fringes of the orebody. Intercalated quartzite bands occur in the ore zone; some of these are traceable over hundreds of feet. These quartzite lenses and bands, and the hanging wall quartzites (see Figure 3) are more correctly described as sericitic arkosic sandstone. The sandstone is green, coarse-grained, with individual grains of quartz (ranging from 1/8 to 1/16 inch in diameter) and feldspar (about 15 percent of the grains) embedded in an arkosic matrix. In the sandstone, the bedding ranges from obscure to markedly cross-laminated, and the colour ranges from green to pink to white. The arkosic sandstone directly overlying the quartz-pebble conglomerate contains pebbles of quartz within it, but higher up in the formation pebbles are not present. These quartzites generally show crude graded bedding; and crossbedding, usually of torrential type, is moderately- to well-developed. Pyritic or chloritic seams are common along fractures defining the crossbedding in the quartzites. Similar fractures and imbrication of pebbles define current structures in the conglomerate. Occasional bedding planes in the quartzite members show ripple-marks. Generally the sediments near the granite contact are arkosic sandstones showing little or no recrystallization and retaining their original sedimentary features. To the south, over an interval the sandstone becomes tougher and more recrystallized, until eventually it is more correctly termed a quartzite.

Post-Ore Dikes

Within the mine workings four diabase dikes of mappable size transect the ore-bearing conglomerate. P. C. Masterman (company files) has also observed two dikes which cut basement rocks but not the ore zone, these may be of pre-Huronian age. Masterman in an unpublished company report (Masterman 1960) describes the ore cutting dikes as follows:

> The four dykes shown trend north west except that to the south which fills an east west fissure. No uranium enrichment has been noted along any of the dykes. The dykes may be described individually [see Figure 4 facing page 100].
>
> Number 1 Diabase is of average width 11 feet and dips north east at 62-80 degrees. It has somewhat sheared margins but there is no displacement. It is unfaulted. Brecciated ore adjoining the dyke to the south east is slightly altered. To the north west this dyke enters a lean area in the ore.

Number 2 Diabase has a width that varies from 55-100 feet and a dip which also varies from 60-85 degrees. The margins are somewhat sheared and movement of the ore in relation to this break has occurred. The elevation difference across the dyke in the north is negligible but there is a difference of 70 feet on 6th level. The drop is on the east side. The dyke interrupts a number of structures but not others. Between 4th and 5th levels there is approximately 60 feet of lateral movement. The structure at this point, is not exposed and in addition a great deal of vertical and horizontal faulting has taken place.

Number 3 Diabase is not recognizably 'diabasic' when seen underground due to excessive shearing particularly along its northern margin. The diabase dips north from 45-65 degrees and tends to steepen eastward. It is dislocated by number 2 diabase. Surface exposures indicate that the dyke is displaced near the west end of the mine, west side north. All other structures are however interrupted.

Number 4 Diabase dyke is dislocated by late stage faulting and also by thrusting sub-parallel to the basal contact.

Structural Geology

Masterman (1960) summarizes the structural geology of the mine as below. The increase in minor faults as the southern boundary is approached he ascribes to the Beaver Pond and Pronto Thrust Faults, which he suggested joined.

The most significant fault in the mine is a major reversed 'dyke filled' fault with 35-60 feet displacement and NW strike. This divides the mine into an upper and a lower section. The northern section is marked by a dominant west to north-west trend; structures in the southern, lower, portion are distinguished by a dominant north east block fault pattern. All faults, with the possible exception of one toward the western end of the mine, terminate where they intersect this dyke.

Two other fault structures are of interest:

1. A north east fault extending through the shaft to the eastern limit. Considerable drag has been observed along this fault in places and at one point a stope was developed in a dragged section. Alteration along the fault is confined to minor hematization in the more highly brecciated sections.

2. An east-west shallow dipping thrust fault above 5th level on the east side which duplicates the ore over a dip length of 50 feet and strike length of 1200 feet. This fault is also believed to dislocate the number 2 Diabase. There is some confusion, however, over the structure at this point due to the complication of numerous other minor vertical and flat lying faults. This fault is believed to post date the alteration phenomena since the alteration appears to be unrelated to it.

Many flat lying drag and thrust faults occur both within and outside the ore. For the most part these are not shown on the plan for obvious reasons. Such faults predominate in the altered areas and in some instances define the top and bottom of the ore.

Multi-directional shearing together with profound brecciation is characteristic of the altered areas, particularly within the chloritized albitites (and chloritites). The extent of this movement is such that in many stopes unsheared ore samples are unobtainable yet dislocation of the ore bed in the vertical plane may be negligible.

Generally the ore dips south between 15 and 20 degrees. Flat dips and even reversed dips along minor synclinal structures have been encountered. The strike in the southern conglomerate area is north to north-west with dip to the west. The change in strike is very sudden and commences on the south side of a flat lying thrust fault. The thrust fault is denoted on the map (approximately) by the contact between albitite and chloritized albitite. Warping within other fault blocks is however very slight. The strike on the east side of number 2 Diabase in the south is fairly regular.

Alteration of the ores was encountered throughout the Pronto Mine. Similar alterations were met locally in the mines of the Quirke and Nordic ore zones (Robertson 1968) where it is thought that the alteration was related to the end stage magmatic fluids from the Nipissing diabase magma, and that the passage of the magmatic fluids was controlled by favourable structures, both macroscopic and microscopic. The following descriptions of the alteration phenomena at Pronto are mainly taken from an unpublished company report by Masterman (1960):

The structural map (Figure 4) shows the somewhat haphazard distribution of the alteration zones on either side of No. 3 diabase. Normal conglomerate may be entirely surrounded by altered ore and conversely. Alteration is not confined to the ore, although it appears to be most intense within the ore bed; this is possibly owing to a greater permeability, and a greater susceptibility to shattering under stress in the conglomerate. Albitic alteration can be seen adjacent to jointing in green arkose in an exposure near the junction of the Pronto access road and the tractor road leading to the Ontario Hydro-Electric Power Commission transmission line to Elliot Lake. The boundary zones to areas of alteration are of four types: 1) Fault or shear plane, 2) transitional, 3) breccia zones, and 4) selective replacement.

Masterman's report continues:

1. Fault or shear plane. Such contacts may be clean cut with little or no alteration extending beyond the fault plane. Conversely there may be considerable brecciation resulting in an admixture of altered and unaltered ore. In some cases the relationships are usually obscured by subsidiary minor faults and fault blocks. In some cases a transitional section occurs and in at least two cases a 'quartzite breccia' has developed which fails to make ore. In one instance this 'barren zone' had a width of over 10 feet.

Flat lying shear planes have resulted in occurrences of conglomerate overlying albitite and albitite overlying conglomerate.

2. Transitional. Fragmentary patches (slides) of conglomerate completely enveloped in albitite are common. Such fragments vary from large quartz grains and remnant pebbles through definite conglomerate patches to areas of unaltered conglomerate. Locally such conglomerates are structurally disrupted but more commonly no signs of movement or brecciation occur within the solid conglomerate. A small amount of alteration 'zoning' is however generally apparent over a narrow section along the borders. This may vary from a few inches to a few feet. The zoning follows the following generalized pattern.

Normal pyritized conglomerate
Unpyritized conglomerate with chlorite and/or hematite
Albitization of matrix accompanied by some loss of quartz pebbles
Albitite or chloritic albitite with sparse pebbles or pebble remnants
Albitite or chloritic albitite

3. Breccia Zones. These are intermediate between the two foregoing relationships and frequently the ore continuity is confused due to obscure movement and severe localized distortion. Uranium values are highly erratic within the 'ore bed' in the brecciated section and quite often such sections are unmineable due to the low grade.

4. Selective Replacement. There are two types of selective replacement.

a) Albitic and b) Carbonate

a) The albitic replacement is a total replacement in which the entire rock is replaced by albite. Great selectivity is generally a feature of these occurrences. This is most evident in conglomerates interbedded with one or more quartzite bands. The conglomerate bands have sometimes been 'attacked' by the solutions first leaving tongues of unaltered quartzite projecting several feet into the albitite. It is interesting to note that the uranium values are not affected in such cases and by diligent wall sampling in the albitite the barren quartzite bands can be traced for tens of feet. It has also been noted that the upper conglomerate bands are generally more susceptible to alteration than the lower bands.

An analysis of albitite alteration from Pronto Mine is listed in Table 3 in "Algoman" section; this analysis clearly indicates major differences between the alteration material and the Post-Huronian granite.

b) Carbonate Replacement. In this connection two areas are of great interest. In both cases this type of alteration is of localized extent and is shown on the map [Figure 4] as 'Metaconglomerate'. Typically the transition between regular conglomerate and 'metaconglomerate' is rapid and ill defined. Outwardly the two rocks may appear identical until close examination discloses that the pebbles in the one case are typically vein quartz and in the other calcite and/or dolomite. The pyrite content is often high and generally minor hematization occurs. The matrix may appear to be unaltered or else may be albitized. Cores of quartz in the pebbles may be seen, but rarely. More intense alteration is marked by a lack of definition to the pebble outlines and/or brecciation. In the former case the carbonate extends well into the matrix enveloping pyrite and some feldspars. The brecciated carbonate ore is transitional into pyritic albitite and albitite. Carbonate veinlets are sometimes well developed but are not generally abundant.

The Non-Conglomeratic Ores

Masterman's (1960, p.13) discussion continues with the "geology of the non-conglomeratic ores".

Relations to Faults

The non-conglomeratic ores do not occur where there are no faults. The intensity of this faulting varies a great deal and also the intensity of brecciation and shearing. The following statements in the opinion of the writer, P. C. Masterman, are true in general.
a. Brecciated unaltered conglomerate is rare.
b. The albitite is marked by numerous ill-defined shears and partings. The well defined shears of greater extent are invariably chloritized and generally occur parallel to nearby faults. Alternatively parallel to the plane of the ore.
c. The chloritic albitite, and the chloritites particularly, are very heavily sheared in three or more directions at right angles to the footwall contact. The slickensides show that most of this movement was vertical. Such movement under lateral compression was small as the footwall contacts are extraordinarily uniform and have constant dip.
d. Pronounced brecciation in the hanging wall quartzites is usual above chloritic rocks.
e. Faults and/or dykes provide the most common limitations to a specific type of ore.
f. The most heavily dislocated areas (faulted) are not necessarily the most altered.

Relations to Dykes

The relationships of dykes to the altered ores are not too clear. Some regional correlation of non-conglomeratic ores to dykes are self evident. (viz. Diabase No. 3). On the local scale, however, such correlation does not apply and clean contacts of diabase with conglomerate occur. Elsewhere minor chloritization extends a few feet from the dyke and more rarely hematization (albitization?). Elsewhere dykes cut conglomerate with no visible alteration. Alteration trends in non-conglomeratic ores towards dykes (or faults) are not apparent. Ore values in all rock types appear to be unrelated to dykes (and faults). The dykes are never mineralized although in one stope fragments of completely replaced diabase were found enclosed in ore some fifteen feet from No. 3 Diabase.

Masterman (1960, p.14-15) discussed "Radioactivity of the non-conglomeratic ores".

A distinct difference in the uranium distribution and values has been noted in the non-conglomeratic ores. Values have been found to follow certain trends while at the same time being more erratic in distribution.

The main trend is one of concentration adjoining the footwall contact. Values in the lowermost one to two feet are almost always well above mine average and generally two to four times mine grade. Experience has indicated that this high grade material can be recognized visually even when microscopic uranium minerals are absent. The features identified with it are the abundance of abundant yellow to buff flecks of leucoxene (anatase). This is particularly noticeable in the chloritic rocks where such grains often concentrate in a simulated bedded fashion parallel to the basal contact. In one instance a narrow band 1" thick containing abundant leucoxene appeared to follow a bedded plane for several feet. In another case two leucoxene rich bands separated by a one foot section where this mineral appeared to be absent could be traced intermittently across a transition zone into conglomerate with an intercalated quartzite band. Uranium values in the two rock types were found to correspond reasonably well; together, these points seem to prove lithological continuity.

High grade albitite is recognized by a darkening or reddening of the colour. A few openings well up into the overlying beds have exposed a monotonous series of almost identical quartzites in one area. These quartzites are pink with scattered red feldspar grains. Near the ore the quartzites gradually become more reddish. Within the ore zone itself the red colour increases rapidly with the uranium content.

Another well recognized trend is that uranium values in the true albitites extend over a very much narrower width than they do in the adjoining areas whether they comprise conglomerate or chloritic ore. Thus 8 feet of conglomerate may narrow to 3 feet of albitite ore. Yet the overall width x grade (foot-pounds) may, and often does, remain about the same.

This feature of narrowing in the non-conglomeratic ores is sometimes true of the chloritic type but generally it is less pronounced. The isopach map[1] shows close correlation between ore type and width despite the fact that these widths are mining widths and in the albititic areas the mining widths included considerable waste rock. The grade contours on the other hand show very little correlation. The reason for this may be partly explained by the fact that considerable grade variations occur throughout the ore body in the normal conglomerate. On a local scale however the conglomerate beds show far greater width and grade consistence (even in individual bands) than do the non-conglomeratic ores.

In the transition and breccia zones values are quite erratic. Areas of waste, areas of low and areas of high grade ore occur 'jostled up' together. In mining there have been times when a development face was 80 percent waste one day and high grade ore on the following day, then mainly waste beyond. Pinching and swelling of the ore from less than a foot to five or six feet in width over a distance of less than ten feet is not unusual in these zones. A good part of the explanation for these occurrences rests with the dragging of ore along faults and shear planes. In other cases the most reasonable view is that the ore has been stretched, rolled and disrupted by movement over a long period of time. In further cases the width can be related to the type of ore.

Uranium values are unknown other than in the single ore bed and in lenses of conglomerate in the overlying Mississagi Quartzites. Secondary enrichment or migration appears to be uncommon but has occurred in one fault adjoining the ore zone; the migration is extremely localized. Secondary uranium minerals frequently occur, however, in faults and more particularly along thrust planes *within* the ore zone. The grade in such areas is frequently high.

Mineralogy and Origin of the Ore-conglomerate

Published and unpublished descriptions of the mineralogy of the Blind River area have been based largely on material from the Quirke Syncline. A detailed summary of this data has been given by the author (Robertson 1968). Additional data on the Pronto ores, based largely on determinations made for Pronto Uranium Mines Limited by Professor E. W. Nuffield of the University of Toronto (1954), and S. Kaiman (1955) and M. R. Hughson (1959) of the Mines Branch, Department of Mines and Technical Surveys in Ottawa, have been made available by Rio Algom Mines Limited.

The principal radioactive minerals of the ores are uraninite, brannerite, and monazite, though the latter is less significant at the Pronto Mine than elsewhere in the camp. Thorpe (1963) estimated that eight percent of the uranium is contained in monazite at the Pronto Mine (average of two samples). Brannerite is regarded as the major ore mineral at the Pronto Mine but in some polished sections examined by Nuffield (1954), Kaiman (1955), and Stieff *et al.* (1956) it was present in traces only or altogether lacking. A mixture of radioactive hydrocarbons with uraninite and coffinite that is found in post-ore fractures as either massive or botryoidal bodies is generally considered to be the mineraloid thucholite. On weathered surfaces either above ground or underground, and within some areas of altered rock in the mine workings, various secondary uranium minerals have been identified; these include uranophane, β-uranophane, boltwoodite, and liebegite (Hughson 1959).

Most authorities suggest that uraninite may be present either as a primary mineral or as a breakdown product derived from brannerite with anatase and (or) rutile. But Ramdohr (1957) has suggested that the brannerite is forming by synthesis from uraninite and anatase or rutile and has termed this "the Pronto reaction". These hypotheses present two conflicting opinions.

[1]Not reproduced in this report.

The second significant group of minerals found in the ores is the sulphides: pyrite, and to a minor extent pyrrhotite, chalcopyrite, and molybdenite. Galena is occasionally visible in hand specimen and has been seen in polished sections where the textural relationships suggest it is largely radiogenic in origin. Such other minerals as have been identified in the Blind River ores are heavy detrital minerals. Gold has been identified in erratic trace quantities both as native gold and as inclusions in the sulphide minerals.

As with the similar Rand deposits in South Africa, there has been much controversy over the formation of the ores. Bateman (1955, p.371), Joubin and James (1957), Davidson (1957, p.668) and Heinrich (1958) have cited as evidence of a hydrothermal origin the supposedly high uranium to thorium ratio, the high titanium to iron ratio, and the association of Ti, Co, Ni, Th, and U in a deposit carrying (gold in South Africa) brannerite, uraninite, and pyrite as characteristic minerals. Patchett (1960) after a detailed study of three samples from the Nordic Mine, regarded the ores as epigenitic. Joubin (1954, p.431-437) suggested the "Keweenawan" diabase as a source but in a later paper (Joubin 1960) commented that mining evidence clearly indicated that the diabase post-dated the uranium mineralization. Davidson (1957) suggested that the post-Huronian granite lying to the southeast was the probable source. However much of the granite formerly considered of possible post-Huronian age and shown as such on the Lake Huron Sheet (Collins 1935) has since been proved older than the Huronian (Robertson 1960). Only the Cutler Granite, exposed south of the Murray Fault, is now considered to be of post-Huronian age (Robertson 1966; see also "Cutler Granite" section).

Abraham (1953) and McDowell (1957; 1963) regarded the ores as fossil placer deposits. Roscoe (1957) and Pienaar (1958; 1963) have also indicated preference for a placer origin. D. S. Robertson and N. C. Steenland (1960), D. S. Robertson (1962), and the author (Robertson 1968) have also assembled much data, particularly on U to Th ratios in the Quirke Syncline, which are suggestive of a placer origin.

Holmes (1956, p. 116) suggested that the ores were of syngenetic (placer) origin but were modified by later events. This view was also given in the guides to the area compiled by the mine geologists for the Sixth Commonwealth Mining and Metallurgical Congress tour in 1957 and a Canadian Institute of Mining and Metallurgical Engineers field trip the following year (C.I.M.M. 1957; 1958).

Derry (1960) suggested a syngenetic origin for the uranium mineralization but considered the possibility that the uranium was mainly carried in solution and reprecipitated in gravel banks by bacterial agencies. Joubin (1960) suggested similar ideas but did not discuss bacterial precipitation.

It may be noted that other conglomerates in the district, that is the Lower Mississagi polymictic conglomerate, the Middle Mississagi conglomerate, the Upper Mississagi conglomerate, the Bruce Conglomerate, and the Cobalt conglomerates do not carry markedly high percentages of uranium, though all, and particularly the Bruce Conglomerate, carry pyrite and pyrrhotite. An exception to this lack of uranium occurs when such a conglomerate unconformably overlies the uranium-bearing sequence or the Algoman basement.

The sericitic matrix of the ore-bearing conglomerates is similar to the sericitic paleosoil (the granite regolith, "Post-Algoman Interval" section) and was probably derived from it; there is no reason to suppose that the sericite was produced by the passage of hydrothermal solutions. Uraniferous oligomictic pebble conglomerates and a green arkosic sequence are characteristic of whichever part of the Huronian that overlies the granitic basement in the North Shore of Lake Huron area; the uraniferous conglomerate shows a progressive northward overlap. Significant thicknesses and grades of uraniferous conglomerate have so far only been found in the Lower Mississagi rocks; the ore zones at Pronto, Nordic, and Quirke Mines occur at progressively younger horizons (Robertson 1966, p. 127).

Quartz veins and other signs of intense hydrothermal activity are not conspicuous in the district and appear to be unrelated to the uranium deposits. Where mineralized rocks are found associated with quartz veins the mineralization consists of copper and other sulphide minerals. Within the Blind River-Elliot Lake camp, there is no indication that either the Nipissing diabase (formerly included with the Keweenawan) or the olivine diabase intrusions are a possible source of radioactive mineralization. There is, however, evidence that the uranium ores were subjected to intense local alteration and that all rocks suffered sulphide mineralization at the same time as the intrusion of the Nipissing diabase and the regional folding. Age determination data is consistent with this concept. Of the uranium mines Pronto is the one in which these alteration effects are most conspicuous.

The overall distribution of beds and the changes in thicknesses and grades, in so far as this is public information, are more rationally explained on the modified placer hypothesis, which the writer has consistently supported (J. Robertson 1960 *et seq.*).

SPRAGGE CREEK OCCURRENCE OF URANIFEROUS CONGLOMERATE

Spragge Creek in the vicinity of the Long-Spragge township boundary flows along the outcrop of a narrow zone of Lower Mississagi Formation preserved as the footwall of the Spragge-Long Lake-Lauzon Heights diabase intrusive body (See "Nipissing Diabase" section). This intrusion has been injected along a thrust fault (see "Spragge Creek Fault" section). Property around the occurrence is owned by Rio Algom Mines Limited.

The rocks are normal Lower Mississagi arkosic quartzite with scattered pebbles towards the base. Diamond drilling indicated some conglomeratic sections but continuity, grade, and thickness did not warrant development or the inclusion of this material in the ore reserves of the Pronto property. Drilling through the diabase showed that the Lower Mississagi Formation was missing at a short distance down dip. Renewed mapping by Pronto personnel in 1959 failed to add any indication of potential ore. One grab sample from a surface outcrop of conglomerate at the fork in Spragge Creek east of the township boundary assayed 2.2 lb. U_3O_8 per ton.

COPPER

CADAMET MINES LIMITED[1]

Twin Lakes Showing[2]

In April, 1964, the property consisted of two surveyed claims (S91634 and S95549) and eighteen unsurveyed claims in the Christie Lake section of southeast-central Esten Township. These claims included the area on the Esten Township aeromagnetic map (O.D.M. 1954a) showing magnetic anomalies trending west-northwest in the vicinity of Christie Lake and the area of the Twin Lakes copper showing lying to the northwest of Christie Lake.

The property, then comprising 36 unsurveyed claims, (see Figure 5) was drilled between March and August, 1956, by Federal Kirkland Mining Company Limited. The drill data were submitted for assessment credit in two groupings. The first grouping consisting of those 20 claims held in 1964 by Cadamet Mines Limited (successor company to Federal Kirkland Mining Company) was submitted under the name of H. E. Martin, one of the directors of Federal Kirkland Mining Company, and the second group (16 claims) lying to the west of the first group was submitted under the name of Anglo Luria option.

Holes 1 to 24, and 26 were located in the eastern grouping with the majority located on claim S91631 (see Figure 5) and Holes 25, 27, and 28 were located in the western group.

The property was described by Thomson *et al.* (1957, p. 91) as follows:

Geology Chalcopyrite occurs in stringers and disseminations in highly silicified schists and breccias within a strong northwest-trending sheared zone. Talc and chloritic schists and diabase are present within the sheared zone and within the adjacent rocks, which are predominantly granitic. The better concentrations of chalcopyrite were obtained within a few hundred feet of the intersection of the main sheared zone and a strong sub-parallel zone of shearing and silification.

Dimensions and Grade A large number of good grade intersections were obtained in the drilling over a length of 380 feet and to a depth of 400 feet. More intensive drilling of this area would have to be done in order to more accurately determine the grade and tonnage. However, an estimate of probable ore is as follows: tons, 76,900; grade 1.73 percent copper; average width, 8.04 feet. (W. P. Murdock, Jan., 1957.)

The property is crossed by the jeep-road connecting the Ontario Hydro-Electric Power Commission transmission line with Highway 108. In 1961 this road was drivable to Christie Lake. A log cabin had been constructed at the northeast corner of the lake; this lake is sufficiently large to allow small float planes to land.

Mineralized rock was exposed on one outcrop and several drill collars were identified.

In view of the comparatively easy access to the property, and the availability of milling facilities at Pronto Mine, the possibility of a small scale operation being profitable during a period of relatively high copper prices should be examined.

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[1]Company formed September, 1958 to acquire assets of a number of companies including Federal Kirkland Mining Company Limited. Name changed September, 1966 from Cadamet Mines Limited to Terrex Mining Company Limited.

[2]Twin Lakes is the name Cadamet personnel use for Christie Lake.

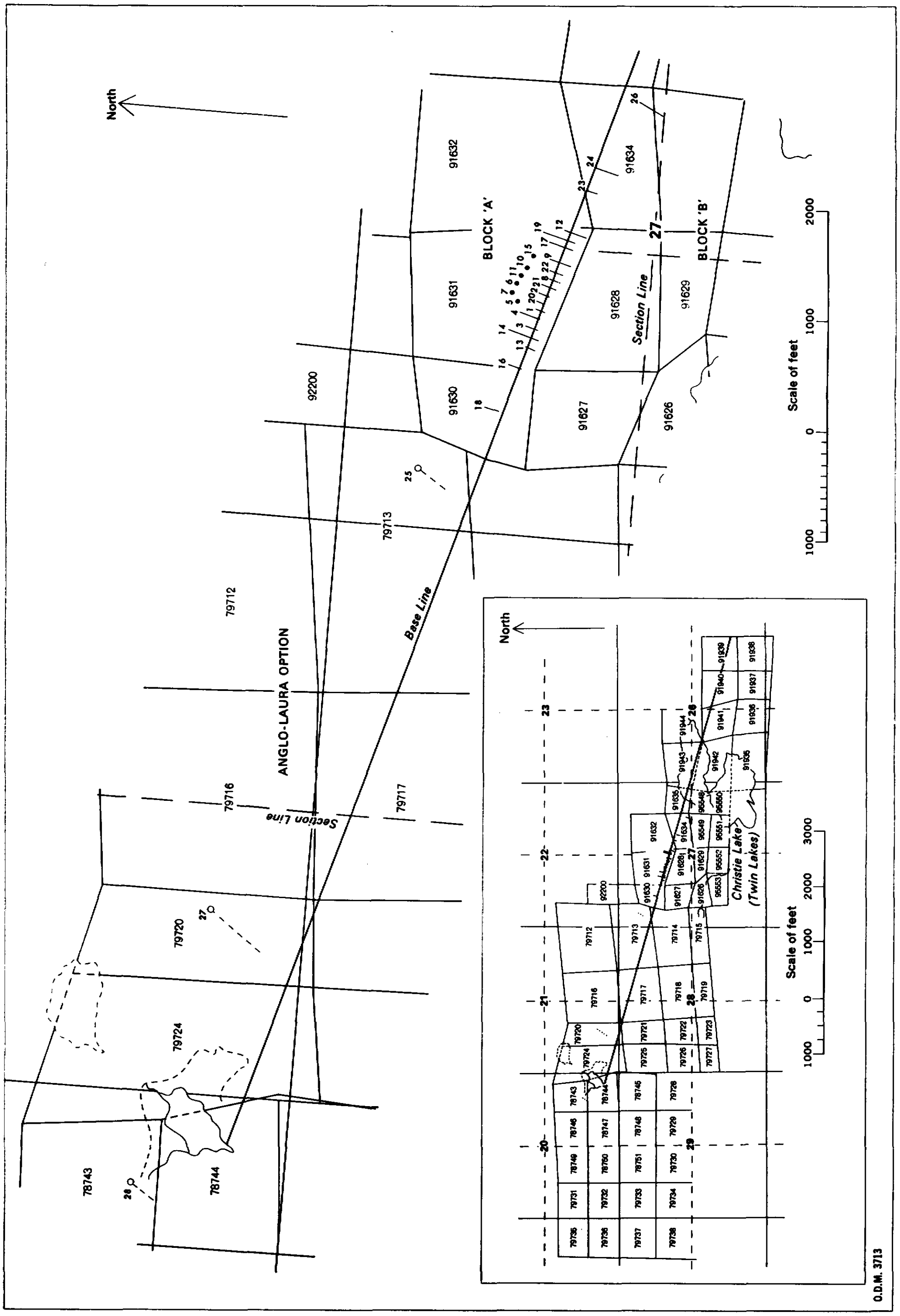

Figure 5 — Twin Lakes copper prospect, Esten Township, showing location of drill holes by Federal Kirkland Mining Co. (later Cadamet Mines Ltd.); redrawn from company plans.

PRESTON MINES LIMITED[1]

Surprise Lake-Hastie Lake Property

This company in 1964 held 27 claims in the Surprise Lake-Hastie Lake sector of Long Township to the northwest of the Pronto property. The claims are SS24471 (water only) and SS24472 to SS24479 inclusive, SS24539 to SS24547 inclusive, and SS24647 to SS24655 inclusive. These were staked in 1953 by Preston personnel.

Between October 1953 and June 1955, eleven drill holes were put down. Nine of these explored the Lower Mississagi contact with the Algoman basement north of Hastie Lake; the maximum depth was 300 feet. Two deeper holes intersected basement rock at a depth of between 800 and 900 feet; these latter drill records were submitted by W. H. Bouck (President of Preston East Dome Mines Limited in 1956) for assessment credit (Resident Geologist's file SSM 100). These eleven drill holes intersected typical greenish arkosic Lower Mississagi quartzite cut by a few narrow diabase dikes. Occasional scattered pebbles were found, particularly at the contact, but there was no indication of a conglomerate bed of ore type or grade. However, the property was brought to patent and has been held in good standing.

RIO ALGOM MINES LIMITED

Buckles Property

In 1954 Buckles Algoma Uranium Mines Limited acquired 75 claims in southern Township 149 and northern Esten Township. These were originally staked to protect a copper showing in Township 149 to the north of Nordic Lake. Some 53 claims lie mainly or partly in Esten Township. Many claims cross township boundaries, fractions of some claims lie in Township 149, and fractions of some claims, largely in Township 149, lie in Esten.

In May, 1953, between the date when uranium was known to occur at what is now Pronto Mine, and before prospecting had started on the "middle belt", Harry Buckles, Don Smith, and R. C. Hart were flown to Nordic Lake by Preston to look at a copper occurrence which had been reported to Buckles by the claim owner, C. Metevier, of Sault Ste. Marie. No copper showings were seen on that trip. Later that summer the claims were re-staked by the Preston men and other claims were added.

Buckles Algoma Uranium Mines Ltd. was incorporated in April, 1954, to take over the property.

Uranium was discovered in 1953, on the northern fringe of the property in Township 149. In March, 1955, the company was merged into Spanish American Mines Limited. Spanish American was at the same time incorporated into Northspan Uranium Mines Limited which in 1960 was merged with the other Rio Tinto companies to form Rio Algom Mines Limited.

[1]Company formed August 31, 1960, by amalgamation of Preston East Dome Mines Limited and Stanleigh Uranium Mining Corporation Limited.

Also, late in 1953, an airborne scintillometer and magnetometer survey was performed. Geological mapping was carried out in 1954 with special attention being given to that part of the property lying in Township 149 (Resident Geologist's file SSM 366, Ontario Department of Mines file 63A-296). The development work was sufficient to bring the property to patent and the claims were surveyed.

That part of the property in Esten Township is underlain by the Nordic Lake-Esten Lake diabase-quartz diorite bodies. Minor sulphide mineralization (including copper) is associated with this body. The country rock is grey to pink gneissic granite grading westward into red porphyritic quartz monzonite. Lineaments controlling the drainage pattern may be the surface expression of faults. As nothing of economic interest was found, that part of the property in Esten Township was allowed to lapse. By April, 1966, only five claims remained.

Pater Mine

Following the discovery of the Pronto uranium deposit Pater Uranium Mines Limited was formed to acquire and explore 23 claims and 10 patented lots lying in southern Spragge Township between the east end of the Pronto discovery property and the Pronto east property (east of Waugush Lake).

This area comprised section 28, section 29, the southern half of section 30, the east half of the northeast quarter of section 30, and a block of 16 claims lying to the north of section 28 and 29 and part of section 30. The property is crossed by the Canadian Pacific railway, the Trans-Canada Highway (Highway 17) and the Ontario Hydro-Electric Power Commission transmission line. The community of Spragge lies in section 29. Docking facilities formerly existed at Spragge, and the Serpent River estuary is capable of handling medium-sized lake vessels.

History and Development[1]

Initial exploration of the property comprised surface mapping, radioactivity surveys, an aeromagnetic survey, and diamond drilling; the drilling was carried out near the Archean-Lower Mississagi contact. Only traces of uraniferous oligomictic pebble conglomerate were found and these were insufficient to encourage further development of the property. Those claims lying north of the subdivided portion of Spragge Township were underlain only by basement rocks and were allowed to lapse.

However, during the surface exploration, a sulphide-bearing shear zone was discovered in outcrop south of the Canadian Pacific Railway track at the eastern approaches to Spragge station. This zone had been pitted, possibly in the 1920s or 1930s. It is believed that the early prospectors lost interest in the showing because

[1]An article with sketches "Rio Algom uses ingenuity to squeeze profit from Pater's modest-size pipelike orebody" appeared in the Northern Miner, April 25, 1968, p. 18 and 26. Ed.

of the high pyrrhotite content of the rocks which was unaccompanied by nickel, the barely visible component of chalcopyrite, and the possibly little or no indication of the presence of precious metals. Assuming continuity between outcrops, the zone could be traced over several hundred feet.

Initial surface drilling was carried out in 1954 to test the continuity of the sulphide-bearing shear zone. The drill cores showed the zone was continuous, and had an average, near surface, grade of 1.6 percent copper, plus a trace of cobalt, over a width of 5 to 6 feet. As there was some evidence that both grade and width improved with depth a further drilling program was undertaken.

This drilling indicated reserves of 525,000 tons of 1.98 percent copper within a zone averaging 8 feet in width, at least 1,200 feet long and 1,000 feet deep.

During 1956 and 1957, a three-compartment shaft was sunk to 1,030 feet and a level developed in the ore zone at the 960-foot level. A crosscut was driven southward to test the lower levels of the ore zone by diamond drilling.

Twenty-nine holes were drilled from the 960-foot level, eighteen of which were horizontal; these increased the reserves to 1,069,000 tons of 2.07 percent copper across an average width of 9.05 feet. The block covered by drilling was 600 feet long at the surface, 1,400 feet long at 1,200 feet with an average depth of 1,300 feet (this information is from company reports of Pater Uranium Mines Limited, by P. L. Hooper, November, 1957, on file with the Ontario Department of Mines.)

It was recognized (in 1957) that the shear zone was the expression of a fault striking about east-west and dipping 80° to 85° S. It was oblique to the Murray Fault and also to the strike of the metavolcanic rocks of the Spragge Group. The sulphide mineralization apparently post-dated brecciation of the quartz veins in the shear zone and therefore the ore physically resembled a conglomerate with scattered rounded quartz blebs surrounded by pyrrhotite and about 6 percent of disseminated and streaky chalcopyrite. As there was a southward dip to the ore zone the company applied for, and was granted, in January, 1958, a Mining Lease covering 525 acres underlying the Serpent Harbour (Mining Lease 12529) to the south of sections 28 and 29 of Spragge Township; the company had previously held a license of occupation (No. 12176) to this area.

Development operations on the property were halted in October, 1957, owing to a marked drop in the price of copper; the price dropped to a level at which the grade and reserves of the property would have precluded the construction and operation of a mill.

In 1959, when the uranium at Pronto Mine was nearing depletion and current exploration had failed to reveal further ore reserves, officials of that company (Pronto) examined the feasibility of mining the Pater deposit and trucking the ore to the Pronto mill for treatment. In November, 1959, Pronto Uranium Mines Limited acquired Pater Uranium Mines Limited. Subsequently, owing to the reorganization of the Rio Tinto group of companies, the Pronto Mine was closed in April, 1960, and the company merged into Rio Algom Mines Limited.

In January, 1960, the rehabilitation of the Pater Mine was begun (see photo 12): the mine was dewatered and examined; the mine was prepared for production above the 960-foot level; deep drilling from the 960-foot level was started; the Pater and Pronto holdings south of the Murray Fault were remapped; a number of other shear zones with low grade sulphide mineralization and characteristic rusty-weathering gossans were found.

ODM8197

Photo 12 – Pater Mine; surface plant at Pater copper mine, spring 1961. Spragge village, Spragge Township. (Right foreground shows remains of stockpile since removed.)

This development and exploration work took the greater part of 1960. The reserves were re-assessed as 910,000 tons of 1.9 percent copper, limited to a strike length of 900 feet, but to a depth of at least 2,000 feet. It was considered that 640,000 tons of reserves were actually above 960-foot level. Ore produced during development was stockpiled along with the ore from the original development.

Milling operations were begun at Pronto mill on January 2nd, 1961, at a rate of 500 tons per day, with the stockpile providing the bulk of the material. As the milling capacity of the Pronto mill exceeded the hoisting capacity of the Pater Mine, the company announced its readiness to undertake custom milling of suitable quantities of ore grading in excess of 2.0 percent. This sparked a re-examination of copper showings on the north shore of Lake Huron. However, the only extra ore that was sent to the Pronto mill consisted of small test shipments made from properties near Iron Bridge in 1962 (Robertson 1963b, p. 53; 1964, p. 62-65). By the year end the mill production had increased to 680 tons per day, derived entirely from the mine. Recovery was 96 percent. The shaft at Pater Mine was deepened to 2,150 feet and development was carried out below the 960-foot level.

The mine was laid out as follows: six levels at about 150-foot intervals to the 960-foot level; six levels at about 200-foot intervals to the 12th or 2,100-foot level (see Figure 6, chart A, back pocket).

During 1961 concentrates were trucked to Sault Ste. Marie for transhipment to foreign ports, and about 5,700,000 pounds of copper were shipped during the 1961 navigation season.

To facilitate shaft sinking and development, without interruption of production, the shaft was enlarged to four compartments below the 960-foot level. Further drilling was started from the 12th level.

In 1962, development of the block between the 6th and 12th levels continued; during the second half of the year production was derived from this zone. The underground drilling program continued and the ore zone was shown to extend to at least 3,000 feet with slight improvement in width and grade at depth. The Pronto mill operated at 95 percent recovery, producing a 25 percent copper concentrate containing a total of 8,244,349 pounds of copper. The concentrate was again shipped via Sault Ste. Marie.

During 1963 the mine was developed to the 2,900-foot (16th) level (the limit of existing hoisting capacity) with levels at about 200-foot intervals. Underground drilling was resumed at the end of the year. A program was carried out which included detailed geological study, lateral work, and surface and underground diamond drilling. Lateral work totalled 1,300 feet and diamond drilling 10,141 feet. Results were negative and the existence of a second orebody within reach of the present undergrouund facilities was not considered probable (Rio Algom Mines Limited, Annual Report, 1963). Copper mineralization was found at a number of localities on the surface. The places with showings included one about two miles west of the Pater Mine, and one east of the Pronto East subdivision. A drilling program was initiated to investigate these showings and to test the Murray Fault zone as a possible host structure for copper mineralization.

During the year (1963) the mill treated 258,499 tons of ore, recovery was improved to 96.2 percent and concentrates to 27.1 percent copper. The concentrates were trucked to the Pronto siding and sent by rail to the International Nickel Company of Canada Limited smelter at Coppercliff under contract with the metal merchants (Rio Algom Mines Limited, Annual Report, 1963).

In 1964 development was concentrated between the 12th and 15th levels. The deep drilling initiated the previous year was continued and preparations were begun for further shaft sinking. As the original shaft could not be deepened without installing more powerful hoisting machinery, or without penetrating the bad ground associated with the Murray Fault, it was decided to sink an internal shaft from the 15th level about 600 feet southeast of the No. 1 shaft. Preparations for this were begun in 1964 and shaft sinking started in 1965. Dilution, particularly from schists in the hanging wall, at depths greater than 2,000 feet in the shrinkage stopes required change of the mining method to cut and fill. Fill was provided by back-hauling from the Pronto mill; equipment for handling and pumping the fill was installed. Rather than using conventional timber platforms in the cut and fill stopes, concrete was poured over the fill, and when hardened, this provided a satisfactory base for drilling and slushing operations.

In 1964, 256,226 tons of ore (1.83 percent copper) were milled. The recovery was 96.5 percent and the copper concentrate produced contained 27 percent copper. Total production for 1964 was 8,609,230 pounds of copper.

The surface exploration continued with diamond drilling, geological mapping, and geophysical exploration. However, none of the areas examined provided encouragement for further exploration and the program was terminated following the field season. Table 9 lists the available production data for the operation of the Pater Mine.

Table 9 PRODUCTION DATA FOR PATER COPPER MINE*

RIO ALGOM MINES LTD. (PRONTO DIVISION)

Year	Tons milled	Pounds copper produced	Value of copper $	Tons milled per day	Millhead: percent copper	Recovery; percent	Concentrate; percent copper
1961**	238,600	7,072,952	...	654	...	96**	...
1962	256,325	8,244,349	1,629,524	730	...	95.0	25
1963	258,499	9,708,367	1,511,658	708	1.96	96.2	27.1
1964	256,226	8,609,230	...	702	1.83	96.5	27
1965	248,613	8,248,613	...	681	1.83	96.4	26.4

NOTES
*Data compiled from company annual reports.
**Production began Jan. 2nd, tune up and stockpile used first six months, percent recovery for year-end.

Geology of Pater Mine Area

The property is crossed by a series of units and structural features; the general trend of these geological features is east-west. From the north the following rock types and structural features are encountered:

1) The Algoman basement complex.
2) The pre-Huronian unconformity along Spragge Creek and Waugush Lake.
3) The Lower Mississagi Formation; at the east end of Waugush Lake the overlying Middle and Upper Mississagi Formations are also found.
4) The Spragge-Long Lake-Lauzon Heights diabase intrusion, probably in a thrust fault.
5) The eastward continuation of the Beaver Pond Fault.
6) Part of the Upper Mississagi Formation; overlain, west of Spragge village, by the Bruce (Conglomerate) Formation; and unconformably overlain by the Gowganda Formation south and east of Spragge village.
7) The Murray Fault.
8) The Spragge Group; comprising an assemblage of mafic metavolcanics and associated metasediments overlain by a series of metaquartzites and schists, all intruded by diabase metamorphosed to epidiorite.
9) The Cutler batholith; south of the mine on the south bank of the Serpent River estuary. Only rare granite and pegmatite dikes are found on the islands in the estuary.
10) A northwest-striking Keweenawan olivine diabase dike forms the west end of Nobles Island; and parallel but thin dikes are found elsewhere south of the Murray Fault.

The geology of the country rocks of the Pater deposit is discussed in the sections on "Areas Containing Huronian(?) Rocks" and "Spragge Group", and in thesis by Knight (1963, 1965, 1967) and Beger (1963).

IRON

Hematite occurs as stringers and veinlets in bleached Gowganda quartzites near the Murray Fault.

A more substantial zone of hematitization is found on Location X, Long Township, (an old mining location) in the vicinity of old Highway 17.

Iron Occurrence, Location X, Long Township

The deposit is mentioned in the Report of the Ontario Iron Ore Committee (O.D.M. 1923, p. 200) as follows:

> On *location X,* near Algoma Mills, a little exploration has been done on a hematite prospect. The ore, which is of good grade, occurs in innumerable small veins only a few inches in width scattered irregularly through a diabase outcrop 120 feet long and 30 feet wide.
> Reference: A. Hassellbring for Lake Superior Corporation, Sault Ste. Marie, Ontario, 1907.

Apart from trenches and pitting, little is to be seen of the original development. A stock pile of hematitic (specularite) ore is located near the shore of Lake Huron and there may have been provision for loading this material onto freighters.

Abraham (field notes) indicated several drill holes in the area but no details are given in his notes. One drill hole was filed for assessment credit by J. H. Hirschhorn who had the area staked during the uranium boom. The property is of historical interest in that radioactivity on it was among the indications leading to the discovery of the uranium deposit at Pronto Mine (see "Pronto Mine" section). There is little probability of further work being done on the iron deposit.

SAND AND GRAVEL

Pleistocene and Recent deposits are mentioned in "Post-Precambrian" section.

There are no substantial deposits within the map-area and only limited production of the small pits for local usage.

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APPENDIX: PROPERTIES (NOW ABANDONED) ON WHICH DEVELOPMENT WORK WAS CARRIED OUT.

PROPERTY	LOCATION	NUMBER OF CLAIMS	PERIOD	S.S.M. FILE NO.	TORONTO FILE NO.	TYPE OF WORK	NOTES
Belville Gold Mines Ltd.	Long Tp. Con II, Lots 9, 10.	9 claims[1]	June-Sept. 1953	98	63.431	Surface mapping. RA survey.	Granite cut by gabbro – No RA anomalies.
Blind River Uranium Mines Ltd.	Long Tp.	13 claims[2]	March-May 1955	1198	....	2 drill holes.	Holes not completed to basement. All water claims.
Bonville Gold Mines Ltd.	Spragge Tp. N of Waugush Lake.	29 claims[3]	1953-1956	172	63.399	9 drill holes. Surface mapping. RA survey.	Holes are entirely in basement. Gneissic basement complex, late aplite and pegmatite with slight RA. Barren NE quartz veins, cut by NW diabase dikes.
Bowsinque Mines, Ltd.	W McGiverin Tp.	20 claims[4]	1954	109	63.595	Surface mapping. RA survey.	Lower Mississagi S65E, RA up to 7 x B.G. No RA over basement or thin diabase dikes.
British Columbia Explorers (1953) Ltd.	N shore Lauzon L. Long Tp.	12 claims	1954	1199	....	2 short drill holes. BC 1, 2.	Granite contact at 97 feet, pebbles at contact. Company merged into Panel (see below).
British Columbia Explorers (1953) Ltd.	Spragge Tp.	6 claims[5]	1954-1955	576	....	4 short drill holes.	Entirely in basement.
Caswell Showing	Long Tp. Con. II, Lot 8.	2 claims	Aug. 1953	1021	....	2 pits.	Specularite-quartz veins in quartzite and shale cut by diabase. RA several times B.G.
Confederation Mining Corp. Ltd.	Long Tp.	2 claims	1955	101	....	10 drill holes.	Only two logs submitted, one completed to basement. No conglomerate.
Cusco Mines Ltd.	McGiverin Tp. near boundary with Mack Tp. and NW corner Long Tp.	18 claims[6]	1954-1955	110	....	9 drill holes. Sketch maps.	Basement contact. Deepest intersection 350 feet. Only one hole (No. 7 on SS25299) with conglomerate – 5 foot section. Three feet 5 x B.G. Two feet 3 x B.G. Quartzites locally feldspathized.
Dominion Uranium Corp.	N Esten Tp. and S Tp. 149.	12 claims in[7] Esten Tp.	1954	55	63.561	Self potential, magnetic surveys.	Low anomalies trend NW, west of Nordic Lake and trend E near Esten L., Spur L., Marshland L. Little probability of sulphides.
Dominion Uranium Corp.	Spragge Tp.	18 claims[8]	1954	173	63.589	Self-potential, RA surveys. Surface mapping.	Granite with inner greenstone, barren quartz veins, cut by diabase. No indication of RA or sulphides.
East Long Uranium Mines Ltd.	Long Tp.	9 claims[9]	1955	99	....	3 short drill holes.	Collared in diabase, passed into basement. No sedimentary rocks.
Gwillim Lake Gold Mines Ltd.	Long Tp. N of Lauzon Lake.	50 claims[10]	1955	102	63A.241 1 claim Long Tp.	Geological mapping in Long Tp. 9 drill holes in Long Tp.	Joint hole (1) on north shore Lauzon Lake: 5b-0 to 766; diabase-766 to 1310; 4a-1310 to 1354; granite 1354 to 1374. No conglomerate.
Gwillim Lake Gold Mines Ltd.	Striker Tp.	24 claims	1955	(see also 183)	....	2 joint holes with New Kelore, near tp. line. 3 drill holes in Striker Tp.	Same property as Mid-North Engineering (see below). Logs for joint holes and holes in Striker submitted for assessment credit.
Harico Mining and Development Co. Ltd.	Long and McGiverin Tps.	19 claims[11]	1956	71	....	....	Northeast part granite, southwest Lower Mississagi Formation(?).
Harico Mining and Development Co. Ltd.	Long Tp.	6 claims[12]	1956	71	....	....	Largely diabase, but Lower Mississagi Formation in southwest.
Hirshhorn, J. H.	Long Tp.	1 claim[13]	1965	1200	....	1 short drill hole.	Diabase dike in quartzite.
Huclif Porcupine Mines Ltd.	SW McGiverin Tp. Mack Tp.	25 claims[14] 1 claim	1954-1955	111	63.586	Geological mapping. Six drill holes.	Same property as Matachewan Canadian Gold Ltd. (see below). East half largely granite with Lower Mississagi outliers. West half Lower Mississagi Formation. RA showing in claim 25872, area cut by diabase. In holes near RA showing up to five feet conglomerate, low values. Other holes, no conglomerate.
Kenmay Claims (D. W. Sullivan)	Hastie, McFadden Lakes, Long Tp.	21 claims[15]	1953-1954	103	63A.190	Surface geology. RA survey.	Granite – Lower Mississagi contact. Strike SE, dip 12°SW. One thin bed coarse clastics with few pebbles and low RA. Rest of property large dia-

Ltd.	Mack Tp.					RA survey.	(see above). RA zones on contact with basement. Main showing is typical RA conglomerate, 320 feet by 260 feet, up to ten feet thick, 4 x BG. Four smaller zones of RA, lower intensity and smaller area. Drilling suggested (see above).
Mid-North Engineering Service Ltd.	NW Long Tp. E Striker Tp.	50 claims[10] 24 claims Same ground and nos. as Gwillim Lake	1954	1201	....	9 drill holes.	Same property as Gwillim Lake (see above). Logs for holes. Intersected quartzite and argillite, quartzite RA towards basement granite, 525-foot diabase sill in southernmost hole. Other holes lie to north of sill.
New Kelore Mines Ltd.	Long Tp.	1 claim[16]	1956	184	....	2 joint holes with Gwillim Lake. (SSM 183).	Holes on Striker-Long Tp. boundary. Intersect diabase sill. (See above).
New Kelore Mines Ltd.	Striker Tp.	27 claims	1955	184 and 183	63.582	Geological survey, RA survey in Striker Tp.	Mississagi quartzite present. Slight RA. RA anomalies may be owing to mass effect.
Panel Consolidated Uranium Mines Ltd.	Long Tp.	88 claims	1956	104	....	One drill hole (BC 3).	Includes same group of claims as the British Columbia Explorers (1953) Ltd. Basement at 345.5 feet.
Pebble Uranium Mines Ltd.	Long Tp.	2 claims[17]	Previous to 1957	1202	....	2 drill holes.	Intersect basement contact between 200 and 300 feet.
Quebec Developers and Smelters Ltd.	Spragge Tp. (SE central)	12 claims[18]	1955	174	63.588	Surface mapping. Ground magnetic survey.	Basement granite and diabase intrusive. Magnetite and pyrite observed.
Randex Uranium Mines Inc.	McGiverin Tp. S shore McGiverin L.	20 claims[19]	1955	113	63A.255	Mapping, RA survey. 5 drill holes.	Down faulted Mississagi Formation drilled at 300 feet. No RA.
Randex Uranium Mines Inc.	W of McGiverin Lake, McGiverin Tp.	21 claims[20]	1954	114 114	63A.255 63.485	Mapping, RA survey.	Granite area, local spots 3 x BG. Quartzite up to 4 x BG. One zone pyritic conglomerate 5 x BG on boundary claims SS28104-105.
Red Bark Mines Ltd.	Long Tp. 1½ mi. NW Pronto Mine.	15 claims[21]	1953	105	63.395	14 short drill holes. Geological mapping. RA survey.	Granite and greenstone cut by diabase. Pegmatite granite slightly RA.
Roy option	Long Tp., Con. II, Lot 8.	2 claims[22]	1953	1203	....	2 short drill holes.	Two holes in hematite zone at diabase contact. Claim SS24228 equals SS50479 (see Hirshhorn).
Skyline Uranium and Minerals Corp. Ltd.	Mack and McGiverin Tps.	20 claims	1954	1204	....	3 drill holes.	500 to 700 feet, Lower Mississagi Formation. Only slight RA. No conglomerate resting on granite, greenstone basement.
Stancan Uranium Corp. Normingo Option	Lauzon Lake, W Long Tp.	15 claims	1955	92 107 108	.... 63A.168	1 drill hole.	1190 feet of arkose quartzite, siltstone. Some claims same as for Tungsten Corp., Oslund Group (see below).
Tungsten Corp. of Canada Ltd.	Kenmay Group, Long Tp. (Hastie and McFadden Lakes).	21 claims[15]	1954	103 (see above)	63A.190	Geological map. 8 drill holes.	Early report covers only part of area. Holes in vicinity of Hastie Lake. Low RA and coarse clastics with scattered pebbles near contact. Deepest hole to contact at 350 feet.
Tungsten Corp. of Canada Ltd.	Oslund Group (S of above)	16 claims[23]	1953	108	63A.168	Geological report and geological map.	

NOTES

[1]Claim numbers: SS24887-95.
[2]Claim numbers: SS24713-25.
[3]Claim numbers: S66330-38, S68396-404, S69071-2, S69211-12, S72033-4, S72038-42.
[4]Claim numbers: SS26345-47, SS26349, SS27142-43, SS27448-56, SS30277, SS30280, SS30876-77, SS30881.
[5]Claim numbers: SS66209-214.
[6]Claim numbers: SS25288-305; SS25297 in Mack Tp.
[7]Claim numbers: S74790-74814, S75853-59; 20 claims in Tp. 149.
[8]Claim numbers: S77741-58.
[9]Claim numbers: SS47916-24.
[10]Claim number: SS24504 work completed on this claim
[11]Claim numbers: SS44871-89.
[12]Claim numbers: SS44865-70.
[13]Claim number: SS50979.
[14]Claim numbers: SS25036-47, SS25063-66, SS25872-74, SS25878-80, SS25884-86, SS25302; drill hole in SS25302; SS25065 in Mack Tp.
[15]Claim numbers: SS24681-96, SS29785-89.
[16]Claim numbers: SS24880-84, SS25095-99, SS25100-01, SS25089, SS25072, 1st group; SS24767-75, SS24885-86, SS25386, SS30465-66, 2nd group; SS25098 in Long Tp.
[17]Claim numbers: SS29787-88.
[18]Claim numbers: S73908-16, S81765-67.
[19]Claim numbers: SS32915-16, SS32920-37.
[20]Claim numbers: SS28103-17, SS28120-22, SS28127-29.
[21]Claim numbers: SS24576-83, SS24585-89, SS24593-94.
[22]Claim numbers: SS24227-8.
[23]Claim numbers: SS24668-73, SS24677-80.

INDEX

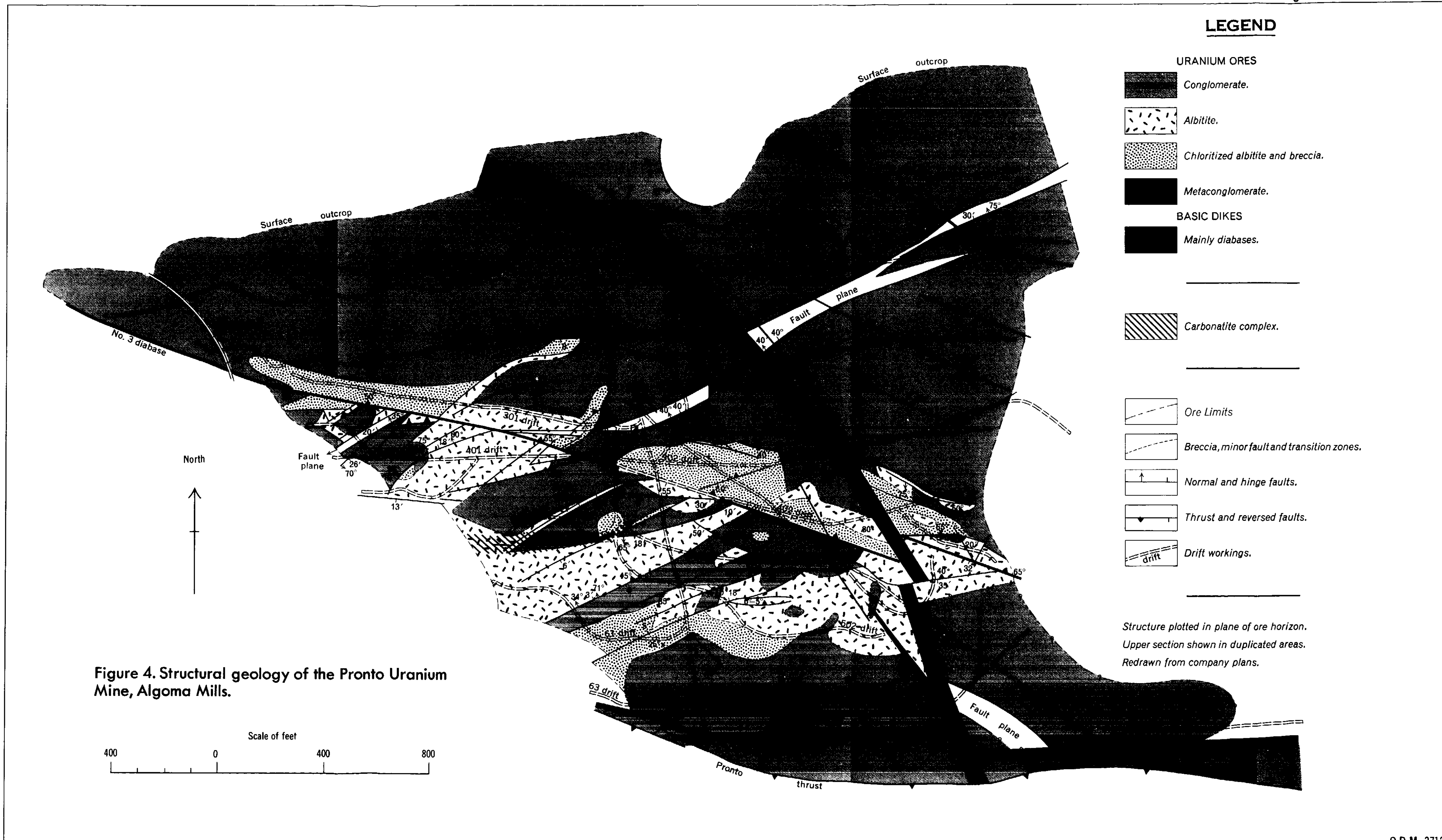
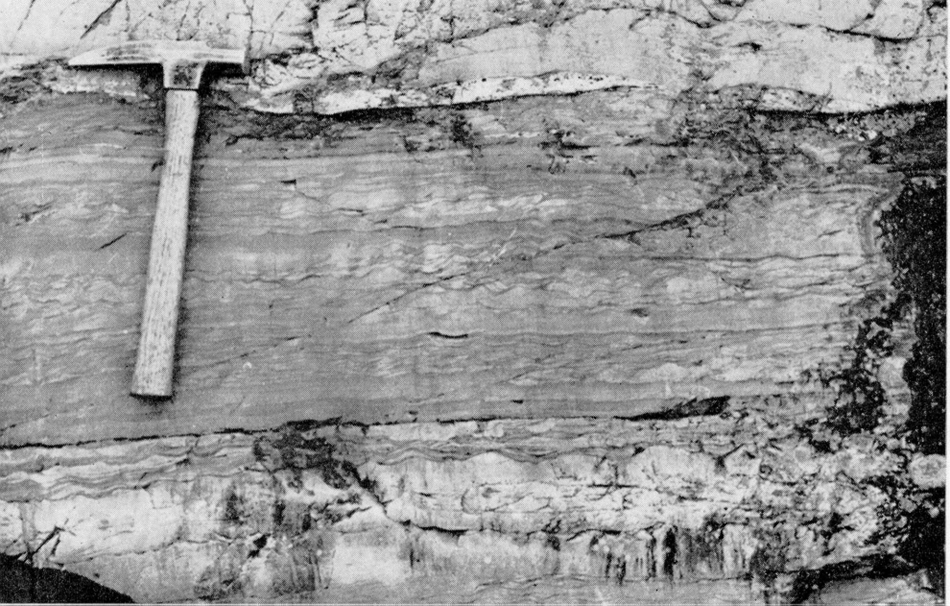


Figure 4. Structural geology of the Pronto Uranium Mine, Algoma Mills.



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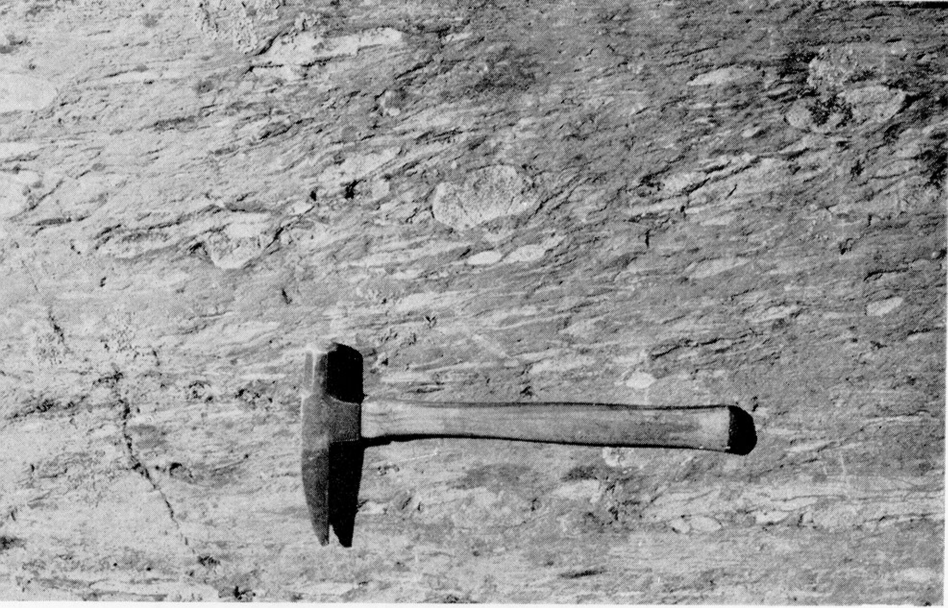

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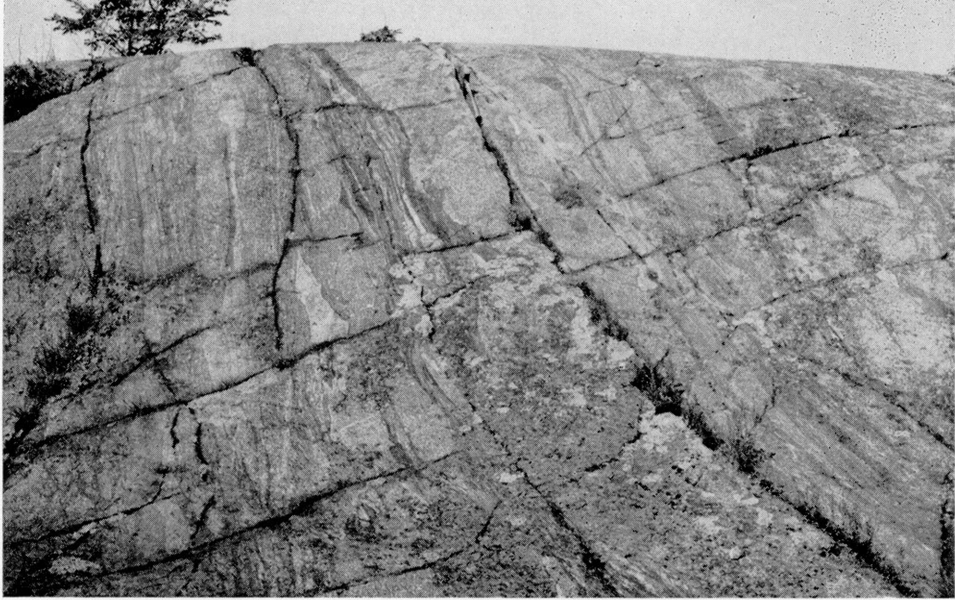
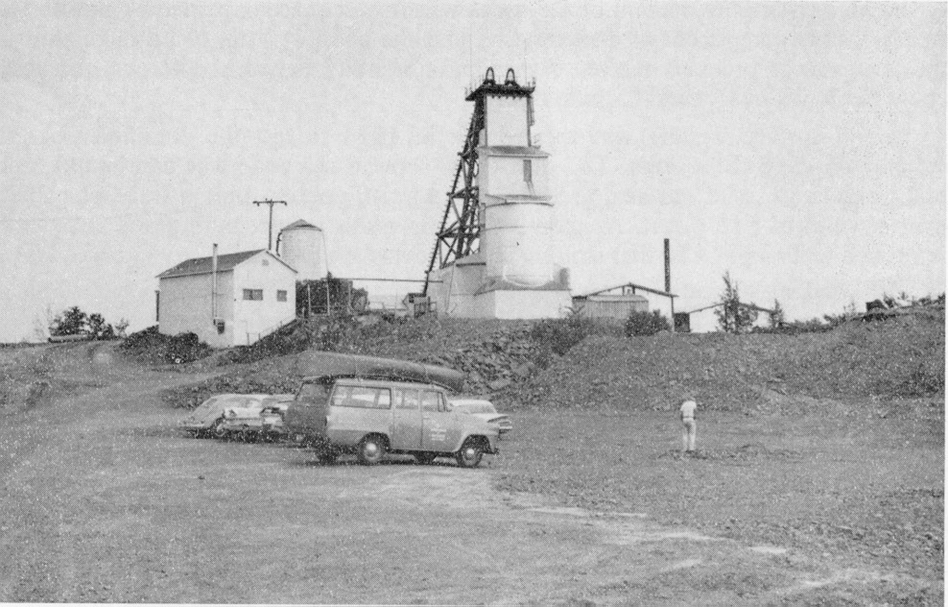




Spragge Area.
Chart A.
Figure 6.

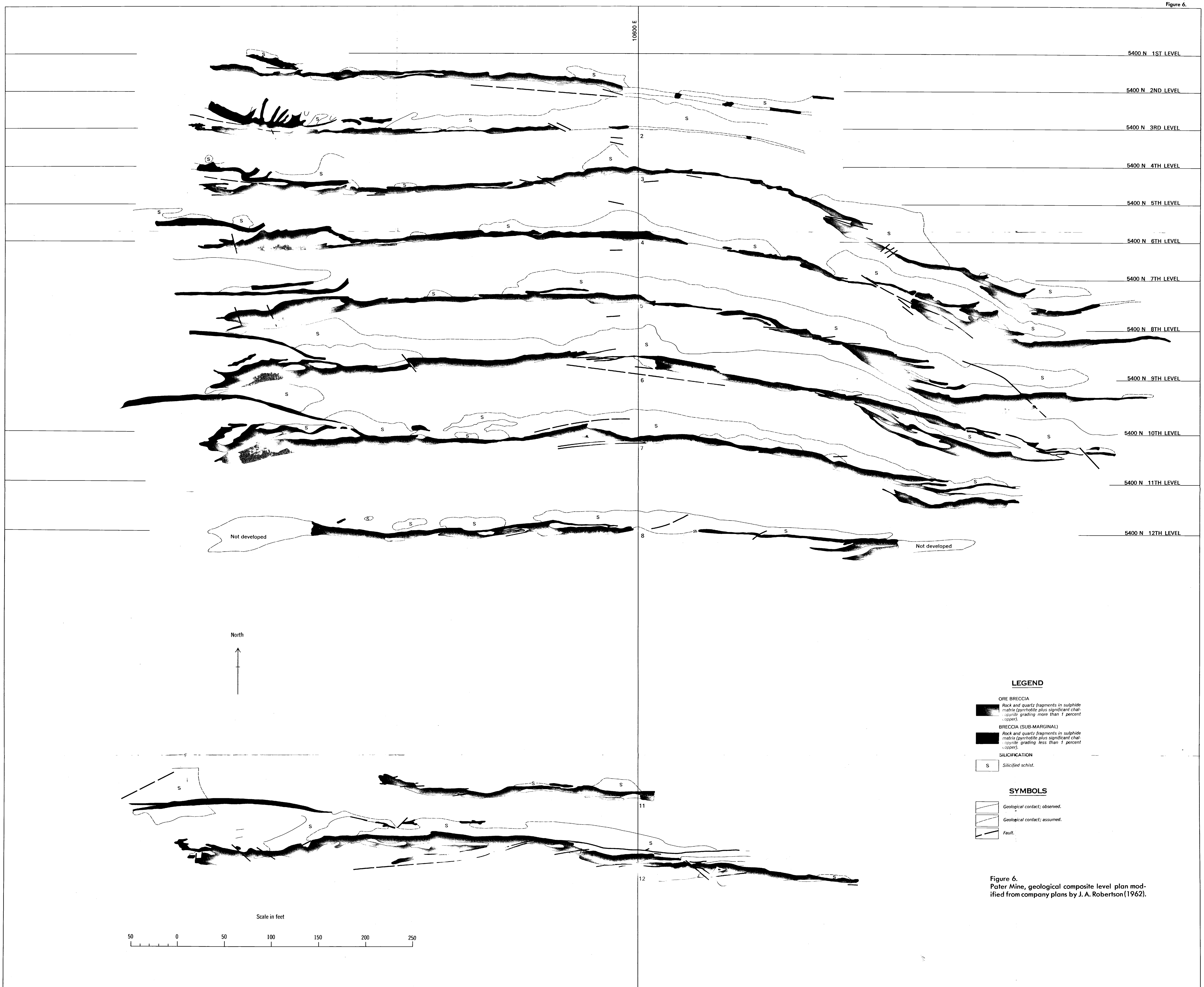


Figure 6.
Pater Mine, geological composite level plan modified from company plans by J. A. Robertson (1962).

ONTARIO
DEPARTMENT OF MINES
HON. ALLAN F. LAWRENCE, *Minister of Mines*
D. P. Douglass, *Deputy Minister* J. E. Thomson, *Director, Geological Branch*

SYMBOLS

- Glacial striae.
- Small bedrock outcrop.
- Area of bedrock outcrop.
- Bedding, top unknown; (inclined, vertical).
- Bedding, top indicated by arrow; (inclined, vertical, overturned).
- Bedding top (arrow) from cross bedding; (inclined, vertical, overturned).
- Schistosity; (horizontal, inclined, vertical).
- Schistosity; dip unknown.
- Gneissosity (horizontal, inclined, vertical).
- Foliation; (horizontal, inclined, vertical).
- Geological boundary, observed.
- Geological boundary, position interpreted.
- Fault; (observed assumed). Arrows indicate horizontal movement.
- Anticline, syncline, with plunge.
- Vein, vein network. Width in feet.
- Muskeg or swamp.
- Motor road. Provincial highway number encircled where applicable.
- Other road.
- Trail, portage, winter road.
- Building.
- Township boundary, with mileposts, approximate position only.
- Claim line, surveyed, approximate position only.
- Property boundary, approximate position only.
- 2 Location of mining property, surveyed. See List of Properties.
- ① Location of mining property, unsurveyed. See List of Properties.

PROPERTY LIST*

McGIVERIN TOWNSHIP

No properties.

ESTEN TOWNSHIP

1. *Cadamet Mines Limited.*
2. *Rio Algom Mines Limited.*

*As of 31 December 1966.

SOURCES OF INFORMATION

Geology by E. M. Abraham and assistants 1953,1954; J. A. Robertson and assistants 1960, 1961. Compilation by J. A. Robertson 1960, 1961. Geology is not tied to surveyed lines.

Geological and drilling plans of mining companies.

Preliminary maps: P70 McGiverin Township; P130 Esten Township; scale 1" to ¼ mile; issued 1960, 1961.

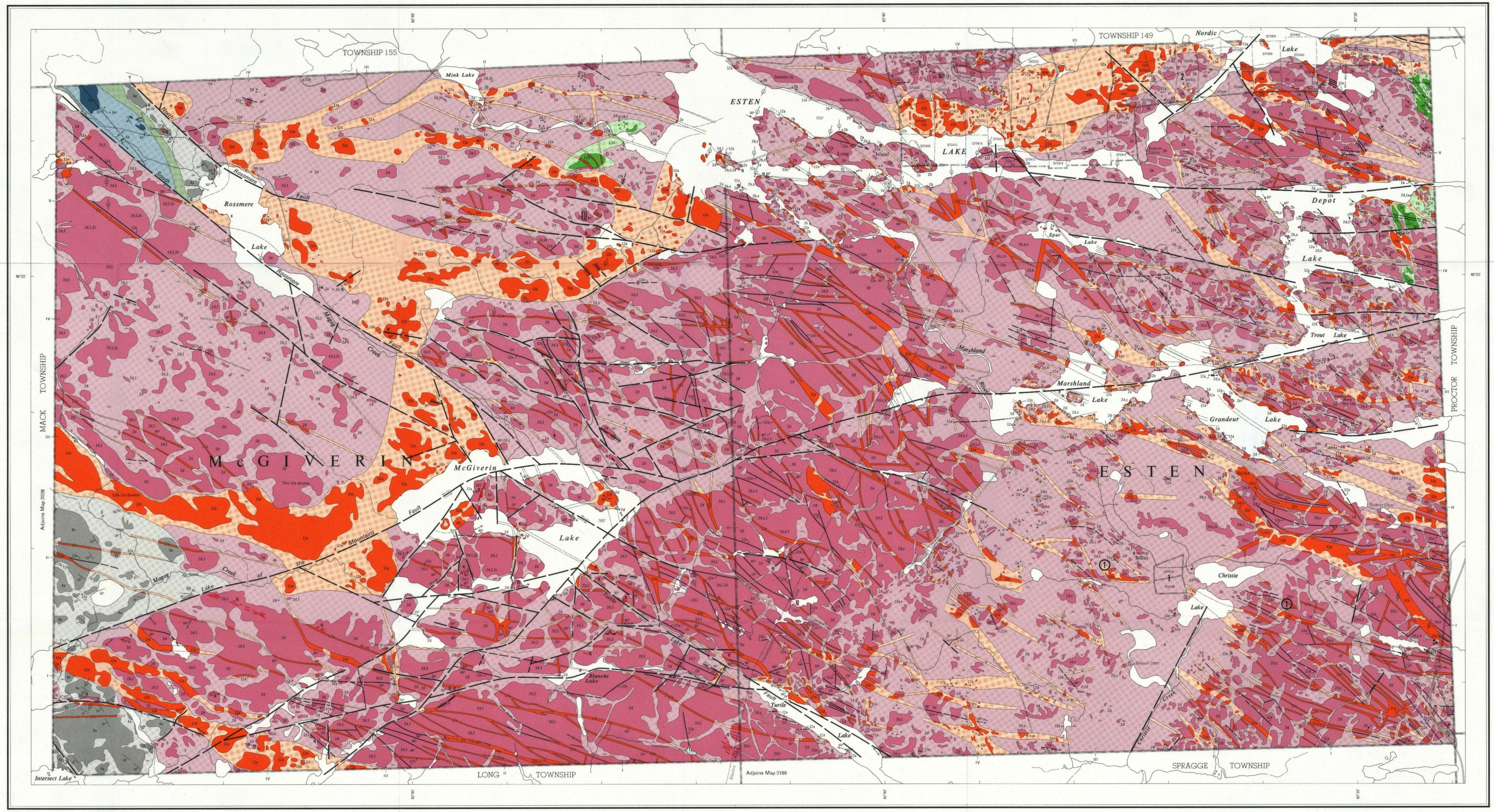
ODM Provincial Aeromagnetic and Radioactive Survey Series: McGiverin Sheet, No. 47; Esten Sheet, No. 48; scale 1 inch to 1 mile, 1954.

ODM-GSC Aeromagnetic Map 3237G, Elliot Lake Sheet, scale 1 inch to 1 mile, published 1964.

Cartography by Lockwood Survey Corporation, 1969.

Basemap derived from maps of the Forest Resources Inventory, Ontario Department of Lands & Forests, with additions and amendments by E. M. Abraham and J. A. Robertson.

Magnetic declination approximately 6°W., 1964.



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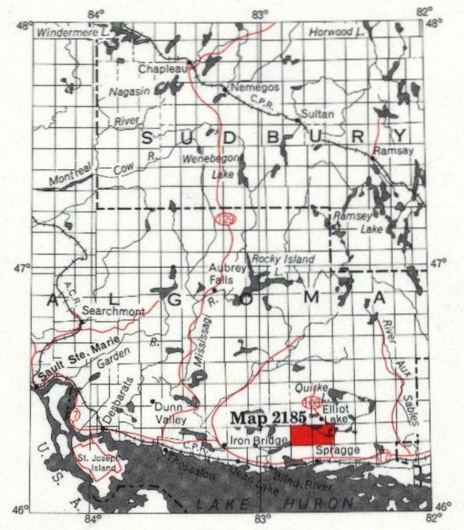


Scale 1 inch to 50 miles
NTS reference 41J/2, 41J/7

LEGEND

CENOZOIC*

RECENT
Swamp, lake, and stream deposits.

PLEISTOCENE
Gravel, clay, till, sand.

UNCONFORMITY

PRECAMBRIAN**

PROTEROZOIC

KEWEENAWAN

14 *Olivine diabase.*

INTRUSIVE CONTACT

FELSIC INTRUSIVE ROCKS

CUTLER GRANITE §

13a *Muscovite-biotite granite.*
13b *Pegmatite.*

INTRUSIVE CONTACT

METAMORPHIC ROCKS

MAFIC INTRUSIONS†

12b *Metadiabase, epidiorite, amphibolite, amphibolite gneiss.* §

SPRAGGE GROUP††

METASEDIMENTS§

11 *Undifferentiated metasediments.*
11a *Muscovite, chlorite, biotite, cordierite, staurolite, garnet, quartz-feldspar schists.*
11b *Quartzite.*
11c *Conglomerate.*

METAVOLCANICS§

10a *Massive hornblende, biotite, chlorite, garnet, metavolcanics.*
10b *Pillow lava.*
10c *Amygdaloidal lava.*
10d *Chlorite, biotite, hornblende, plagioclase metagreywacke with or without 10a, 10b.*

METAMORPHIC CONTACT
(Not visible in map area)

MAFIC INTRUSIVE ROCKS

POST-HURONIAN INTRUSIONS †††

12a *Diabase, gabbro, and diorite cut by later felsic and mafic dikelets.*

INTRUSIVE CONTACT

HURONIAN

COBALT GROUP

GOWGANDA FORMATION§

9a *Polymictic conglomerate with or without interbedded quartzite, argillite, siltstone, greywacke.*
9b *Feldspathic quartzite with or without interbedded conglomerate, argillite, siltstone, greywacke.*
9c *Greywacke with or without interbedded conglomerate, argillite, siltstone, quartzite.*
9d *Argillite, siltstone, with or without interbedded quartzite, greywacke, conglomerate.*

UNCONFORMITY

BRUCE GROUP

ESPANOLA FORMATION

Bruce Limestone. §

8 *Limestone with some interbedded siltstone.*

CONFORMABLE CONTACT

BRUCE FORMATION§

7a *Polymictic conglomerate with occasional lenses of quartzite and siltstone.*
7b *Impure quartzite.*

CONFORMABLE CONTACT

(continued in next column)

(legend continued)

UPPER MISSISSAGI FORMATION

6a *Feldspathic quartzite, quartzite, arkose.*
6b *Feldspathic quartzite, arkose with pebble bands of quartz, chert, jasper.*§
6c *Greywacke and argillaceous quartzite.* §
6d *Polymictic conglomerate.* §
6e *Calcareous laminated quartzite.* §

MIDDLE MISSISSAGI FORMATION

5a *Greywacke and argillaceous quartzite with minor siltstone, argillite.*
5b *Quartzite with greywacke, siltstone, argillite.* §
5c *Argillite with minor quartzite and greywacke.* §

LOWER MISSISSAGI FORMATION

4a *Feldspathic quartzite, arkose.*
4b *Polymictic conglomerate.* §
4c *Oligomictic conglomerate.* §

GREAT UNCONFORMITY

ARCHEAN

3 *Granite regolith.*††††

ALGOMAN

YOUNGER

2a *Massive granite, quartz monzonite, granodiorite, and allied rock types with or without mafic inclusions.*
2b *Porphyritic granite, quartz monzonite, etc.*
2c *Aplite dikelets common (individual dikelets too small to show on map).*

INTRUSIVE CONTACT

OLDER

2d *Variable granite, granite gneiss, and allied rock types with occasional mafic inclusions (probably partly of metamorphic origin).*

INTRUSIVE CONTACT

KEEWATIN (?)

1 *Undifferentiated metavolcanics and metasediments (as inclusions in granite).*
1a *Metasediments, quartzite, greywacke.*

Cu	*Copper*
hem	*Hematite*
q	*Quartz*
S	*Sulphide mineralization*
U	*Uranium*

**Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured parts of the map.*

***Bedrock geology. Outcrops and inferred extensions of each rock map unit are shown respectively in deep and light tones of the same colour. Where in places a formation is too narrow to show colour and must be represented in black, a short black bar appears in the appropriate block.*

†*Probably equivalent to Post-Huronian mafic intrusions.*

††*Probably equivalent to parts of Lower and Middle Mississagi Formations.*

†††*All Post-Huronian mafic intrusions in the Blind River-Elliot Lake area were classified as Keweenawan but age-determinations indicate the bulk of these are older.*

††††*Granite regolith takes the colour of the underlying parent rock.*

§ *Occurs on adjacent sheet; Map 2028, or Map 2186.*

Map 2185

McGIVERIN and ESTEN TOWNSHIPS

ALGOMA DISTRICT

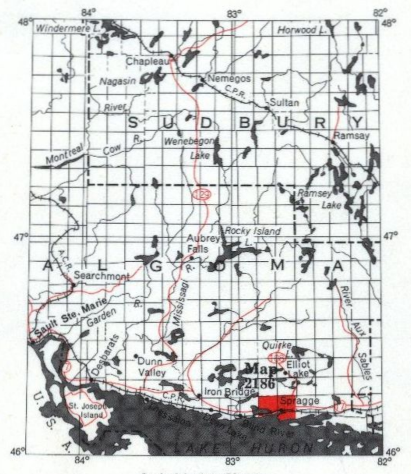
Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles
Metres 1000 0 1 2 3 Kilometres
Feet 1000 0 5,000 10,000 Feet

ONTARIO
DEPARTMENT OF MINES

HON. ALLAN F. LAWRENCE, *Minister of Mines*
D. P. Douglass, *Deputy Minister* J. E. Thomson, *Director, Geological Branch*

Map 2186
Long & Spragge Townships &
Part of Indian Reserve No. 7



Scale 1 inch to 50 miles
NTS reference 41J/2, 41J/7

LEGEND

CENOZOIC*

RECENT

Swamp, lake, and stream deposits.

PLEISTOCENE

Gravel, clay, till, sand.

UNCONFORMITY

PRECAMBRIAN**

PROTEROZOIC

KEWEENAWAN

14 *Olivine diabase.*

INTRUSIVE CONTACT

FELSIC INTRUSIVE ROCKS

CUTLER GRANITE

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INTRUSIVE CONTACT

METAMORPHIC ROCKS

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METAMORPHIC CONTACT
(Not visible in map area)

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UNCONFORMITY

BRUCE GROUP

ESPANOLA FORMATION

Bruce Limestone.

8 *Limestone with some interbedded siltstone.*

CONFORMABLE CONTACT

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CONFORMABLE CONTACT

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YOUNGER

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INTRUSIVE CONTACT

OLDER

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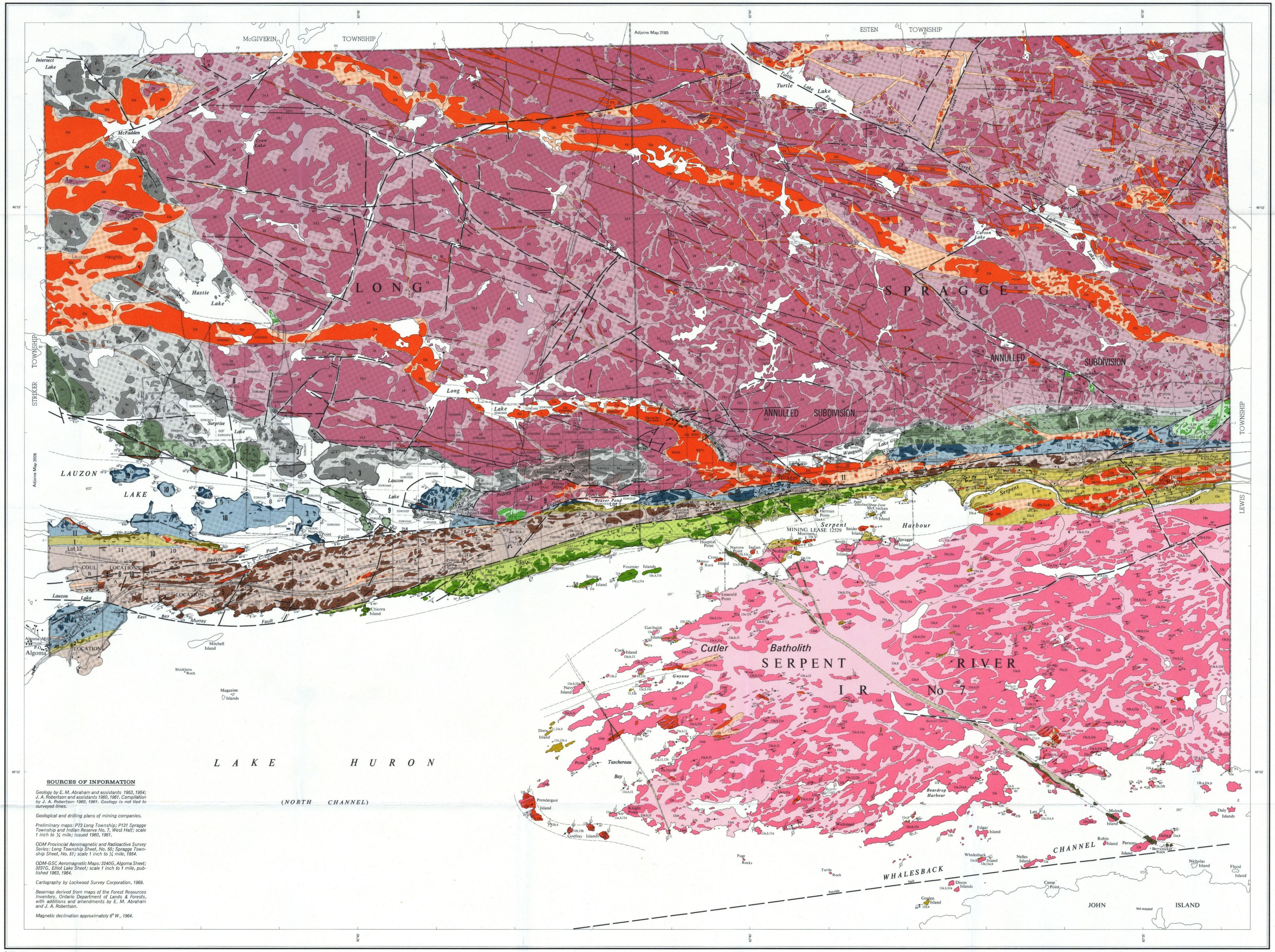
§Occurs on adjacent sheet; Map 2028



SOURCES OF INFORMATION

Geology by E. M. Abraham and assistants 1953, 1954; J. A. Robertson and assistants 1960, 1961. Compilation by J. A. Robertson 1960, 1961. Geology is not tied to surveyed lines.

Geological and drilling plans of mining companies.

Preliminary maps: P73 Long Township; P131 Spragge Township and Indian Reserve No. 7, West Half; scale 1 inch to ¼ mile; issued 1960, 1961.

ODM Provincial Aeromagnetic and Radioactive Survey Series: Long Township Sheet, No. 50; Spragge Township Sheet, No. 51; scale 1 inch to ¼ mile, 1954.

ODM-GSC Aeromagnetic Maps: 2240G, Algoma Sheet; 3237G, Elliot Lake Sheet; scale 1 inch to 1 mile, published 1963, 1964.

Cartography by Lockwood Survey Corporation, 1969.

Basemap derived from maps of the Forest Resources Inventory, Ontario Department of Lands & Forests, with additions and amendments by E. M. Abraham and J. A. Robertson.

Magnetic declination approximately 6° W., 1964.

SYMBOLS

- *Glacial striae.*
- *Small bedrock outcrop.*
- *Area of bedrock outcrop.*
- *Bedding, top unknown; (inclined, vertical).*
- *Bedding, top indicated by arrow; (inclined, vertical, overturned).*
- *Bedding top (arrow) from grain gradation; (inclined, vertical, overturned).*
- *Bedding top (arrow) from cross bedding; (inclined, vertical, overturned).*
- *Lava flow; top (arrow) from pillows shape and packing.*
- *Lava flow; top in direction of arrow.*
- *Schistosity; (horizontal, inclined, vertical).*
- *Schistosity; dip unknown.*
- *Gneissosity (horizontal, inclined, vertical).*
- *Foliation; (horizontal, inclined, vertical).*
- *Geological boundary, observed.*
- *Geological boundary, position interpreted.*
- *Fault; (observed assumed). Arrows indicate horizontal movement.*
- *Jointing; (horizontal, inclined, vertical).*
- *Drag folds with plunge.*
- *Anticline, syncline, with plunge.*
- *Drill hole; (vertical, inclined).*
- *Drill hole; (projected vertically, projected up dip).*
- *Drill hole completed to basement; uraniferous quartz-pebble conglomerate of marginal to submarginal grade.*
- *Drill hole completed to basement; little or no uraniferous quartz-pebble conglomerate.*
- *Drill hole not completed to basement.*
- *Vein, vein network. Width in feet.*
- *Orebody projected to surface.*
- *Shaft; depth in feet.*
- *Muskeg or swamp.*
- *Railway.*
- *Motor road. Provincial highway number encircled where applicable.*
- *Other road.*
- *Trail, portage, winter road.*
- *Building.*
- *Township boundary, with mileposts, approximate position only.*
- *Claim line, surveyed, approximate position only.*
- *Lot, concession or section line, approximate position only.*
- *Property boundary, approximate position only.*
- 11 *Location of mining property, surveyed. See List of Properties.*

PROPERTY LIST*

LONG TOWNSHIP

3. Confederation Mining Corporation.
4. Duffie, J. W.
5. Hirshhorn, Joseph H.
6. Langs, John F. (Co-exec)
7. Murray, C. L.
8. Preston Mines Limited.
9. Rio Algom Mines Limited.
10. Wettlaufer Engineering Div., Pioneer Engineering and Manufacturing Co.

SPRAGGE TOWNSHIP

11. Rio Algom Mines Limited.

*As of 31 December 1966.

Published 1970

Map 2186

LONG and SPRAGGE TOWNSHIPS and Part of INDIAN RESERVE No. 7

ALGOMA DISTRICT

Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles
Metres 1000 0 1 2 3 Kilometres
Feet 1000 0 5,000 10,000 Feet