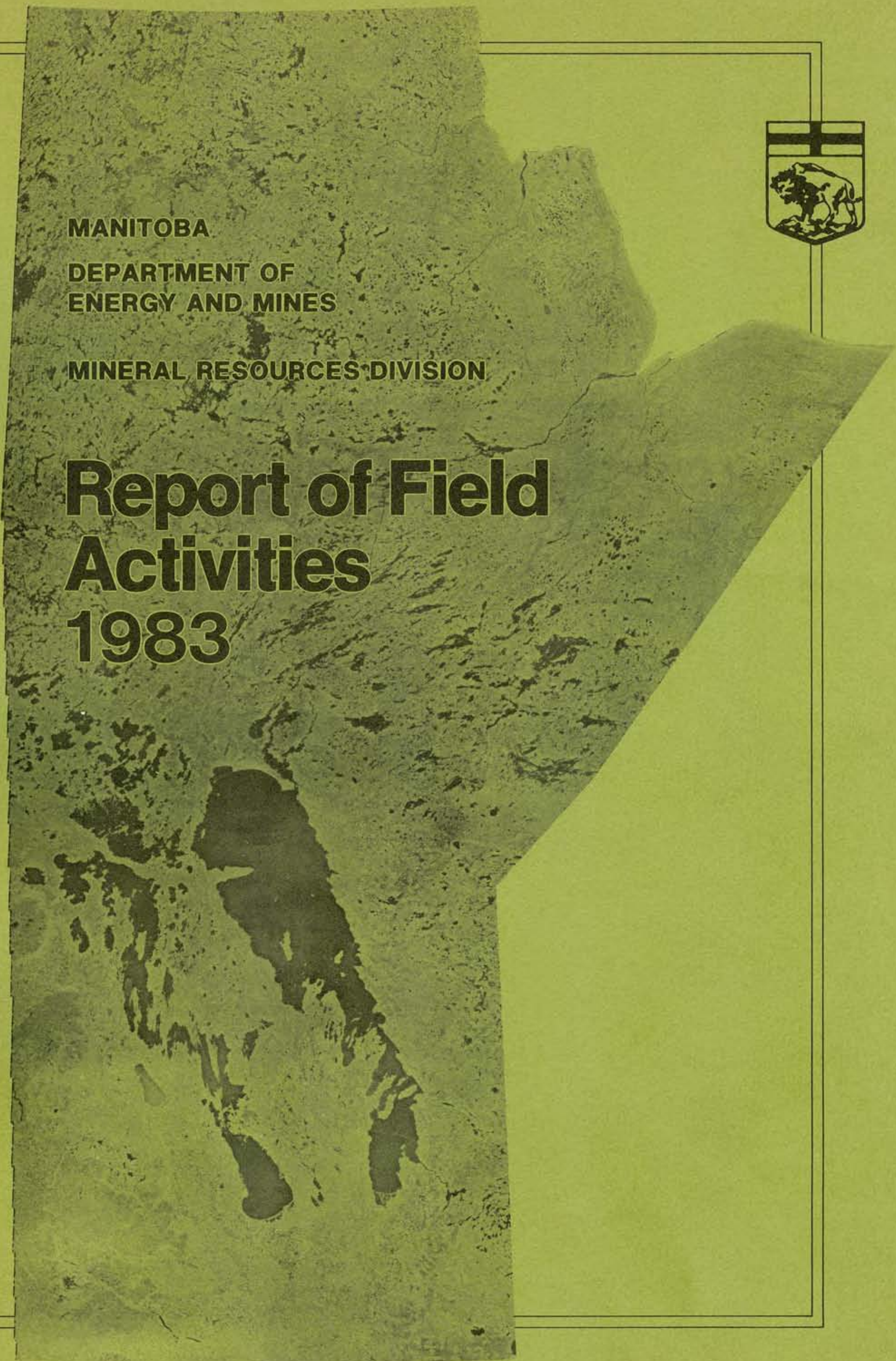
MANITOBA

DEPARTMENT OF
ENERGY AND MINES

MINERAL RESOURCES DIVISION

Report of Field Activities 1983



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GEOLOGICAL SERVICES BRANCH

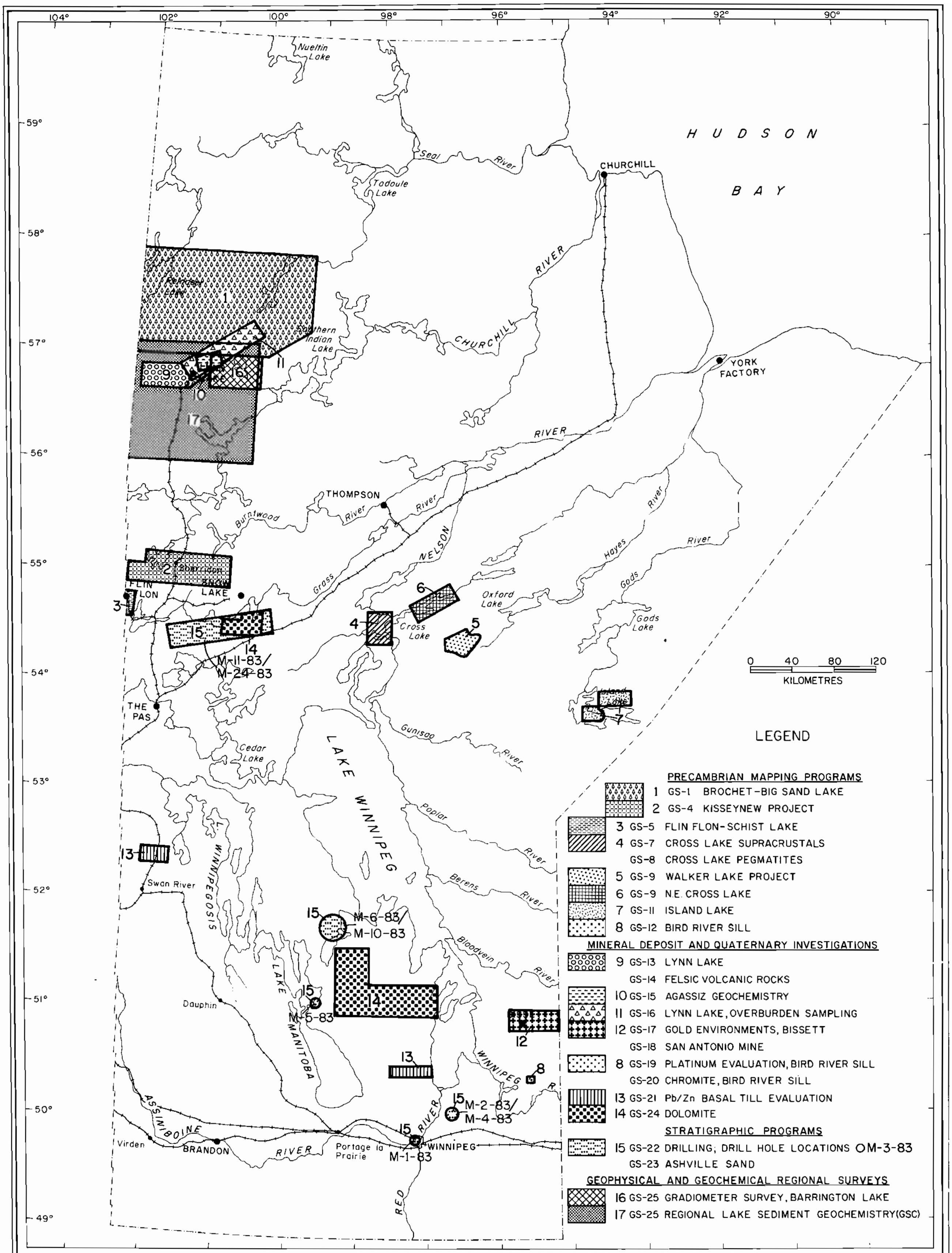


Figure GS-1: Location of field projects 1983.

SUMMARY

The principal focus of programming during the 1983 field season continued to be the Lynn Lake district, where there is an urgent need to find new ore deposits that could sustain the existing communities' mining infrastructure now that the reserves in the operational mines are dwindling.

Activities conducted by the Provincial Geological Services Branch were substantially augmented by ground and airborne surveys mounted by the Geological Survey of Canada under the umbrella of the cost-shared Canada/Manitoba Interim Mineral Agreement (1983/85), signed June 17th, 1983. During the 2-year period of the Agreement, Canada and the Province will direct approximately one million dollars of operational expenditures to geoscientific, geophysical, geochemical and mineral deposit oriented survey activities in the Lynn Lake district to complement and assist in targetting mineral exploration in that area,

Within the Lynn Lake region, much of the initial groundwork in the greenstone terrain has been completed by the Province during the period 1976-82, as a result of which 1:50 000 scale geological maps are now available for the entire area south of latitude 57°. In 1983, geological mapping was completed for the Brochet-Big Sand Lake granitoid and gneissic terrain to the immediate north of Lynn Lake. Previous surveys had indicated a potential for stratiform base metal mineralization similar to that anticipated in the Kisseynew region. However, no new sulphide occurrences were encountered this year and the overwhelming predominance of high-grade gneisses and deep-seated granitic rocks is not encouraging from a mineral deposit perspective,

Mineral deposit studies in the greenstone belt focussed on geological settings deemed favourable for base and precious metal occurrences. Stratabound gold mineralization of probable exhalative origin at the Agassiz deposit is now known to occur within a sequence of sulphide-bearing rocks that include ultramafics, metasediments and oxide iron formation that has been followed from west of Agassiz to north of Arbour Lake where similar mineralization has been identified. Sporadic occurrences of gold mineralization have now been identified at this stratigraphic level over a strike length of 15 km, and this sequence is known from regional geological studies and geophysical signatures (INPUT, gradiometer and total field magnetic surveys) to extend for a further 20 km east of Arbour Lake.

Geochemical studies included lithogeochemistry of host rocks to selected base metal deposits, alteration studies around the Agassiz deposit and biogeochemical studies over several other gold deposits. Samples of spruce trees, Labrador tea and humus material were collected at several localities in the Lynn Lake district and initial results, showing gold, antimony and arsenic anomalies downslope (north) of the Agassiz mineralized zone, point to the potential usefulness of this technique in this sparsely exposed terrain. Samples collected from the Lynn Lake Rhyolitic Complex in 1982 were analyzed to determine if geochemical alteration haloes existed adjacent to the known sulphide mineralization.

Till sampling, initiated in 1982, was augmented by an additional 255 holes dug in the Agassiz deposit-Minton Lake area in order to locate down-ice dispersion of heavy minerals from ore deposits buried beneath the overburden. Quaternary stratigraphic investigations continued in the area, and biogeochemical sampling was augmented by 40 samples taken from frozen peat in the sphagnum bog south of the Agassiz mineralized zone.

The Geological Survey of Canada undertook regional lake sediment surveys for the Granville Lake area, providing a sample density of one per 13 km^2 in the south and one per 7 km^2 in the north over the greenstone terrain. A portion of the water samples obtained during the survey were analyzed by the Manitoba Department of Environment as part of their evaluation of the impact of acid rain on the Province. The sediment analyses will be reported on in early 1984, with data presentation in the customary format as 1:250 000 element abundance and ratio maps.

Airborne gradiometer surveys were extended east from the 1982 test site, to encompass a 1500 km^2 area including Barrington Lake. This completes the vertical gradient magnetic coverage for the entire east-trending segment of the greenstone belt from Lynn Lake to longitude 100°. Ground EMP measurements were made at selected sites in co-ordination with Sherritt Gordon Mines Ltd.

Regional surficial mapping was also undertaken by the GSC to provide background information for the analysis of the lake sediment surveys and to add a regional perspective to the basal till studies undertaken by the Province.

Geological mapping of the Churchill Province in Manitoba is now well advanced; however, there continues to be an acute lack of baseline isotopic data that can be used to confirm the Proterozoic/Hudsonian age of the component supracrustal assemblages. To address this need, the Provincial Geological Services Branch and Geological Survey of Canada have embarked upon a uranium/lead zircon dating program, which this year focussed on the volcanic and intrusive units of the Lynn Lake and Flin Flon belts and the selection of samples amenable to zircon concentration.

Detailed 1:20 000 scale geological mapping in the Flin Flon-Schist Lake area completed the initial coverage assigned for this project, defined the stratigraphic setting of the Flin Flon ore deposit, and established important new guidelines for future exploration in the area.

In the Lobstick Narrows area, detailed structural and stratigraphic investigations laid the foundation for more regional mapping - on the south flank of the Kisseynew belt - which will be of critical importance in targetting the search for stratiform base metal, tungsten and gold mineralization from Kisseynew to File Lakes.

At Cross Lake, geological mapping, conducted in conjunction with the rare element pegmatite investigation and vanadium, titanium and anorthosite evaluation, succeeded in establishing a sound stratigraphic and structural framework for the area as a reference base for future work scheduled for this district. More regional mapping completed coverage for the Lawford and Walker Lake area and documented in detail barren greenstone occurrences on northeast Cross Lake and unique sapphirine mineral occurrences on Sipiwesk Lake. No pegmatites of economic significance were encountered in this area. However, rare element pegmatite investigations, conducted at Cross Lake in co-operation with the Department of Earth Sciences, University of Manitoba, established an intrusive history for the belt, confirmed the regional zonation of pegmatite minerals, and pointed to the eastern group of pegmatites as being the most fractionated and economically significant segment of the pegmatite field.

On Island Lake, activities were restricted to completing the mapping of the entire western half of the greenstone belt. Mineralized zones were encountered in siliceous metasediments and associated with felsic intrusives near Henderson Island.

In southeastern Manitoba, gold-oriented mineral deposit investigations, conducted in the Wallace Lake-Bissett district, were augmented by detailed geochemical sampling in the San Antonio Mine. Underground mapping resulted in a reinterpretation of the factors controlling the occurrence of gold-bearing quartz veins and suggested the mine "package" constitutes a volcanogenic (exhalative?) association of felsic and mafic tuffs (with only minor diabase), with good strike length, and on the surface, zones to the east that may not have received appropriate attention. A similar stratigraphic control to mineralization is indicated for the iron formation, carbonates, and associated "paragabbros" and metasediments that extend along the north flank of the Rice Lake Greenstone Belt from Siderock Lake to at least the Jeep deposit.

The second phase of the platinum metal group evaluation of the Bird River Sill was concluded with the cutting of a 400 m slice across the intrusion. Detailed stratigraphic mapping of the sill has outlined lower dendritic and layered units, which remain to be sampled.

The evaluation of the chromite deposits in the Bird River Sill focussed on the "Chrome" and "Page" properties, and entailed a detailed stratigraphic analysis of the intrusion and sampling of all chrome-bearing units. The mapping indicated a 60 metre wide zone containing a total of 26 chromite-bearing layers, which can be grouped into 6 zones, each with diagnostic characteristics that are consistent along strike lengths of over 1.5 km and possibly up to 4 km. Detailed analysis of individual chromites, chromitite seams and intervening host rock is continuing, partly with support of work contracted by the GSC to Dr. F. Hawthorne, Department of Earth Sciences, University of Manitoba.

The evaluation of the lead-zinc potential of Paleozoic rocks is continuing with geochemical analysis of drill core and basal till sampling of selected profiles in the Interlake area.

Industrial minerals investigations entailed mapping of dolomite outcrops and quarries in the central Interlake and Wekusko-The Pas area, providing additional data on the vast resources of dolomite in the province. Drilling of high-calcium limestone at Dolly Bay, near Oakview, gave mixed results as to the extent of reserves in the area. A report on potash deposits in southwestern Manitoba was completed and indicated reserves approaching one billion tonnes grading better than 18% K_2O as sylvite.

The stratigraphic mapping and core hole program for 1983 involved a total of 24 core holes and five separate projects. A single hole was drilled in the City of Winnipeg area to aid in evaluating groundwater hydrogeology in the vicinity of an abandoned sanitary landfill site; this hole also provided data for the limestone and dolomite resources studies. Three holes were drilled in the Green Oak area to ground-truth a reflection seismic profile run by the Geological Survey of Canada in 1982, in the vicinity of an anomalous Precambrian high. A single drill hole in the Dolly Bay area of Lake Manitoba tested the Elm Point limestone beds to determine the quality of the high-calcium limestone deposits and the structural control for distribution of limestone and dolomite beds in the area. Five holes were located in the Lake St. Martin area to aid in interpretation of the complex structure of the crater fill in this probable meteorite impact feature. Finally, fourteen holes were drilled in the general Simonhouse Lake-Wekusko Lake area to determine the nature of Precambrian basement rocks in this area of thin Paleozoic sedimentary cover, and specifically to ground-truth a number of anomalies outlined by recent Federal-Provincial airborne gradiometer surveys. Ground magnetometer profiles were run to pinpoint drill targets. Phanerozoic core from these holes also provided data for the dolomite resources study and structural and stratigraphic Phanerozoic studies.

In the late fall, Branch personnel commenced a car-borne radiation survey of SE Manitoba to obtain measurements of background radiation from bedrock sources. Results of this survey are required by the Environmental Management Services Branch as part of their program to evaluate the sources and levels of radiation in ground waters from the Powerview/West Hawk area.

Several field tours were conducted in various parts of the province for the benefit of company geologists and geologists from the GSC, the latter engaged in compilation work for the Canadian contribution to the Decade of North American Geologypublications.

Branch programming was again augmented by the co-operative research activities of NASA, and by isotopic work conducted by the universities of Manitoba, Windsor, Alberta, the Royal Ontario Museum, and GSC programs in various sectors of the Province.

W.D. McRitchie. Sept. 29/1983

GS-1 BROCHET-BIG SAND PROJECT

(NTS 64F, 64G west half)

by D.C.P. Schledewitz

INTRODUCTION

Regional mapping has been completed within the project area bounded by the Manitoba-Saskatchewan border on the west and, on the east, by the western limit of the Southern Indian Lake project. Reconnaissance-scale mapping was carried out in the southwest quarter of the Big Sand Lake map area (NTS 64G). Mapping at a scale of 1:100 000 was carried out in the area of Jordan Lake and the southern part of Big Sand Lake. This mapping extends the 1:100 000 mapping of the Le Clair Lake region (Schledewitz, 1982) to the north and northeast. Additional mapping at a scale of 1:100 000 was also carried out in the Paskwachi Bay area (Reindeer Lake).

GENERAL GEOLOGY

Bedrock exposures in the Jordan Lake to Le Clair Lake and Big Sand Lake area comprise the following suite of rocks:

1) medium grey biotite (12-15%) ± garnet ± sillimanite-feldspar-quartz gneiss to migmatite (unit 3a)
2) light grey biotite (5-3%) ± magnetite-feldspar-quartz gneiss with sporadic hornblende-bearing and/or biotite-rich layers (unit 4)
3) grey biotite (10%) + garnet ± cordierite + pyrite + feldspar + quartz (35-4%) gneiss (unit 3b)
4) gneissic diorite to hornblende-biotite migmatite with gneissic diorite lenses (unit 7a and 7a)
5) layered amphibolite, metagabbro, metabasic rocks, generally agmatitic (unit 5)
6) light to medium grey, medium- to coarse-grained biotite ± magnetite-quartz monzonite, weakly to very well foliated and/or lineated (unit 9)
7) olive, honey-brown coarse-grained to megacrystic pyroxene-hornblende-biotite-monzonite to monzogranite with localized dioritic phases (unit 12)
8) honey-buff medium-grained leucocratic quartz monzonite and/ or medium-grained green anorthosite to anorthositic gabbro (restricted to the south end of Big Sand Lake) (Unit 12a)
9) brownish-pink coarse-grained to megacrystic hornblende (5-8%)-biotite (5-8%) monzogranite (unit 12b)
10) white, medium- to coarse-grained pegmatitic biotite (5-8%) ± garnet granite (unit 14)
11) metabasic dykes (unit 15)
12) pink, coarse-grained to megacrystic granite ± hornblende (3%) + biotite (5%) (unit 16)

In the region immediately south of Jordan Lake, metagabbro to metabasic rocks occur as sills within a zone of biotite-garnet-sillimanite-feldspar-quartz gneiss (Fig. GS-1-1). The metabasic rock to metagabbro in turn forms numerous inclusion lenses in a biotite leucotonalite. This intrusion complex in turn is agmatitic, occurring as blocks within a vein network of white granite. A gneissic diorite to hornblende-biotite migmatite (units 7 and 7a) strikes easterly to north of east across the south half of Jordan Lake. However, the age relationship of the gneissic diorite and hornblende-biotite migmatite with garnet-biotite gneiss and metagabbro sills is uncertain.

The region between Jordan Lake and Le Clair Lake is a complex of: i) medium- to coarse-grained grey biotite (5%) ± magnetite-quartz monzonite (unit 19) with large- and small-scale lenses of metadiorite to gneissic diorite; ii) diorite, biotite (8%)-garnet gneissic diorite, thinly interlayered amphibolite; and iii) a grey, fine- to medium-grained biotite (5-8%)-feldspar-quartz granoblastic rock. This zone, including the gneissic diorite and hornblende-biotite migmatite (unit 7a) on the south half of Jordan Lake, is comparable to lithologies (Fig. GS-1-2) described for Paskwachi Bay on Reindeer Lake at the extreme western boundary of the Brochet-Big Sand Lake Project (Schledewitz, 1982).

The gneissic diorite to hornblende-biotite-migmatite exposed at the southeast end of Jordan Lake was intruded by an olive, honey-brown megacrystic pyroxene-hornblende-biotite monzonite to monzogranite (unit 12) (Fig. GS-1-1). A pinkish brown hornblende-biotite-megacrystic monzogranite (unit 12b) appears to be an altered phase of the olive, honey-brown monzonite to monzogranite. The contact between the pyroxene-hornblende-megacrystic monzonite to monzogranite and the intrusive complex of the biotite ± magnetite quartz monzonite, between Jordan Lake and Le Clair Lake, is a fault contact that trends west of north. The presence of a pinkish brown megacrystic monzogranite as sills within the biotite ± magnetite intrusive complex to the west of the fault zone 4 km south of Jordan Lake indicates the pyroxene-hornblende monzogranite is younger.

The olive, honey-brown pyroxene-hornblende-monzonite to monzogranite contains megacrysts of perthitic microcline in a matrix of coarse-grained pyroxene-hornblende-biotite-plagioclase and quartz. This rock has been dated by the rubidium-strontium method and has yielded an age of 1815 ± 55 Ma (Clark, 1981). The body of the pyroxene-hornblende monzonite to monzogranite observed southeast of Jordan Lake extends east and can be traced across the south end of Big Sand Lake. The southern contact of this pyroxene-hornblende-monzogranite lies immediately south of Big Sand Lake (Fig. GS-1-1), where it is in contact with the grey biotite ± magnetite quartz monzonite (unit 9). The biotite-quartz monzonite at the contact is hematized, potassium metasomatized and exhibits a strong foliation with flattened quartz grains and an incipient cataclastic texture.

The exposures of the pyroxene-hornblende monzonite to monzogranite on Big Sand Lake are inhomogeneous. Gradational variations are common between the olive, honey-brown pyroxene-hornblende monzonite (unit 12) to monzogranite and a hornblende-biotite-monzogranite (unit 12b) with pinkish brown to pink potassium feldspar megacrysts with a rusty brown weathering. Inclusion blocks of metadiorite, which contain variable amounts of basic inclusions, occur sporadically. The size of these inclusions varies from 1 to 5 metres to 5 by 100 metres. The larger inclusions have a layered aspect, comprising sills of pink aplite interleaved with the granoblastic medium- to coarse-grained metadiorite and lenses of an olive, honey-brown coarse-grained to pegmatitic hornblende ± pyroxene monzonite.

The nature of the northern contact of the pyroxene-hornblende monzonite to monzogranite as exposed on the south half of Big Sand Lake is variable (Fig. GS-1-1). The pyroxene-hornblende monzonite to monzogranite is in contact with an intrusion complex of basic rocks (unit 5) that is best developed on the eastern side of Big Sand Lake, where it is 5 to 7 km wide and narrows to 1 km at its southwestern extent (Fig. GS-1-1). The contact between these rocks is not sharp but appears to contain numerous granite sills and zones of alteration within the pyroxene monzogranite. A pink, coarse-grained, porphyritic to locally coarsely porphyritic biotite granite to quartz monzonite lies to the north of this contact zone.

The basic intrusive complex comprises a metagabbro (unit 5), green-coloured anorthosite to anorthositic gabbro (unit 12a), honey-buff leucotonalite and an intrusive breccia zone. The intrusive breccia zone comprises blocks of metagabbro, which contain variable amounts

Figure GS-1-1: **Map units based on Map 1983M**

16	- Biotite ± hornblende coarse grained to megacrystic granite
15	- Metadiorite, metadiabase
14	- White granite ± garnet
13	- Pyroxene-hornblende monzonite to monzogranite
12a	- Anorthosite to anorthositic gabbro
12b	- Hornblende-biotite monzonite to quartz monzonite
9	- Biotite ± magnetite quartz monzonite
9a	- Hybrid gneiss of grey biotite ± magnetite quartz monzonite and gneissic diorite
9b	Gneissic biotite ± magnetite quartz monzonite, red in colour due to hematization
8	Biotite ± hornblende tonalite
7	- Gneissic diorite
7a	- Biotite ± hornblende granodiorite gneiss
5	- Amphibolite, metagabbro, locally agmatitic
4	- Fine grained grey ± magnetite-quartz-feldspar gneiss
3a	- Light grey-biotite-garnet-feldspar-quartz gneiss
3b	- Biotite ± cordierite ± sillimanite ± garnet ± disseminated pyrite-feldspar-quartz gneiss
2	- Biotite ± garnet ± graphite-feldspar-quartz gneiss
	- Zones of granulite facies metamorphic mineral assemblages
	- Occurrences of pyrite

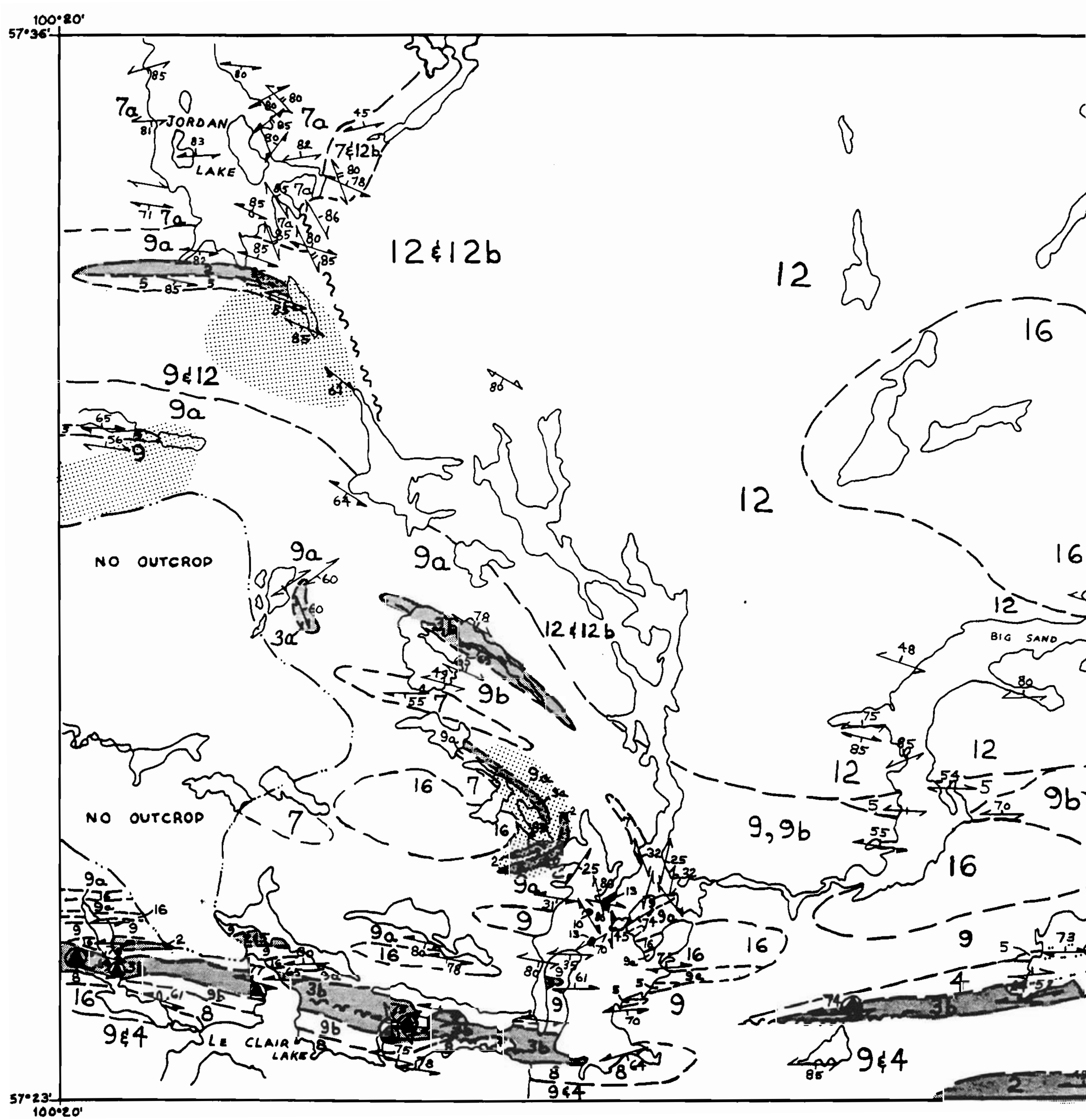
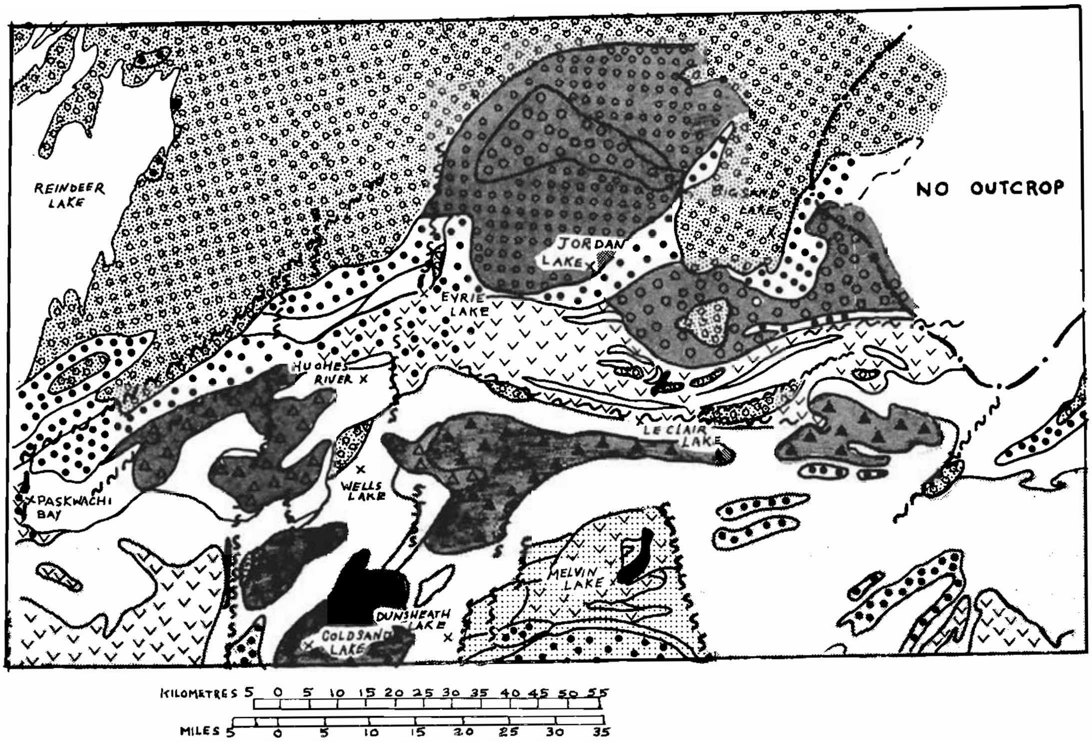


Figure GS-1-1: Outline geology of the LeClair Lake, Jordan Lake and Big Sand Lake regions.

A complete version of Figure GS-1-1 is included at the end of this file.



- Region with abundant group 3 granite (unit 16) intrusive rocks with inclusions of group 2 biotite megacrystic granite (unit 13) and group 1 dioritic gneiss and granodioritic gneiss (unit 7, 7a)

Areas of metadiabase and metadiorite (unit 15)

- Region of group 2 syn- to late-metamorphic megacrystic granites to monzonites
  - Biotite granite with pink megacrysts of potassium feldspar (unit 13)
  - Pyroxene-hornblende monzonite to monzogranite with olive, honey-brown megacrysts of potassium feldspar (unit 12)
  - Hornblende-biotite-granite to monzogranite with pinkish brown megacrysts of potassium feldspar (unit 12b)
  - Biotite ± hornblende white megacrystic granite with white megacrysts of potassium feldspar (unit 11)

- Region with areas of conglomerate and meta-arkose (units 6, 6a), locally exhibits areas of lower to middle amphibolite facies of metamorphism

- Region of varied suite of quartzofeldspathic gneisses (units 4, 3a, 3b and 2) as inclusions in a granodioritic gneiss (unit 7a) and grey quartz monzonite (unit 9)
  - Grey ± magnetite-biotite quartz monzonite (unit 9) (group 1 intrusive rock)
  - Meta-diorite and granodioritic gneiss (units 7a, 7a) (group 1 intrusive rocks)

- Region of ± graphite ± garnet ± sillimanite-biotite feldspar-quartz gneiss with intrusions of biotite ± hornblende tonalite (unit 8), both rocks contain 40 to 80 per cent white leucogranite (unit 14)

Figure GS-1-2: *Lithologic zonation of the Brochet (NTS 64F) and Big Sand Lake (NTS* 64G, *west half) map sheets and schematic representation of structural relationships.*

of inclusions of basic rock, within a metadiorite. This intrusive complex occurs as blocks within an agmatite. The young intrusive component of the agmatite is an olive, honey-brown, coarse-grained to pegmatitic hornblende ± pyroxene monzonite to monzogranite and/or a buff, honey-brown, medium- to coarse-grained leucocratic tonalite. This agmatitic intrusion breccia is similar to the agmatitic basic intrusion breccia observed at the south end of Jordan Lake, 35 km to the west.

The agmatitic intrusion breccia at Big Sand Lake is intruded by post-agmatite intermediate to basic dykes (unit 15), which are locally foliated and deformed. These dykes are similar in character to post-migmatite basic dykes observed in the Brochet map area to the east at Paskwachi Bay, Eyrie Lake and immediately north of Le Clair Lake (Fig. GS-1-2).

The youngest rock type in the Big Sand Lake and Jordan Lake area is a porphyritic to coarsely porphyritic biotite-bearing granite with sporadic occurrences of hornblende. This rock is cut by aplite and granite pegmatite dykes.

The rocks of the Jordan Lake to Le Clair Lake and Big Sand Lake areas were subjected to a period of deformation and metamorphism prior to the intrusion of the basic dykes and the porphyritic granite. The nature of the early deformation is uncertain. Minor structures are outlined by deformed metamorphic layering. The minor structures vary from isoclinal folds to more open structures. The grade of metamorphism as indicated by the mineral assemblages in the ± garnet ± sillimanite + biotite-feldspar-quartz gneiss to migmatite (units 2, 3a and 3b), are consistent with the upper amphibolite facies of metamorphism. Very locally and sporadically, there are indications that granulite facies conditions were reached. Immediately north of Le Clair Lake, the preservation of the mineral pair hypersthene and garnet in a biotite-bearing quartzo-feldspathic rock is indicative of granulite facies of metamorphism. Plagioclase and potassium feldspar in these rocks are olive, honey-brown and have a pearly to greasy lustre. This appearance is characteristic of quartzo-feldspathic rocks in a granulite terrain. The sporadic and discontinuous nature of zones exhibiting granulite facies metamorphism is consistent with a post-granulite facies deformation. The textures and structures of the rocks affected by the post-granulite facies deformation occurred initially at high temperatures consistent with the upper amphibolite facies of metamorphism. This second period of deformation is characterized by major shear belts, very tight minor folds, extreme rodding of minerals and inclusions in igneous rocks. Basic dykes (unit 15) were emplaced during this period of deformation. The basic dykes are altered and deformed. The dykes are weakly foliated to foliated, but primary igneous zonations are still visible. Primary minerals such as pyroxene have been replaced by more hydrous minerals such as hornblende and biotite. The dykes are deformed by being either faulted or boudinaged The emplacement of the dykes may mark a change in the style of deformation to a more brittle style characterized by faulting.

REGIONAL CONSIDERATIONS

The regional mapping carried out in the Big Sand Lake area in 1983, when combined with regional mapping carried out by McRitchie (1977) and Schledewitz (1981), indicates an eastward extension of lithologies (Fig. GS-1-2), and a comparable sequence of geological events as observed in the Brochet map area (Schledewitz, 1982).

In summary, a zone of graphite ± garnet ± sillimanite-biotite-feldspar-quartz gneiss (unit 2), intruded by a biotite tonalite (unit 8) and also a white leucocratic granite to quartz monzonite (unit 14), occurs in the southern third of the Brochet-Big Sand map area (NTS 64F, 64G west half). A zone of interlayered gneiss of varied compositions forms discontinuous segments within a biotite ± magnetite quartz monzonite (unit 9) across the central third of the map area. The gneissic sequence comprises layers of:

i) biotite (5-20%) + garnet ± magnetite + feldspar +quartz (unit 3b);
ii) hornblende ± garnet + feldspar + quartz (unit 3b);
iii) hornblende ± magnetite + feldspar + quartz (unit 4);
iv) biotite (5-12%) + magnetite + feldspar + quartz (unit 4);
v) discontinuous amphibolite and metabasic lenses (sills?) (unit5);
vi) biotite (10-15%) + sillimanite ± garnet ± cordierite ± feldspar ± quartz (unit 3b).

Metavolcanic-derived gneisses were observed only in the Paskwachi bay area.

Intrusive rocks constitute approximately 70 per cent of the map area. The intrusive rocks can be subdivided into three groups. Group one comprises:

i) an intrusive complex of metadiorite and granodiorite (units 7 and 7a);
ii) a biotite ± hornblende tonalite (unit 8);
iii) a biotite ± magnetite quartz monzonite to tonalite (unit 9).

These intrusive rocks are foliated or lineated and variably gneissic to migmatitic.

The second group of intrusive rocks is coarsely megacrystic with potassium feldspar as the megacrysts. These rocks intrude rocks of group one. The rocks of group two comprise:

i) biotite (12%) ± hornblende granodiorite with white to pale pink megacrysts of potassium feldspar (unit 11);
ii) olive, honey-brown pyroxene-hornblende monzonite to monzogranite with olive, honey-brown megacrysts of potassium feldspar (unit 12);
iii) pinkish-brown hornblende-biotite monzogranite with pink to variagated pink and brown megacrysts of potassium feldspar (unit 12b):
iv) biotite (8-10%) ± magnetite monzogranite to quartz monzonite with pink megacrysts of potassium feldspar (unit 13);
v) white, leucocratic, medium-grained to pegmatitic quartz monzonite to granite (unit 14).

These rocks are weakly foliated to very well foliated in discrete zones. A set of basic dykes postdates the intrusion of the megacrystic rocks and predates the third group of igneous rocks.

The third group of igneous rocks comprises a pink megacrystic biotite (5%) ± hornblende granite to a porphyritic biotite ± magnetite granite (unit 16). These rocks exhibit a fracture cleavage and very locally a cataclastic foliation.

The large volume of granite intrusive rocks is spatially related to a batholithic complex of considerable areal extent - the Chipewyan domain. The southern edge of the Chipewyan domain extends across the northern third of the map area. The granites of group three also occur as isolated stocks in the central third of the map area.

The overwhelming abundance of intrusive rocks has, in large part, obscured many of the structures relating to earlier deformational and tectonic events. However, the following sequence appears to be consistent for the map area:

1) deposition of graphitic sediments in the southern third of the map area and a more varied suite of quartzo- feldspathic rocks to the north; localized development of metavolcanic rocks (Paskwachi Bay, Reindeer Lake);
2) intrusion of numerous sills of basic and ultrabasic rocks (unit 5);
3) intrusion of diorite to granodiorite (units 7 and 8);
4) intrusion of biotite-quartz monzonite;
5) localized deposition of conglomerate and arkosic sediments;
6) intrusion of megacrystic rocks (units 11 to 13); accompanied by high-grade metamorphism and deformation (D_1);
7) deformation along major shear zones (D_2), with related folding (Fig. GS-1-2), emplacement of basic dykes;
8) emplacement of granites and continued deformation, faulting.

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GS-2 LYNN LAKE PROJECTS: STATUS REPORT

by Herman V. Zwanzig

Regional geological mapping in the vicinity of Lynn Lake, Granville Lake and Rusty Lake was completed in 1982. Supplementary chemical sampling of the mafic volcanic rocks in the Pickerel Narrows suite (Zwanzig, 1981b) was carried out in the 1983 field season. This status report provides a listing of maps and references for the recent cycle of projects. Locations are given in Figure GS-2-1.

Remapping of the western part of the Lynn Lake Greenstone Belt was started in 1977 and continued under the Canada/Manitoba General Development Agreement (DREE) in 1978 and 1979. The following geological maps are published in final format at 1:50 000 scale:

1980-1-1 to 5 (NTS 64C/10, 11, 12, 14, 15)

A description of the volcanic rocks and related metasedimentary rocks is given in the accompanying Geological Paper 80-1 (Gilbert, Syme and Zwanzig, 1980).

Mapping was extended to the east half of the Lynn Lake Belt by H. Paul Gilbert (1979, 1980) The following maps of that area are available in preliminary format at 1:50 000 scale:

1979L-2 (part of NTS 64F/1

1980L-1 and 2 (NTS 64C/16 and 64B/13)

A report and final maps are in preparation.

Mapping of the post-volcanic metasedimentary rocks, volcanic screens and small greenstone belts in the intrusive terrane on the south margin of the Lynn Lake Belt was carried out by Zwanzig (1979, 1981a, 1981b) and Cameron (1979, 1981b) NTS areas 64C/10 and 11 are covered by final maps 1980-1-4 and 5. The following preliminary maps are available at 1:20 000 scale:

1981 L-1 (part of NTS 64C/7)

1981 L-2 (parts of NTS 64C/2 and 7)

1981 L-3 (part of NTS 64C/1)

A report is in preparation.

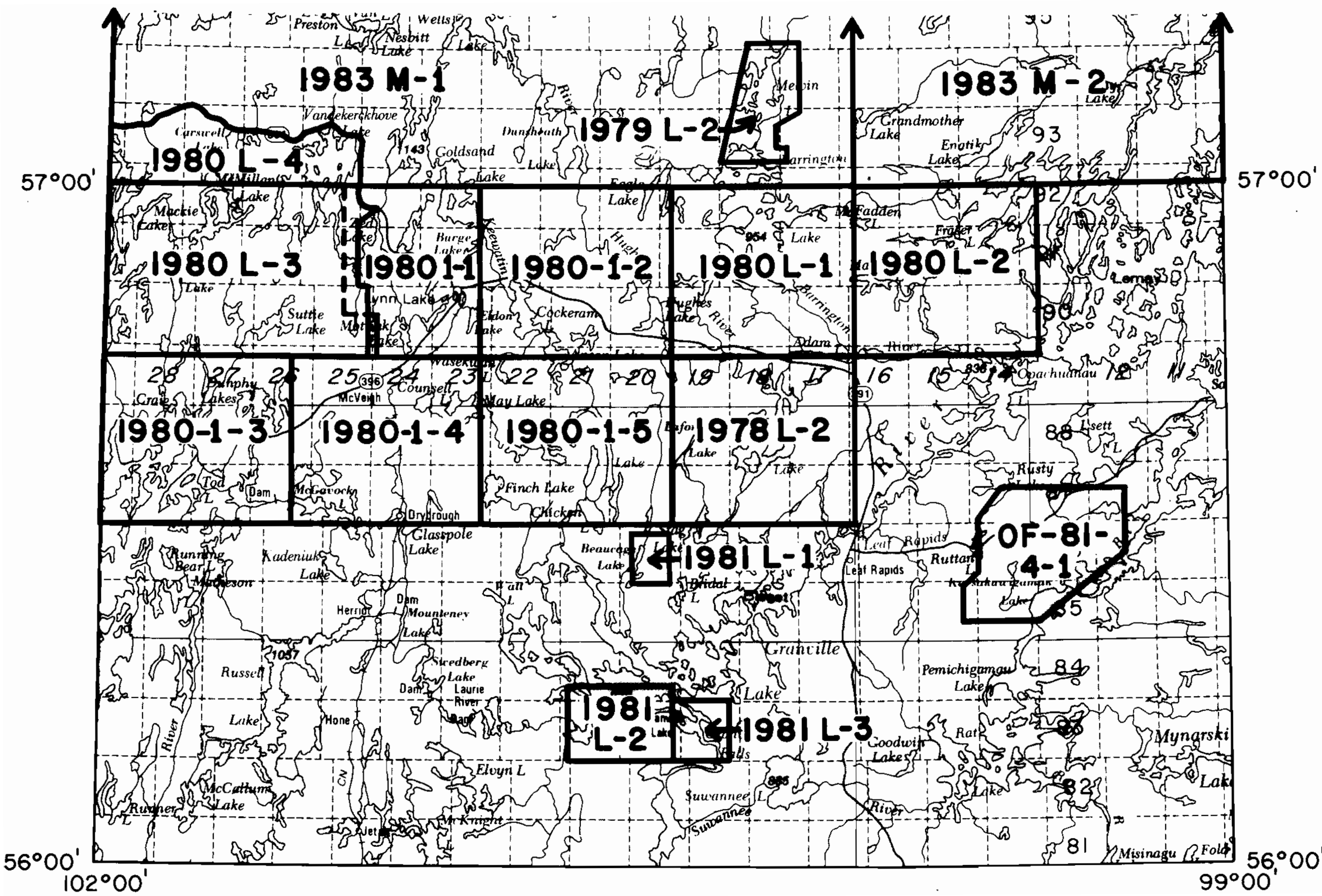

Figure GS-2-1: Location of recent mapping in the Lynn Lake region.

Granitoid terranes southeast and northwest of the greenstone belt were mapped by H.D.M. Cameron (1978, 1980 and 1981a) providing preliminary 1:50 000 scale maps:

1978L-2 (NTS 64C/9)
1980L-3 (parts of NTS 64C/13 and 14)
1980L-4 (parts of NTS 64F/3 and 4)

Revised maps and a report are in preparation.

The Ruttan Lake area was remapped by D.A. Baldwin (1982) and an Open File Report was prepared as part of a mineral deposit study. The map is available at 1:50000 scale:

OF-81-4-1 (parts of NTS 64B/5, 6, 11 and 12)

Additional work was done in the Rusty Lake area (part of 64B/12) by A.H. Bailes and E.C. Syme (1982), and in the Issett Channel area (64B/10SW) by W.D. McRitchie (1981) and in part of 64B/6 by HV.Zwanzig (1982).

A field trip guidebook of the Lynn Lake-Rusty Lake greenstone belts was prepared for the 1982 G.A.C. Winnipeg Meeting by Gilbert, Zwanzig, Chornoby and Olson (1982).

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1981b: Granville Lake Project; **in** Manitoba Mineral Resources Division, Report of Field Activities, 1981, pp. 17-21.

1982: Rat River channel; **in** Manitoba Mineral Resources Division, Report of Field Activities, 1982, pp. 11-14.

in prep. Provisional Geological Compilation, Granville Lake area (64C) scale 1:250000. Manitoba Mineral Resources Division, Geological Services Branch, Open File.

GS-3 LYNN LAKE/FLIN FLON U/Pb ZIRCON GEOCHRONOLOGY PROGRAM

by E.C. Syme

A joint Federal-Provincial geochronology project was initiated in January 1982, in which U-Pb zircon isotopic studies would be conducted in the Lynn Lake and Flin Flon greenstone belts of the western Churchill Province, During this project samples were to be collected from the greenstone belts by Provincial geologists and sample preparation, zircon separation, chemistry and isotopic analysis would be conducted by geochronologists of the Geological Survey of Canada in Ottawa, The program was conceived in order to aid in the regional tectonic and metallogenic synthesis of the area, thereby providing a better geological base for mineral exploration, It would also aid in the interpretation of Rb/Sr results (Clark, 1980).

In the winter of 1982 the initial planning for the project was carried out, with Dr. T.M. Gordon of the Geological Survey of Canada co-ordinating efforts at the Federal level while Dr.H.V.Zwanzig, E.C. Syme and H.P. Gilbert of the Manitoba Mineral Resources Division determined the rock units to be sampled in the Lynn Lake belt. During the 1982 field season E.C. Syme and A.H.Bailes collected material from four separate rhyolite bodies and two pre-Sickle granitoid plutons in the Lynn Lake belt (Fig. GS-3-1), and from two micrographic tonalites in a differentiated gabbro sill in the Flin Flon belt. Zwanzig collected another pre-Sickle granitoid sample from the Lynn Lake belt. These samples, plus those from a Missi felsic ash flow and synvolcanic felsic hypabyssal intrusion at Wekusko Lake (collected by Gordon) and a Wasekwan rhyolite flow in the Rusty Lake belt (collected by D.A. Baldwin) were submitted to the G.S.C. geochronology section for zircon testing. The pre-Sickle granitoid rocks and the Missi felsic volcanic rocks produced positive test results (zircons were identified in the heavy mineral concentrate), the Wasekwan rhyolite from Rusty Lake gave qualified positive results, and the four Wasekwan rhyolites from the Lynn Lake belt plus the two micrographic tonalites from the Flin Flon belt produced negative results. Due to the importance of obtaining an age from the Wasekwan Group at Lynn Lake it was decided that further, on-site testing for the presence of zircon in rhyolite (Table 1) would be conducted during the 1983 field season. Consequently during a one-week program under the direction of Dr. R.D. Stevens (geochronologist with the G.S.C.), T.Gordon, D.A. Baldwin and E.C. Syme tested several rhyolite lavas and pyroclastics in the Lynn Lake rhyolite complex (Baldwin, this report). Five quartz-phyric flows that tested positively for zircon were sampled - four from the southern unit and one from the northern unit. The locality in the Rusty Lake belt also was re-sampled, from two separate rhyolite lava flows.

At the time of this writing two pre-Sickle granitoid samples have zircon separates prepared and are awaiting hand picking of the zircon into separate populations. The Missi ash flow sample and another pre-Sickle granitoid have the zircons picked and are scheduled for the next stage in the analytical sequence. The newly-collected material

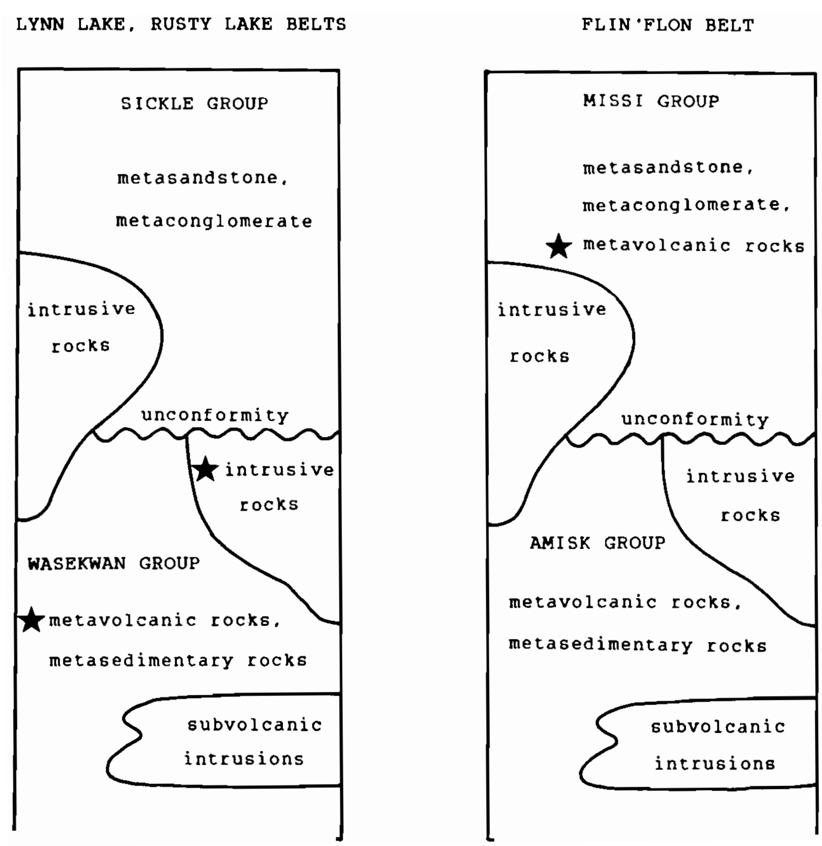

Figure GS-3-1: Stratigraphic terminology in the Lynn Lake belt (Gilbert et al., 1980) and Flin Flon belt, showing major units that have been sampled for zircon geochronology.

TABLE GS-3-1
G.S.C. ZIRCON SEARCH TECHNIQUE

1. Crush a few grams of sample chips in a mortar.
2. Sieve (100 mesh): fines go to step 3; coarse fractions to further crushing.
3. Separatory funnel: heavy mineral fraction sinks in methylene iodide. Heavies are decanted to filter paper.
4. Wash heavies in filter paper with acetone. Discard washing.
5. Remove magnetite from heavy mineral separate on filter paper with small magnet.
6. Heavy mineral grains are embedded in nail polish applied to microscope slide, by brushing from filter paper or by pressing glass slide to centre of filter paper.
7. Examine slide with polarizing microscope.
8. a) zircons identified: approximately 50 kg of rock is collected for lab separation and analysis of zircon.
   b) zircons not present: rock does not contain enough zircon to warrant collection of a sample. Another rock unit or sample site must be chosen and tested.

will be processed this fall and winter. Hand specimens of Amisk rhyolites from the Flin Flon belt will be tested for zircons this fall and winter; a number have already been tested with negative results.

The primary phase of any zircon geochronology study in volcanic belts - that of sampling suitable, zircon-bearing rhyolites- has proved to be the largest obstacle in the program to date. Very few rhyolites contain enough zircon to provide a reasonable separate. Field testing for zircon, using a heavy liquid kit and a simple polarizing microscope, is essential in the search for suitable sample sites.

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GS-4 KISSEYNEW PROJECT: LOBSTICK NARROWS

(Parts of 63K/13, 14 and 63N/3, 4)

by Herman V. Zwanzig

INTRODUCTION

The Kisseynew Project, (a new mapping program on the south flank of the Kisseynew Sedimentary Gneiss Belt) will aim to provide reliable structural and stratigraphic control for the base- and precious-metal deposits in the Kisseynew Lake- Sherridon- Batty Lake region (Fig.GS-4-1). The investigation will establish a stratigraphic subdivision of the Sherridon Group, separate the Nokomis Group from the granitoid complexes, and trace the Amisk Group at the margin of the Flin Flon Greenstone Belt.

During one week of the 1983 field season, a reconnaissance was carried out on Kisseynew Lake, Kississing Lake, Nokomis Lake and Puffy Lake. During the following four weeks an area of 50 km^2 was mapped at 1:20 000 scale at Lobstick Narrows and north of Kisseynew Lake.

The regional reconnaissance indicates that considerable revision is required to the existing maps (Tanton, 1941; Bateman and Harrison, 1945; Kalliokoski, 1952; Robertson, 1953; Frarey, 1961; Pollock, 1964). Most of the area between latitudes 54°27' and 55° 15' from Saskatchewan to Limestone Point Lake should be remapped at 1:50 000 scale (Fig.GS-4-1). Key areas with significant stratigraphic and structural relationships will be mapped at a scale of 1:20 000.

The most recent cycle of mapping has been conducted in the Sherridon area (Froese and Goetz, 1981), on Kisseynew Lake (Froese and Gall, 1981) and additional work was done by Tuckwell (1979), Gale (1980) and McRitchie (1980). The leadership of Dr. Edgar Froese of the Geological Survey of Canada during the reconnaissance and his hospitality and the use of his field map are gratefully acknowledged. I thank David Seneshen for his able assistance camping and his contributions to the geological work. David McRitchie provided valuable guidelines for access and mapping.

The focus of this report is a preliminary structural interpretation of an area encompassing Lobstick Narrows and the excellent exposures in the MANFOR cutting sites northwest of the narrows (Fig.GS-4-2 and Preliminary Map 1983K-1). A tentative stratigraphic subdivision of the Sherridon Group based on the structural interpretation is provided (GS-4-3). Only the central part of the map area was done in detail. Further work is planned to revise and complete the map.

SUMMARY GEOLOGY

The Lobstick Narrows area is a medium- to high-grade metamorphic terrane that straddles the boundary between the Flin Flon Greenstone Belt and the Kisseynew Sedimentary Gneiss Belt. The following groups of rocks are exposed in the vicinity.

Amisk Group: mafic and felsic metavolcanic rocks, related metasedimentary rocks and early mafic intrusions. These are considered the oldest rocks in the area and are intruded by granodiorite. Amisk Group rocks are best exposed south of Weldon Bay where Froese has divided them into several composite units Froese and Gall, 1981). No further work was done.

Nokomis Group: garnetiferous metagreywacke-mudstone (staurolite schist or sillimanite gneiss) and minor amphibolite. The greywacke is exposed in the core of a refolded anticline and north of a major fault zone. It is correlated with the File Lake Formation which forms the upper part of the Amisk Group at File Lake on the north margin of the Flin Flon Belt (Bailes, 1980). A thin unit of amphibolite locally overlying the greywacke is considered the top of the Nokomis Group and is tentatively correlated with the Amisk Group. Correlative metagreywacke, migmatite and minor amphibolite including volcanic rocks are called the Burntwood River Metamorphic Suite in the main part of the Kisseynew Belt (Gilbert, et al., 1980).

Sherridon Group: quartz rich metasedimentary rocks, mafic to intermediate and felsic metavolanic rocks. These units are correlated with the Missi Group (Bailes, 1980) and with similar rocks on the northeast margin of the Flin Flon-Snow Lake Greenstone Belt (Bailes, in prep, and 1975; Gordon and Gall, 1980). The Sherridon Group is intruded by rare porphyritic granodiorite and pegmatite. Mafic volcanic rocks were considered to be paragneiss and intrusive rocks by McRitchie (1980). Froese and Gall (1981) suggested a possible volcanic origin for pink felsic gneiss.

Defender Lake Granitoid Gneiss: medium grained quartzofeldspathic gneiss, locally garnetiferous. An intrusive origin of the dome is indicated by:

i) the persistence of a small number of uniform phases over a large area;
ii) relict granitic textures; and
iii) the presence of amphibolite inclusions some of which have been altered to diorite. Local banding may represent schlieren. The foliation is tectonic.

Froese and Gall (1981), Gall (1981) and Bateman and Harrison (1945) concluded that the dome contains significant volumes of paragneiss.

STRUCTURE

The structure of the area is dominated by the Defender Lake dome in the southwest, by a gently curved belt of Amisk Group rocks in the southeast, and by complex folds in Sherridon and Nokomis rocks in the north.

The Defender Lake dome is flattened and dips north at a moderate angle. It is a noncylindrical structure (Gall, 1981) and differs in that respect from the fold-interference structures to the north (Fig. GS-4-4). The ellipsoidal shape of the dome was probably inherited from its intrusive precursors. Strong deformation and high-grade metamorphism have produced a prominent foliation with local garnet blastesis and segregation of lighter colour veins. Amphibolite inclusions are interpreted as Amisk Group into which the original granodiorite, granite and tonalite were intruded.

The dome has a mantle of foliated amphibolite which is less than 100 m thick on the north flank but widens to the east where it joins recognizable Amisk Group rocks.

A gently curved, east-trending belt of foliated mafic and felsic metavolcanic rocks and related metasedimentary rocks and intrusions occurs south of Weldon Bay. Sherridon Group rocks lie to the north. The contact is sharp and apparently depositional. Consequently, the narrow belt of Sherridon Group rocks west of Lobstick Narrows is considered to be in depositional contact with the (Amisk) amphibolite in the mantle of the Defender Lake dome. The Sherridon rocks are considered to occupy a tightly appressed syncline that separates the Amisk amphibolite from a very narrow belt of metagreywacke and amphibolite. The greywacke extends west along the north shore of Kisseynew Lake (McRitchie, 1980). On one island west of Lobstick Narrows the greywacke is flanked on both sides by a thin unit of

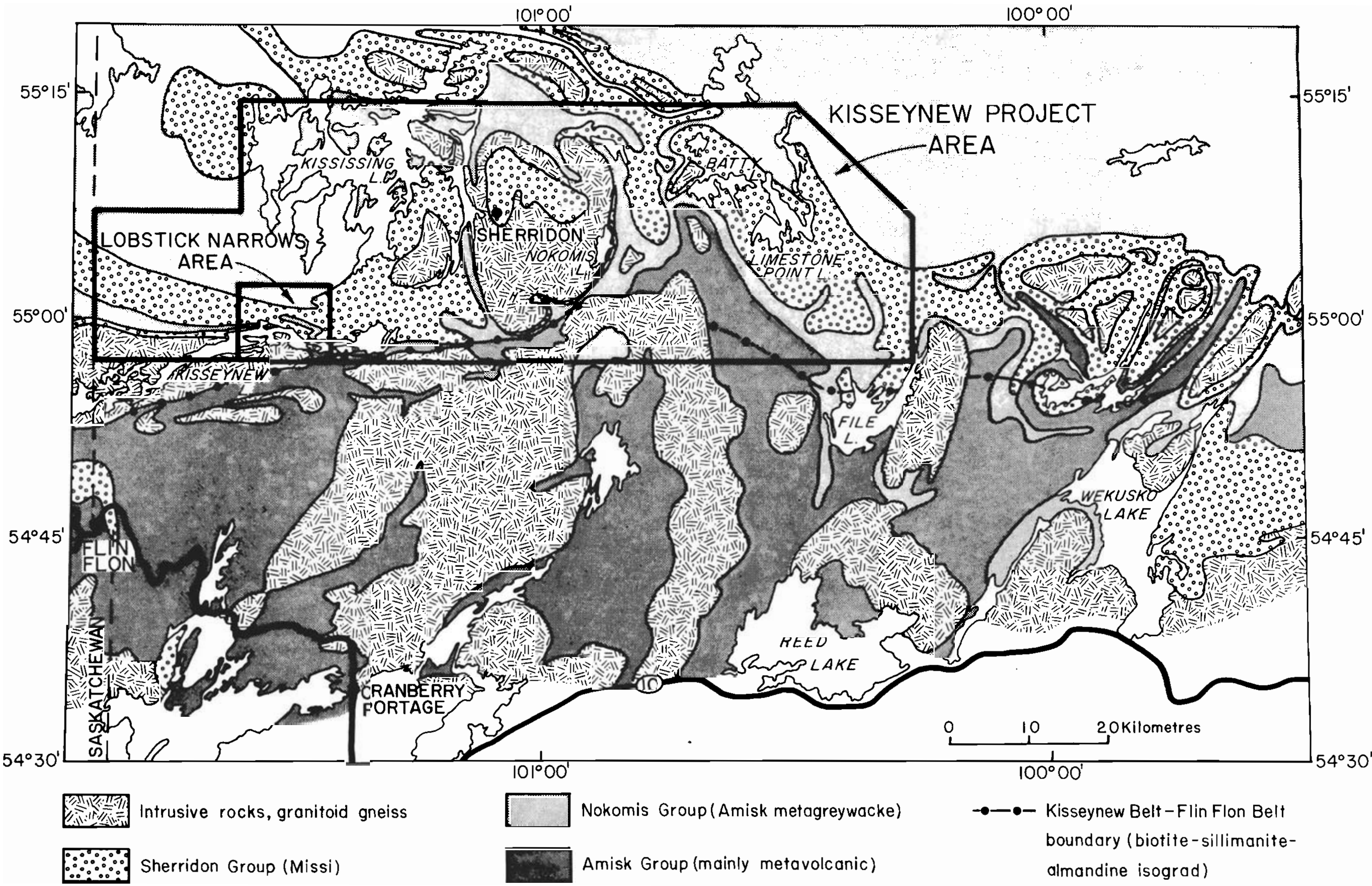

Figure GS-4-1: *Location map and simplified geology of the Flin Flon Greenstone Belt and the adjacent margin of the Kisseynew Sedimentary Gneiss Belt, modified after Froese and Goetz (1981).*

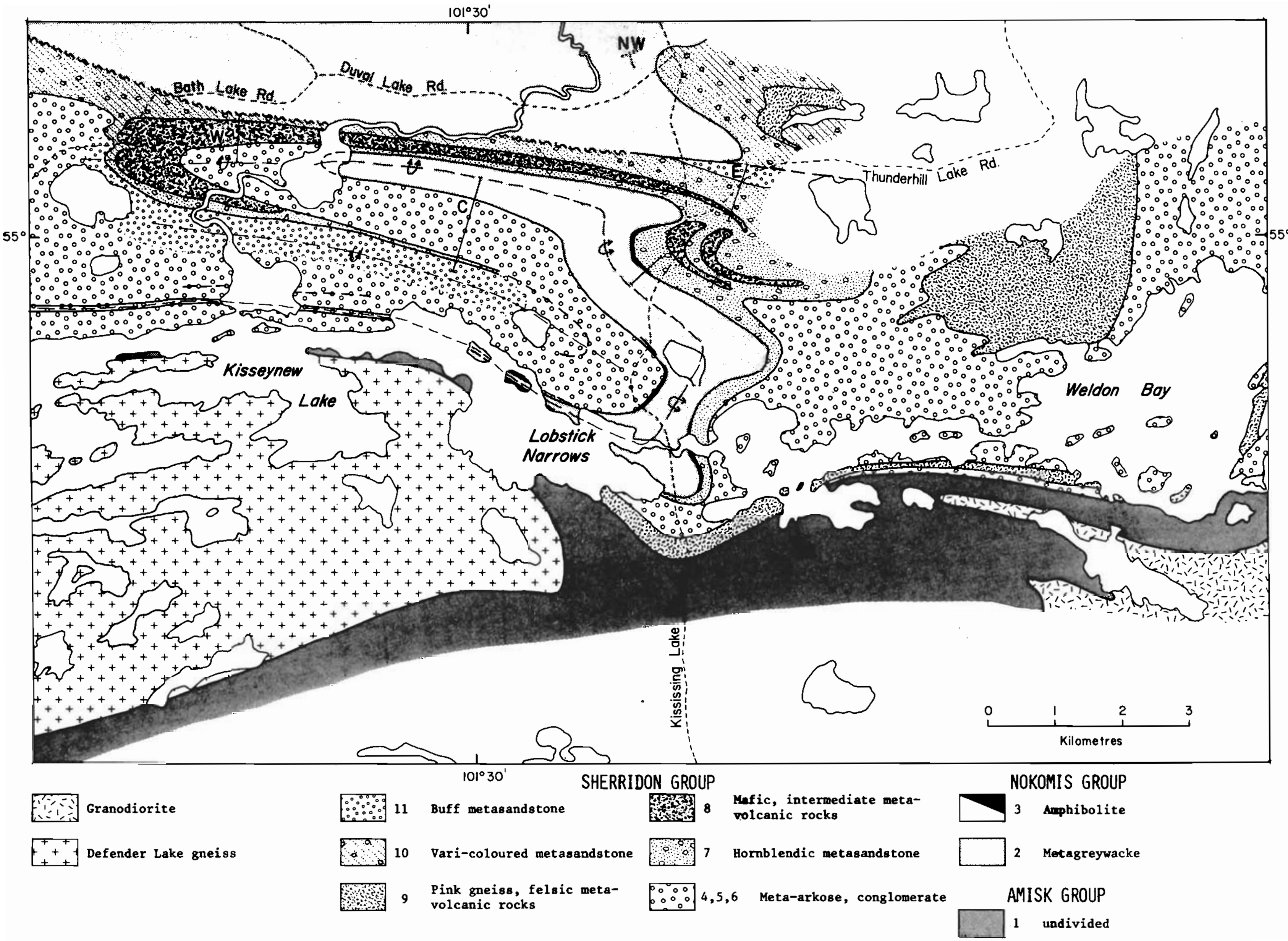

Figure GS-4-2: *Simplified geology of Lobstick Narrows (Zwanzig, this report) and Weldon Bay (Froese and Gall (1981). Stratigraphic section lines are indicated* as W *(western),* C *(central) and E (eastern). The structure section (Fig. GS-4-5) extends from "NW" to "SE".*

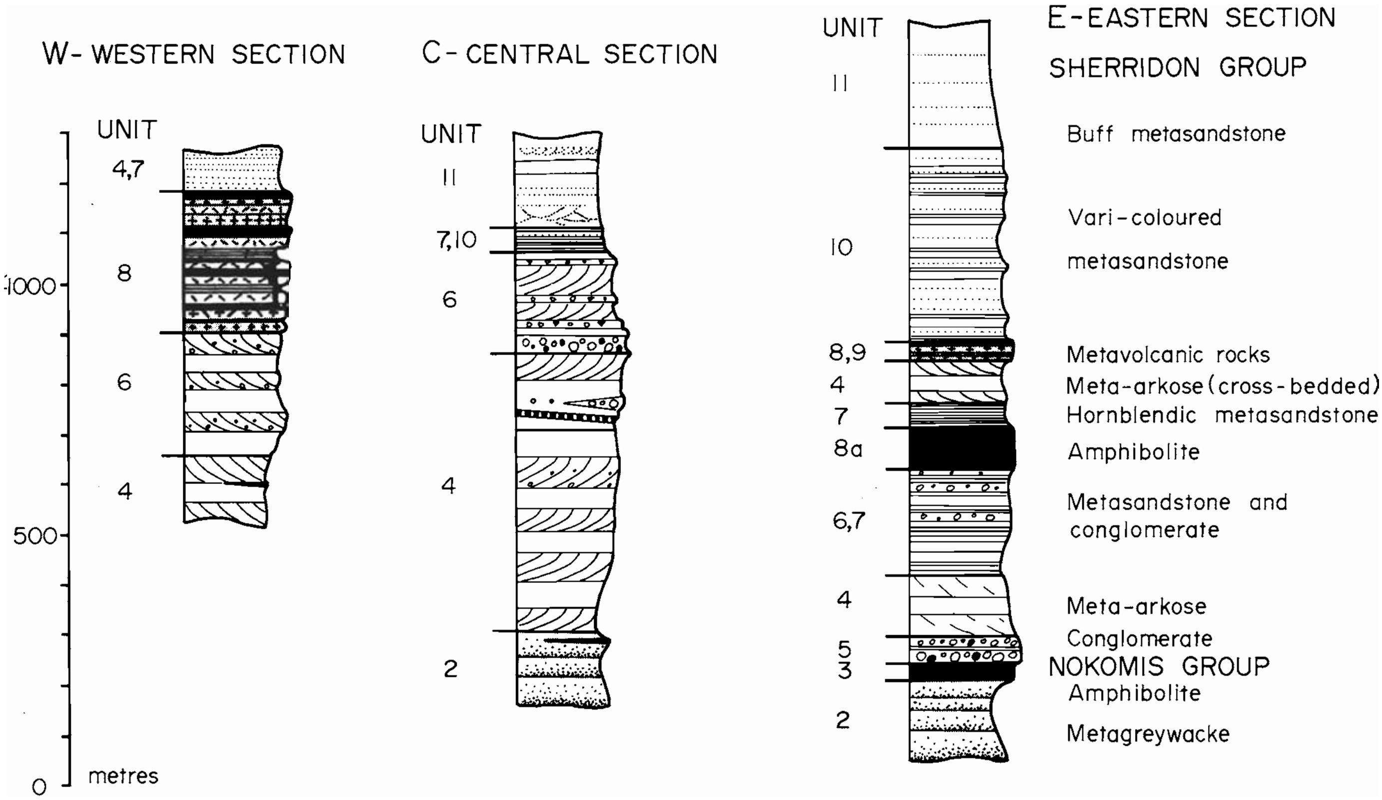

Figure GS-4-3: *Preliminary stratigraphic cross sections based on a structural interpretation given in the text. Section lines are shown on Figure GS-4-2.*

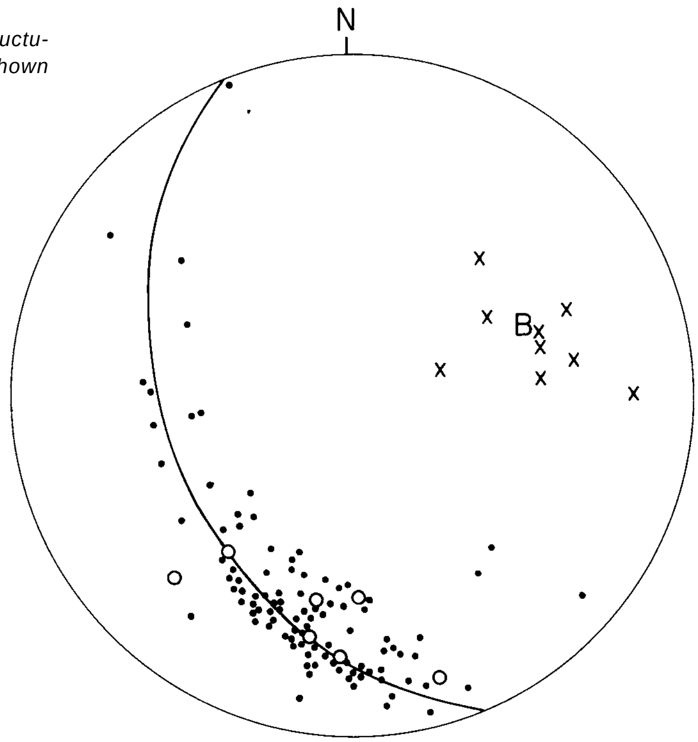

Figure GS-4-4: *Equal-area stereogram of poles to bedding (dots) from the area of detailed mapping. Also shown are poles to axial planes of late minor folds (o) and fold axes (x). Note the great-circle distribution (solid line with pole B) indicating cylindrical folding. Upright and overturned beds follow this distribution and suggest sheath folding or refolding of early isoclinal folds.*

amphibolite. Apparently, the greywacke belongs to the Nokomis Group and lies in the core of an attenuated anticline on the outer mantle of the Defender Lake dome. This interpretation is substantiated at Lobstock Narrows where the anticlinal core widens and turns northwest in a cross-fold structure. Along the Kississing Lake road the greywacke contains small euhedral garnet porphyroblasts and local relicts of graded bedding that identify it as Nokomis Group rock. It contains rare interlayers of amphibolite and at the stratigraphic top, in both limbs of the refolded anticline, there is a distinctive unit of garnet amphibolite overlain by the basal units of the Sherridon Group. A strong aeromagnetic anomaly helps define the early (F_1) fold (G.S.C. Experimental Aeromagnetic Colour Maps C20, 344G and C40, 085G).

The belt of greywacke terminates in the northwest near the Kississing River in the core of the anticline. West of the river the fold is clearly delineated by abundant outward facing tops on cross-bedding and by a zone of tight folding. The cross-bedding establishes way-up criteria for the stratigraphic section. Minor folds plunge NE at 44° (Fig.GS-4-4) and north-striking beds in the hinge, face west and downward. Consequently the anticline is inverted and has the shape of a synform. The hook-shaped structure in the Sherridon volcanic rocks is the western continuation of the synformal anticline.

The large antiform about which the early fold is refolded closes and plunges to the northeast. It contains an inverted succession of Sherridon Group rocks with the youngest in the core (Fig. GS-4-5).

East of the Kississing Lake road the stratigraphic succession is upright. The inversion takes place about a north-trending line parallel to the road and is probably coincident with the F_1 axial surface but related to F_2, north-trending, nearly recumbent folding which is prominent northeast of the area. The euhedral garnets in the north-trending belt of greywacke suggests that F_2 predated the peak of metamorphism. The late east-trending antiformal syncline is parallel

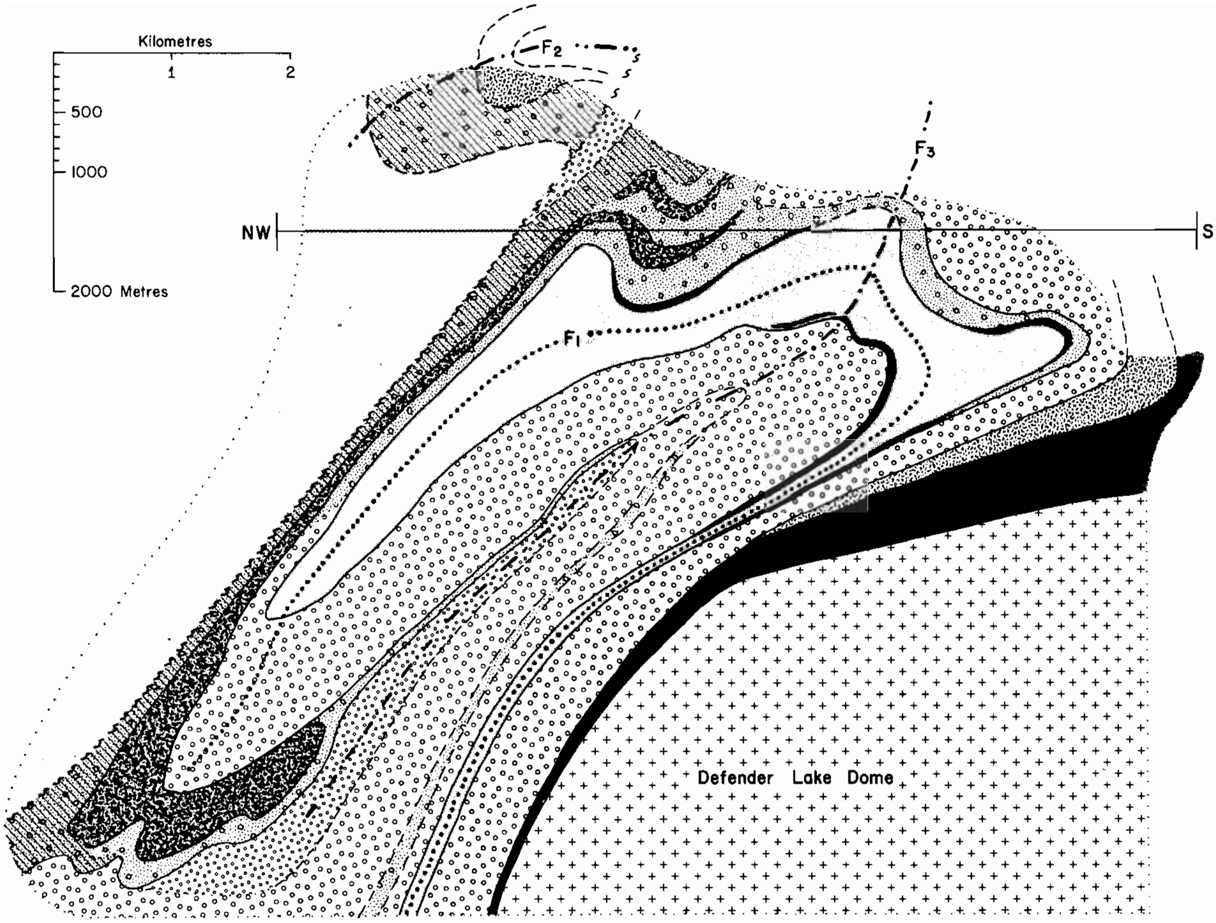

Figure GS-4-5: *Structure section, projected down plunge (towards "8" in Figure GS-4-4) showing the early anticline (F_1) refolded about a late antiform (F_3) and the Defender Lake dome. The recumbent structure (F_2?) at the top of the figure is schematic. The line of section and legend are shown in Figure GS-4-2.*

to a foliation that is curved around staurolite porphyroblasts. The fold is post-metamorphic and can be designated as F_3.

The northwestern part of the area is cut by a fault zone which crosses the Bath Lake Road and may extend northwest across the Duval Lake map area (Pollock, 1962). It is marked by a 200 m wide zone of strong foliation. intense flattening and local retrogressive metamorphism. There are numerous small, northwest-trending faults with pseudotachylite veins, fault breccia and kink bands. Separation is sinistral. The fault zone probably extends east along the Kississing River but there is no intense foliation along strike at the Kississing Lake Road. A less prominent, parallel shear zone may cross the entrance of the Thunderhill Lake road. Strong deformation is confined to the footwall (south) block of the main zone; the hanging wall comprises less deformed staurolite schist and metagreywacke of the Nokomis Group. The fault zone has a late- to post-metamorphic age Its termination and possible **en echelon** arrangement with the smaller zone indicates that it served as a local detachment surface for F_3 folds.

STRATIGRAPHY

The preliminary stratigraphy is based mainly on three sections (Figs. GS-4-2 and 3). Facing is well established in the central and western section but only poorly established in the eastern section. The distribution of grain sizes, bedding thicknesses and a tentative paleocurrent direction indicates that the central section is most proximal and the eastern section most distal to a local depositional lobe in the Sherridon Group clastic rocks.

The following stratigraphic subdivision is a composite of the three sections with additional data from reconnaissance work.

AMISK GROUP

Unit 1

Amphibolite is fine- to medium-grained and may include extrusive and intrusive rocks. Felsic volcanic rocks weather cream to buff and contain small quartz eyes. They are well layered and may be tuff. Metasedimentary rocks are highly variable.

NOKOMIS GROUP

Unit 2: metagreywacke, staurolite schist

This unit is grey to brownish weathering with dark grey fresh surfaces. It contains diagnostic 2 mm euhedral garnet porphyroblasts and locally 3 mm staurolite prisms. The unit includes garnet-biotite gneiss ± sillimanite. It has local white pegmatite veins with biotite and garnet rich selvages. Narrow layers of amphibolite form rare intercalations.

Staurolite is present northwest of the Kississing River and small sillimanite knots are locally present to the southeast. Bedding characteristics, such as the regular alternation of layers and suggestions of grading, are common in the rocks exposed along the Duval Lake road and those at Lobstick Narrows.

Unit 3: amphibolite

Stratigraphically overlying metagreywacke with a sharp contact is a thin unit of fine- to medium-grained amphibolite. The rock weathers grey-green, is weakly banded, or contains dark green, subparallel selvages rich in hornblende and locally garnet. A second variety of amphibolite is patchy hornblende-diopside gneiss, locally with pale grey feldspathic lenses.

The top of the unit is exposed in the sandpit north of Lobstick Narrows: the uppermost layers are unusually rich in garnet and there is garnet schist at the top. Similar rock has been identified as regolith in the Cross Lake area of Manitoba (Corkery, pers. comm.). The contact with Sherridon Group conglomerate is sharp and may be unconformable

SHERRIDON GROUP

Unit 4: meta-arkose, quartz-rich gneiss

A lower unit of light grey weathering meta-arkose is over 300 m thick in the central section. The lowest beds are exposed only in the thick bush north of Lobstick Narrows where they overlie the Nokomis Group and contain layers with large quartz-muscovite-sillimanite knots **(faserkiesel)** and rare, dark bedding-plane partings. Cross-bedding is preserved higher in the section and is ubiquitous in the cuttings west of the Kississing Lake road. It appears to be tabular cross-bedding with foresets indicating a westerly and downward paleocurrent direction (unrestored). The set height is up to 80 cm (probably about 250 cm undeformed). The cross-bedding is commonly deformed such that the bottomsets have remained planar and the foresets are folded and meet the bottomsets at an oversteepened angle. Locally. the foresets are planar and parallel to the foliation, and the bottomsets are folded. These relationships arise where one set is in the deformation field of shortening and the other set in the field of extension (Fig. GS-4-5). “Floating” pebbles are commonly scattered throughout medium- to coarse-grained metasandstone. Conglomerate beds occur in the central section and amphibolite layers in darker, more biotite-rich rock in the west.

On Weldon Bay and north of Kisseynew Lake the unit consists of quartz-rich gneiss in which the partings of what was probably cross-bedding were tightly compressed. Sillimanite knots or garnet porphyroblasts occur sporadically.

Unit 5: conglomerate

In the eastern section Nokomis Group amphibolite is overlain by deformed polymictic conglomerate. The unit is 40 m thick where it is well preserved in the core of a late fold at the sandpit north of Lobstick Narrows. A basal unit is up to 8 m thick and has a matrix of interlayered amphibolite, grey grit and quartzose wacke with flattened clasts of amphibolite and felsic rock. It is overlain by 5 m of grey protoquartzite and 1 m of quartzose grit. The main conglomerate unit is 30 m thick at the edge of the sandpit: the lower 4 m have an amphibolite matrix and the remainder has a greenish-grey sandstone matrix which is recrystallized to epidote- hornblende-bearing rock. Clasts comprise grey and pink fine grained felsic rocks (metasediments?), rhyolite, white quartz, grey cherty iron formation, feldspar porphyry and tonalite. Beds are clast-supported, 20-30 cm thick and locally separated by sand wedges. The unit is overlain by minor grey meta-arkose which is overlain by hornblende-bearing metasandstone.

Unit 6: meta-arkose and conglomerate

An upper sequence, 300 m thick (deformed) of tabular cross-bedded meta-arkose is commonly pebbly and contains intercalations of conglomerate. The conglomerate is coarsest and most abundant at the base of the unit where it lies gradationally on unit 4. In the western section the unit consists entirely of pebbly arkose. The meta-arkose ranges from medium- and coarse-grained grey rock to fine grained buff weathering rock. The conglomerate beds are in the range of 30 cm thick, tabular and continuous along strike. Clasts comprise felsic, fine grained grey rocks, felsic volcanic rocks, quartz; and lesser amphibolite, micaceous sedimentary rock and granodiorite. Clasts of rhyolite, dacite, feldspar porphyry and cherty iron formation occur in the upper part of the unit. The larger clasts (15 cm) are rounded whereas pebbles are rounded to angular.

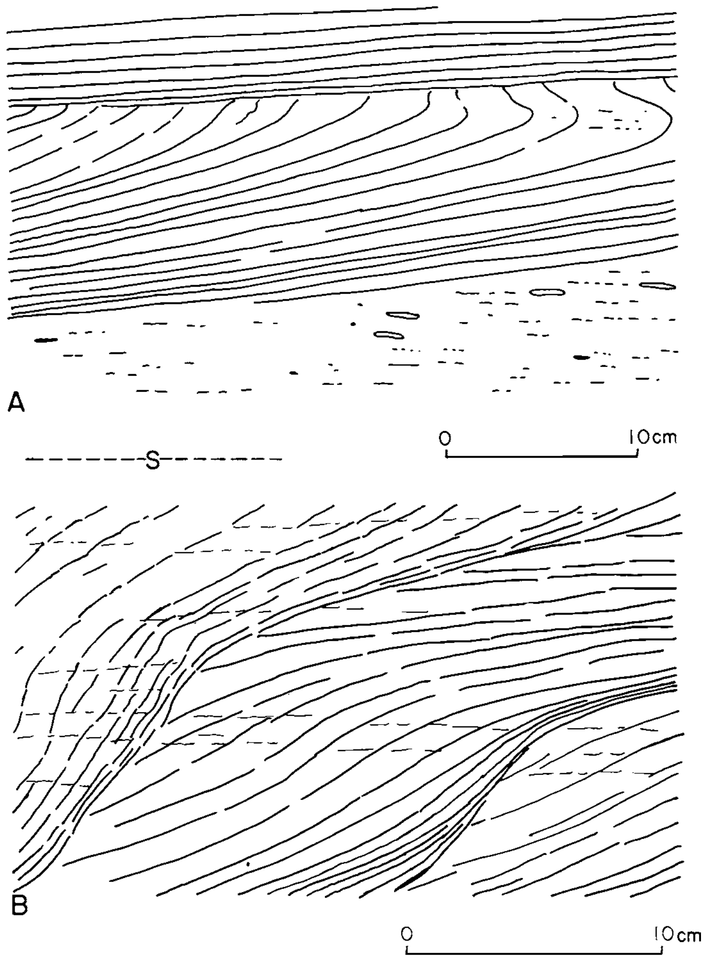

*Figure GS-4-6: Two deformation fields of cross-bedding: (**A**) - from the limb of a major fold where bottomsets are close to the plane of flattening (S); (**B**) - from the hinge area of a major fold where foresets are close to the plane of flattening.*

Unit 7: hornblende- biotite-rich metasandstone

The pebbly meta-arkose is gradationally overlain by a thin unit of medium grey and pale brown weathering micaceous metasediment containing green epidote and hornblende-bearing layers. Beds are 3 to 30 cm thick, cross-laminated at one locality. They are interbedded with the pink, green and grey rocks of unit 9.

The unit thickens from the central section to the west and strike into mafic and intermediate volcanic rocks (unit 8) at the Kississing River. Medium to dark grey and brown hornblendic varieties with about 15 per cent biotite are interbedded with the volcanic rocks.

Unit 8: mafic to intermediate metavolcanic rocks, amphibolite

Bodies of mafic to intermediate volcanic rocks and amphibolite of unknown origin occur in the eastern and western sections. The rocks are interpreted as massive and layered flows, sedimentary rocks and tuff. They are commonly porphyritic: large phenocrysts of plagioclase and hornblende pseudomorphs after mafic phenocrysts are abundant. Interlayered fine grained amphibolite may represent aphyric flows. The composition ranges from highly mafic to intermediate, biotite- or feldspar-rich varieties. The high biotite content in what may be an andesitic composition suggests that the rocks are relatively potassic.

The unit is strongly foliated and the presence of volcanic rocks is apparent only locally from abundant, 1 cm long, quartz amygdales where these have not been flattened into ribbons, Much of the unit may be intrusive but a volcanic origin is more likely because there is complex interlayering of various types of amphibolite and micaceous sedimentary units. Cross-cutting dykes with chilled margins occur in the central section of meta-arkose.

In the western section there are five or six volcanic units, each about 40 m thick (after intense flattening) and alternating with thin sedimentary units. Flows include aphyric and porphyritic units. The latter can be massive, differentiated or layered. Hornblende phenocrysts are commonly more abundant in the lower parts of the 40 m sequences. Plagioclase-phyric rock is abundant in the upper parts and fine grained amphibolite at the top.

The third sequence lacks mafic phenocrysts but contains feldspar phenocrysts in prisms up to 30 mm long mixed with 10 mm long feldspar laths. They constitute up to 50 per cent by volume. The sequence has preserved amygdales up to 25 per cent of the rock at the base of some flows.

The fourth sequence starts with 60%, 50 mm hornblende phenocrysts and 20%, 50 mm plagioclase. This porphyry is overlain by layered plagioclase-phyric rock which is overlain in turn by uniform amphibolite. A lack of amygdales in this sequence suggests a possible intrusive origin. (See also McRitchie; 1980). The upper sequences are hornblende- and plagioclase-phyric. The top of the section is sheared and plagioclase phenocrysts are drawn into ribbons.

In the eastern section, south of the Thunderhill Road amphibolite of unknown origin and interlayered arkosic rocks are overlain by a thin sequence of recognizable volcanic rocks. The amphibolite contains a pink weathering felsic volcanic unit (9) near the base of a highly amygdaloidal mafic to intermediate unit. There are up to 30% amygdales in 5 cm wide horizons. These are filled with quartz or epidote, or epidote with a garnet rim. The unit rests on cross-bedded meta-arkose and was probably extruded subaerially. North of the road there are fragmental units that may have been debris flows.

Unit 9: felsic volcanic rock

Fine grained, pink weathering felsic rock forms much of the south shore of Weldon Bay (Froese and Gall, 1981). It extends west into the main part of Kisseynew Lake. Similar rocks occur on the Thunderhill Lake road northeast of the eastern section. They have a very high aeromagnetic signature.

The rock has a typical, faint, lensoid pseudolayering at a millimetre scale. Slab-cut specimens reveal a flattened-fragment texture. These fragments have diffuse margins and are wispy in one sample. Inconspicuous 1 mm quartz eyes are common. They are rounded or rarely euhedral. Feldspar phenocrysts, 2 mm long, are present in greater amounts but only locally. More coarsely recrystallized varieties of pink felsic rocks crop out north of the Thunderhill Lake road. Quartz eyes or fragments are not visible and felsic volcanic rocks cannot be distinguished from pink weathering metasedimentary rocks with certainty. However, the latter have a greyer fresh surface.

Descriptions of Missi (Sherridon) Group felsic volcanic rocks at Wekusko Lake (Gordon and Gall, 1980) fit the rocks at Lobstick Narrows. At Wekusko Lake a unit of welded ash-flow tuff is described. The association of felsic volcanic rocks with arkosic rocks on Kisseynew Lake suggest a subaerial origin there also.

Unit 10: vari-coloured metasandstone

A 600 m thick succession of hornblende-bearing metasedimentary rocks overlies the Sherridon Group volcanics on the Thunderhill Lake road. They comprise thin-bedded, fine grained metasandstone and argillaceous metasiltstone with pink, green and grey weathering colours. Potash feldspar occurs in the pink beds and hornblende plus epidote in the green layers. Grey beds are micaceous metasandstone to siltstone with or without hornblende. Pink units with bedding up to 30 cm thick alternate rhythmically with parallel-laminated (0.5 - 10 mm) vari-coloured units. Locally there is graded bedding or cross-lamination. Rarely preserved fragment layers interpreted as mud-curls suggest that deposition was terrestrial. These may have been distal sand-plane deposits.

Unit 11: buff metasandstone

A low weathering unit of buff, pale pink or pale maroon metasandstone gradationally overlies the more brightly coloured hornblende-bearing rocks and may form the local top of the Sherridon Group. The rock is generally muscovite-bearing, locally with garnet or sillimanite. The thickest succession occurs on the Thunderhill Lake road but a similar unit may form the top of the central section. That section is more micaceous and has rare trough cross-bedding with distinctive black heavy mineral placers.

CONCLUSIONS

The volcanic stratigraphy within the Amisk Group probably cannot be mapped out because these rocks are so highly deformed. The Nokomis Group is simple and amenable to regional mapping if orthogneiss is properly excluded. There is no transition sequence between the Nokomis and Sherridon Groups in the map area; the contact is knife-sharp and probably unconformable.

There are indications that the Sherridon Group can be subdivided on a regional scale and the position of mineralized strata be predicted. However, the units are apparently lensoid, and there are facies changes along strike. At present, no correlations can be made with stratigraphic units at Sherridon (Froese and Goetz, 1981).

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GS-5 FLIN FLON-SCHIST LAKE PROJECT

(parts of 63K-12, 13)

by A.H. Bailes and E.C. Syme

INTRODUCTION

Mapping at a scale of 1:15 840 was completed for the 100km^2 Flin Flon-Schist Lake map area (Fig. GS-5-1). This project is a continuation of the mapping program carried out in 1979-81 in the adjacent White Lake-Mikanagan Lake area (Bailes and Syme, 1979; 1980). Primary objectives were a stratigraphic subdivision of the Amisk Group in the Flin Flon area and placement of mineral deposits within the stratigraphic framework.

Major findings during this year's work include:

(1) subdivision of the previously defined Flin Flon block (Bailes and Syme, 1982) into three separate blocks (Fig. GS-5-2): an unnamed block bordering Embury Lake, the Hook Lake block, and the Flin Flon block (retained for the area west of the Northwest Arm of Schist Lake);

(2) identification of a major zone of fault slivers (Grassy Narrows zone; Fig. GS-5-2) bordered on the east by the Inlet Arm fault and on the west by the newly-named Narrows fault

(3) definition of the stratigraphy hosting the Flin Flon massive sulphide deposit (Fig. GS-5-3) showing that the orebody (hosted by rhyolite) occurs at the contact between two major basaltic units of different character;

(4) demonstration that the Missi Group was most likely deposited in an alluvial fan environment, as previously suggested by Mukherjee (1971), by measurement of a section through these rocks (Fig. GS-5-4);

(5) delineation of a major angular unconformity between the Missi and Amisk Group (a minimum of 2.5 - 3 km of Amisk section is truncated at the unconformity south of Ross Lake);

(6) definition of a small area of subgreenschist facies volcanic rocks in the Hook Lake area, characterized by the presence of prehnite and pumpellyite.

Revisions to preliminary map 1982W-1 include relocation of portions of the Cliff Lake and Ross Lake faults, refinement of unit boundaries within the Cliff Lake pluton with the recognition of another fault within the pluton, and a revised interpretation of the fold structure northwest of Hook Lake.

STRUCTURAL SETTING

The Flin Flon-White Lake area is characterized by ten major fault-bounded blocks (Fig. GS-5-2). In the White Lake area the blocks each contain a unique stratigraphic sequence which is not repeated in the other blocks. In the Flin Flon area stratigraphy is not straightforward, with blocks defined by differing structural character and by contained intrusive suites. The main features of the fault blocks in the Flin Flon-Schist Lake area are summarized in the following paragraphs.

The Manistikwan Lake block, the easternmost block in the Flin Flon-Schist Lake area, is separated from the Bear Lake block by a newly recognized zone of fault slices (Grassy Narrows zone). The Grassy Narrows zone (up to 1.2 km wide) is characterized lithologically by creamy buff coloured, non-vesicular pillowed basalt flows and by a number of large rhyolite flows. Facing direction within the zone varies from sliver to sliver. The fault zone is bounded on the east by the Inlet Arm fault (probably one of the largest faults in the map area) and on the west by the Narrows fault.

The Manistikwan Lake block is characterized by: (1) a homoclinal west-facing sequence of aphyric intermediate to mafic pillowed flows; (2) a unique suite of intrusions including magnetiferous quartz diorite-diorite dykes and plugs, and coarsely quartz and plagioclase-phyric shallow felsic dykes and plugs; (3) numerous NNW-trending faults and associated zones of carbonate blastesis. The block is bounded to the west by the Big Island fault. This fault outcrops in several locations on the west side of Big Island, where it is expressed as a fault breccia (up to 4 m wide) with a carbonate matrix.

The Embury Lake block (not shown on Fig. GS-5-2) underlies Embury Lake, between the Big Island and Trout Lake faults. The northern part of Embury Lake is underlain by an east-facing sequence of greywacke-mudstone (Price, pers. comm., 1983). The Trout Lake Cu-Zn sulphide orebody occurs within this sequence; it is hosted by schistose quartz-sericite rock, fragmental rhyolite and altered quartz porphyry (Muzylowski and Zbitnoff, 1979), and has a footwall alteration zone.

An unnamed block southwest of Embury Lake occurs between the Trout Lake and Manistikwan Lake faults. It is composed of a sequence of aphyric and porphyritic mafic flows intruded by magnetiferous diorite, Cliff-Lake-type tonalite, quartz diorite, coarse quartz-plagioclase porphyry, and rhyolite. These rocks are affected by a zone of hydrothermal alteration along part of the west shore of Embury Lake. This block is dominated by an open synclinal structure which is terminated at its northern end by the Manistikwan Lake fault.

The Hook Lake block is composed predominantly of porphyritic intermediate to mafic flows, and in the north contains the multi-phase quartz-phyric Cliff Lake tonalite. It differs from the previously described blocks as it contains abundant scoriaceous tuffs and breccias (in the Hook Lake area) and abundant spherulitic rhyolite dykes and plugs. Several large zones of intense epidotization occur within the block.The southern portion of the block is characterized by prehnite-pumpellyite metamorphic assemblages; the upper stability limit of these assemblages is shown on Fig. GS-5-2. The dominant structure in the block is a broad, open, NNW-trending syncline northwest of Hook Lake. The Hook Lake block is bounded to the west by the Cliff Lake fault, a schistose zone 2 - 5 m wide, on which there is estimated to be about 1200 m of post-metamorphic right-lateral movement.

The re-defined Flin Flon block is bounded on the east by the Cliff Lake fault. The west boundary of the block is unknown, but the block is known to continue intact to at least Douglas Lake in Saskatchewan. The block is characterized by an abundance of prominent, moderately tight to isoclinal, NNW-trending folds, including Stockwell's (1960) Mandy Road anticline, Burley Lake syncline, Hidden Lake syncline, and the Beaver Road anticline. Other distinctive features of the block include folded faults (e.g. Club Lake and Railway faults), the post-Missi Boundary Intrusions, and the Flin Flon structural basin (Stauffer and Mukherjee, 1971) containing a maximum of 2.7 km of Missi strata. Amisk Group stratigraphy in the Flin Flon block is more varied than in other blocks and includes common pyroclastic breccias and tuffs between mafic flows. In Saskatchewan this stratigraphy includes at least three large rhyolite formations (Stockwell, 1960). The Flin Flon blocks hosts the 62 million tonne Flin Flon Cu-Zn sulphide deposit, the stratigraphic setting of which is discussed in a later section.

METAMORPHISM

Petrographic examination of samples collected in 1982 has defined a zone of prehnite-pumpellyite facies metamorphism at the south margin of the map area. This zone has a maximum width in the map area of 3 km along the west shore of Manistikwan Lake and has been traced an additional 5.5 km to the south along the peninsula between Inlet Arm and Northwest Arm of Schist Lake. This is the first reported occurrence of subgreenschist facies rocks from the Flin Flon volcanic belt.

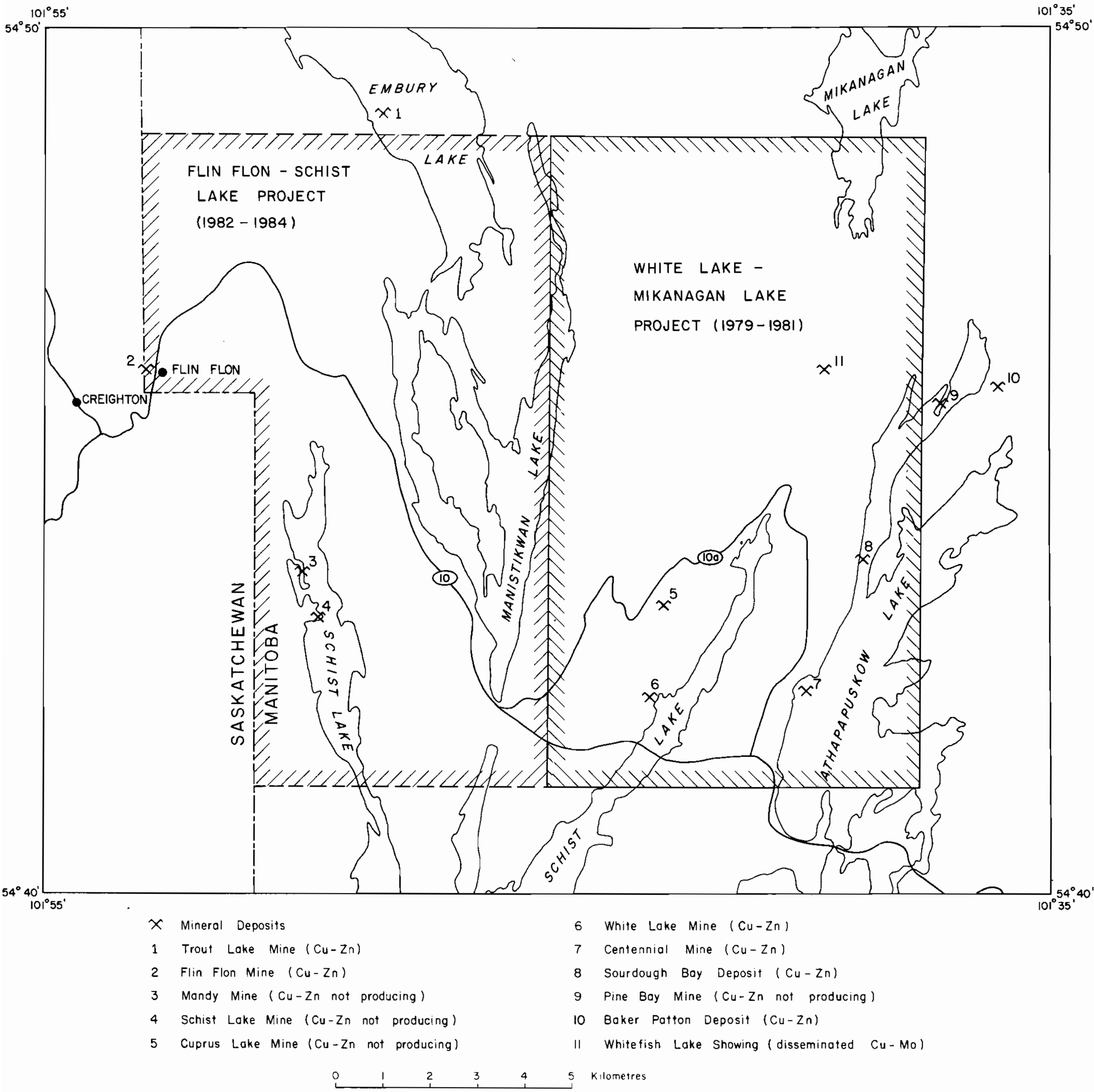

Figure GS-5-1: Location of the Flin Flon-Schist Lake and White Lake-Mikanagan Lake project areas, and location of mineral deposits.

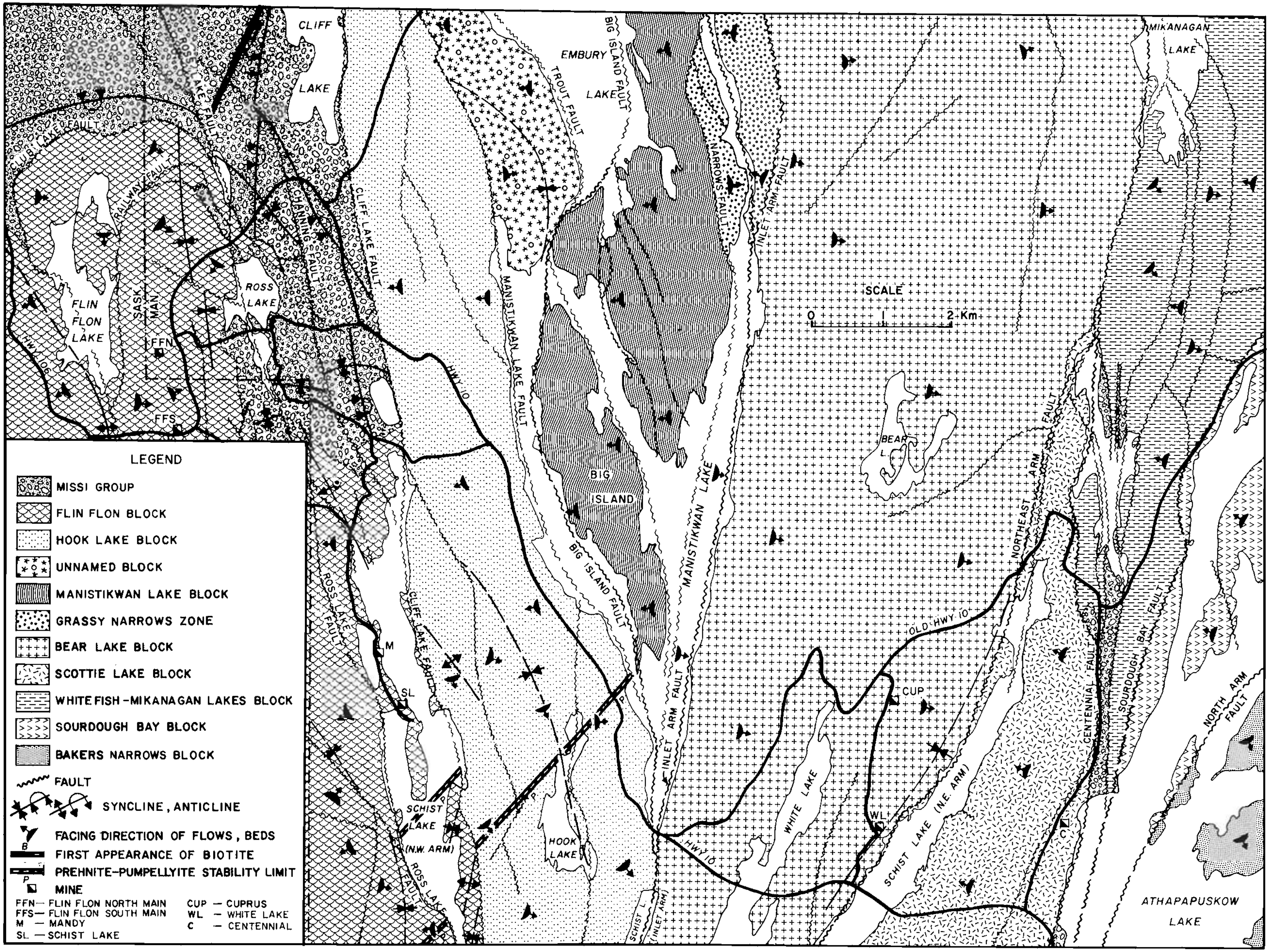

Figure GS-S-2: Structural blocks, major faults and folds, and metamorphic zonation in the Flin Flon-White Lake area. Structure in the Missi Group is from Stauffer and Mukherjee (1971).

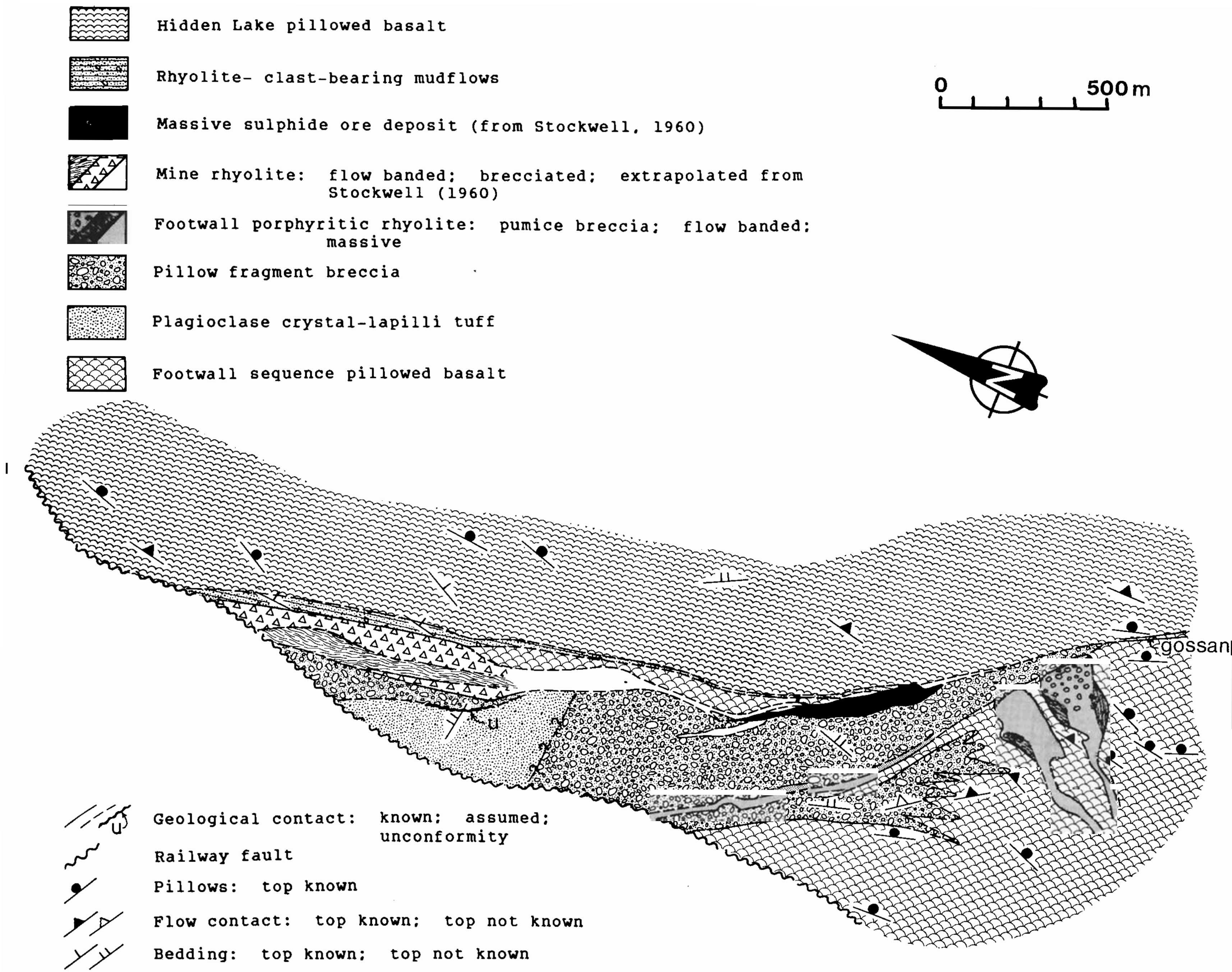

Figure GS-5-3: Geologic sketch map of the stratigraphic sequence containing the Flin Flon massive sulphide deposit. Intrusive rocks are not shown so that volcanic stratigraphy is emphasized. Dips of beds and flows are almost vertical, so that the map essentially represents a vertical section through the volcanic pile in its primary attitude.

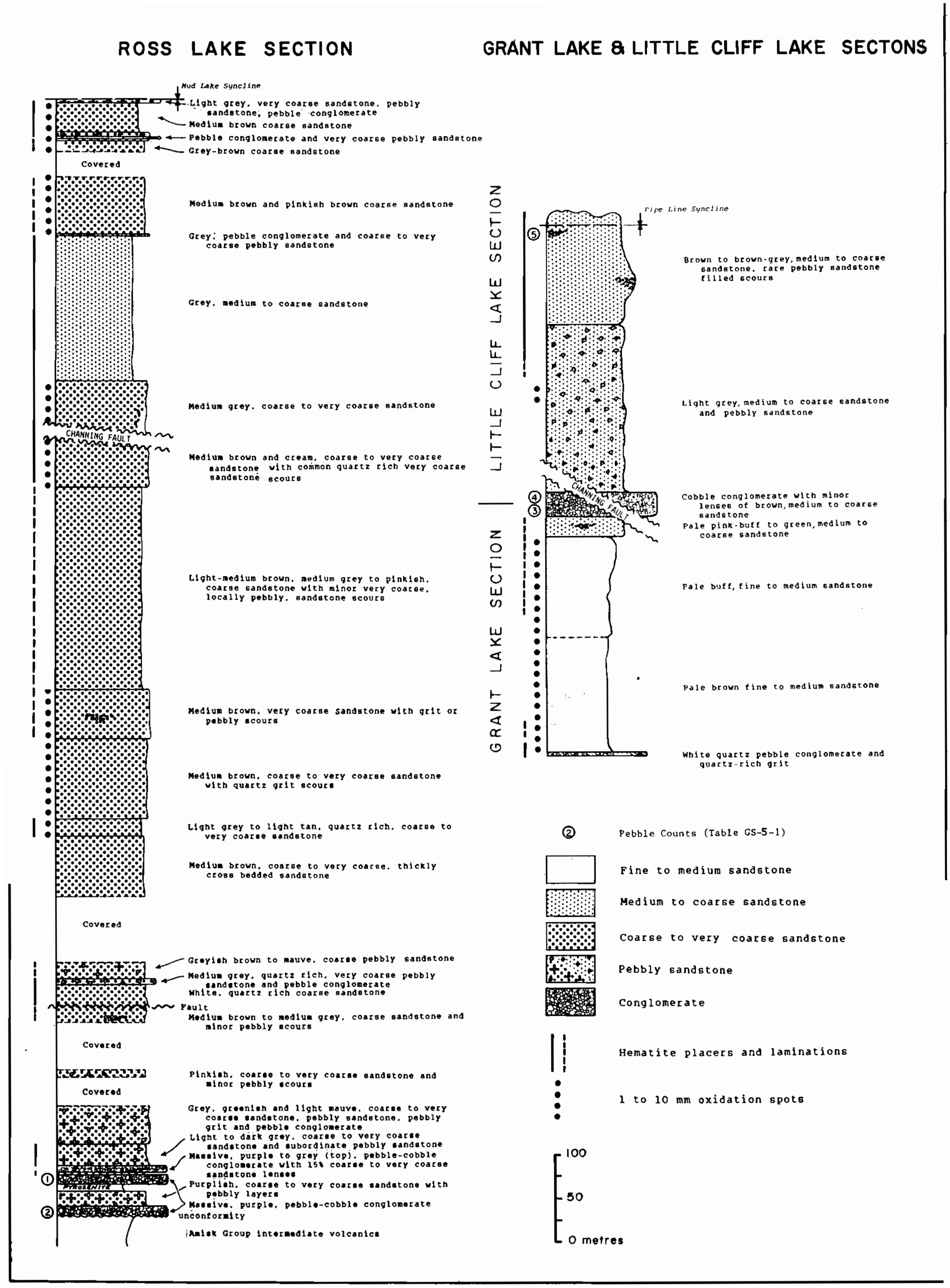

Figure GS-S-4: *Measured section through the Missi Group in the south and east part of the Flin Flon (structural) basin. All of the sandstones are trough crossbedded; individual units shown are characterized by different crossbed set thickness, sand size, colour, quartz content, and the number, distribution and size of contained pebbles.*

The very-low-grade zone is offset by post-metamorphic faults. It is sharply bounded to the east by the Inlet Arm fault, east of which all of the rocks are strongly epidotized basalts containing lower greenschist facies assemblages. The horizontal component of right lateral offset along the Inlet Arm fault therefore exceeds 8.5 km. To the west the prehnite-pumpellyite zone shows 1200 m right lateral offset along the Cliff Lake fault and approximately 1500 m left lateral offset along the Ross Lake fault (Fig. GS-5-2).

Prehnite and pumpellyite (both locally abundant within the zone) tend to occur primarily as open-space fillings, particularly in amygdales. Prehnite also occurs filling veinlets. Both minerals can occur as pseudomorphs after plagioclase. The prehnite-pumpellyite zone is further characterized by the common occurrence of fresh clinopyroxene phenocrysts in lavas and pyroclastic rocks, and by the preservation of delicate primary structures. The upper 700 m to 2 km of the very low grade zone is characterized by the appearance of an increasing abundance of tremolite-actinolite with a concommitant decrease in prehnite and pumpellyite. The upper stability limit of prehnite and pumpellyite is indicated on Fig. GS-5-2.

FLIN FLON MINE STRATIGRAPHY

Mapping in the immediate footwall of the Flin Flon orebody was undertaken to establish the stratigraphic setting of this major (62 million tonne) base metal Cu-Zn massive sulphide deposit. The orebody occurs within two quartz-plagioclase-phyric rhyolite flows which occur at the contact between two major basaltic units of different character (Fig. GS-5-3).

The footwall basalt is strongly altered beneath the Flin Flon orebody. Alteration consists of pervasive epidotization and patchy chloritization, pyritization, and bleaching. Least-altered basalts are aphyric, strongly amygdaloidal, and characterized in the topmost portion of the sequence by radial pipe amygdales. The rocks are harder and have a higher specific gravity than the hanging wall Hidden Lake basalt sequence. To the south (Fig. GS-5-3) the footwall basalts comprise pillowed flows and amoeboid pillow breccias.[1] There is an abrupt northward facies transition into predominant pillow fragment breccias, which form a thick wedge below the Flin Flon orebody.

Plagioclase crystal-lapilli mafic tuff occurs to the north of the pillow fragment breccias, across an unknown structure (synvolcanic fault?). The tuff is unconformably overlain by pillow fragment breccia and the Mine rhyolite. Layering and dykes within the tuff are clearly truncated at the unconformity.

Two porphyritic rhyolite bodies (shallow intrusions and possible domes) occur south of the orebody (Fig. GS-5-3). These rhyolites, restricted to the footwall sequence, contain a variety of features indicating high level emplacement: pumice breccia, flow banding, and spherulites. The narrow dyke-like portions cut across statification in the host basalts and contain mafic volcanic xenoliths.

The Mine rhyolites outcrop north of the smelter, forming a unit 250 m thick composed of two distinct rhyolite flows. The lower flow is 30 m thick (where exposed) and comprises flow breccia containing quartz phenocrysts up to 1 mm across. The upper flow is 130m thick and contains quartz phenocrysts up to 2.5 mm across. The flow is composed of a lower flow-banded portion (45 - 75 m thick) and a flow breccia top (40 - 80 m thick) which contains slabs of flow-banded rhyolite up to 2 m x 20 cm in a finer breccia matrix. On Stockwell's (1960) map these flows are shown as equivalent to the footwall porphyritic rhyolites. Their phenocryst populations and flow morphologies are quite different so they are here considered to be separate entities.

Rhyolite-clast-bearing mudflows overlie the Mine rhyolite and the Flin Flon orebody (Fig. GS-5-3). This unit is a maximum of 40 m thick and apparently thins to the south. It consists of ungraded and reverse-to-normally graded, thin, lenticular beds composed of porphyritic rhyolite clasts in a chloritic to arenaceous matrix.

The hanging wall Hidden Lake basalts overlie the rhyolite-clast-bearing mudflows to the north and gossaned footwall basalts to the south (Fig. GS-5-3). The 15 m thick gossan zone to the south of the orebody is interpreted to represent the extension of the Flin Flon mine horizon. Footwall alteration ends abruptly at the gossan zone and has not affected the overlying Hidden Lake basalts. These basalts are distinctly plagioclase (±pyroxene)-phyric, buff-brown weathering pillowed flows which share many features with the Bear Lake basaltic andesite flows (previously described in Bailes and Syme, 1979). A suite of samples have been submitted for chemical analysis to determine similarities and differences in geochemical signature among the footwall basalts, Hidden Lake basalts, and Bear Lake basalts.

MISSI GROUP STRATIGRAPHY

The Missi Group sandstones and conglomerates unconformably overlie Amisk Group volcanic rocks. At least 2.5 - 3 km of Amisk section is truncated at the Missi basal unconformity west and south of Ross Lake (Preliminary Map 1983W-1; Stockwell, 1960). Previously Byers and Dahlstrom (1954), Byers **el al.** (1975), Bailes (1971) and Stauffer (1974) have incorrectly suggested that no major angular unconformity exists and that the relationship between the two Groups is one of structural conformity. The unconformity is marked by a hematiferous regolith up to several metres thick. The wide variety of intrusive rocks observed in the Amisk Group are not present in the Missi; the only rocks which cut the Missi in the Flin Flon area are the Boundary intrusions and Kaminis granite dykes (Stockwell, 1960).

Spot checks of Stockwell's (1960) mapping of the Missi indicated it could not be substantially improved upon and consequently it

TABLE GS-5-1
FRAMEWORK CLAST PERCENTAGES IN MISSI GROUP CONGLOMERATES. LOCATION OF COUNTS SHOWN ON FIG. GS-5-4

	1	2	3	4	5
Intermediate to mafic volcanic	63.2	54.4	46.6	48.4	47.5
Intermediate to mafic intrusive	4.5	29.2	20.9	7.7	17.7
Epidosite	5.8	3.5	5.1	2.3	1.3
Felsic volcanic	21.0	3.5	2.4	12.7	7.6
Felsic hypabyssal	—	—	9.9	10.9	8.2
Granitoid	—	4.3	tr.	1.8	1.9
Quartz	3.6	4.3	3.6	4.5	tr.
Quartzite	0.5	0.4	—	0.9	0.9
Chert	—	0.4	—	—	—
Sandstone	1.3	tr.	11.5	10.9	13.9
Iron formation	tr.	—	—	tr.	0.6
Fuchsite	0.5	—	—	—	—
Detrital matrix	39.4	27.8	30.3	26.6	57.5
Total counts	371	356	363	301	372

[1]Terminology for mafic flows and breccias is discussed in Bailes and Syme (1982, p. 27 and 28).

was incorporated without changes on Preliminary Map 1983W-1. As an alternative, stratigraphic sections were measured in a number of localities to provide a representative example of the Missi Group in the Flin Flon structural basin (Fig. GS-5-4). This section comprises trough crossbedded sandstone and pebbly sandstone, with minor, thick, massive conglomerates and thin, pebble conglomerate scours. Mudstone layers are conspicuously absent although small mudstone ripups are present as a minor constituent in some sandstone units. Two generally upward-fining sequences are present (Fig. GS-5-4): the lower is the Ross Lake section plus Grant Lake section and the upper is the Little Cliff Lake section. Pebble counts of conglomerates (Table 1) are similar throughout, and indicate an overwhelming Amisk provenance. The sandstones can be subdivided into units approximately 2 to 200 m thick on the basis of grain size, colour, quartz content, character and thickness of crossbeds, and pebble content. Sedimentary structures in the sandstones are consistent with a fluvial/alluvial depositional environment, as previously suggested by Mukherjee (1971) and Stauffer (1974). Structure of the Missi Group has been described by Stauffer and Mukherjee (1971).

SUMMARY

The fieldwork in 1983 concludes the mapping portion of this project. No major changes to unit contacts on Preliminary Map 1983W-1 are expected. Whole rock chemical analyses (in progress) should provide a chemical basis for subdivision of the major basaltic units which dominate the volcanic stratigraphy. They may also provide criteria for correlation of these units between major fault blocks. In the combined White Lake-Mikanagan Lake and Flin Flon-Schist Lake areas 88 of the freshest available mafic rocks have either been analyzed or submitted for analysis. In addition, chemical analyses will also be available for major intrusive suites, felsic flows, and some pyroclastic rocks.

Data from this project will be released over the next few years as an open file report containing descriptions of major rock units, a geological report outlining the main geological features of the Flin Flon-White Lake map area, and papers in technical journals describing specific aspects of the geology.

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GS-6 A REVIEW OF SUPERIOR PROVINCE PROJECTS

by W. Weber

Three survey projects in the Superior Province involved 1:50 000 and 1:20 000 scale regional mapping and two projects were implemented under a Strategic Minerals Evaluation Program conducted as part of the Canada/Manitoba Interim Mineral Agreement. Additional work was conducted in collaboration with the Universities of Manitoba, Windsor (Ontario), and the Royal Ontario Museum, Toronto.

In the Island Lake project low level funding restricted mapping to the central and northern part of the greenstone belt. This completes coverage of the western half of the belt. Evaluation of gold mineralization by BP Minerals continues in the eastern part of the greenstone belt.

The Island Lake project is being undertaken to assist mineral exploration, in particular gold exploration. In addition to major companies, local enterprises are also active in the belt. The mapping revealed that felsic to intermediate metavolcanic rocks are more common than previously mapped near and at Henderson Island. Altered olivine-bearing melanogabbro-norite associated with metaperidotite is a unique rock unit in the northwestern Superior Province. Previously explored base metal mineralization occurs in thin metasedimentary horizons within mafic flows.

At Lawford Lake tonalitic to granodioritic gneiss and migmatite contains sporadic supracrustal remnants which are similar to the nearby greenstone belt associations. This area appears to represent an intermediate crustal level. The transition to the upper level greenstone belt terrain was mapped at the northeastern end of Cross Lake.

Survey work in the Cross Lake area was undertaken:

i) to establish a regional structural framework for the geological setting of the rare element pegmatites; and
ii) to encourage mineral exploration in the Thompson region in an attempt to broaden the mineral resource base of this region.

The supracrustal rocks in the Cross Lake area can be divided into an older, mainly mafic volcanic sequence, and a younger unconformable metasedimentary sequence - the Cross Lake Group - in the southern part of the belt. Layered ultramafic-mafic complexes are associated with the volcanic sequence. A considerable amount of fine grained mafic metasediment is interlayered with mafic flows in the northeastern part of the belt.

Several occurrences of hydrothermal alteration, both regional and local, were found in the greenstone belt; however, non displayed associated mineralization other than pyritiferous sulphides in iron formation. Most gossans are associated with interflow metasediments.

The pegmatites of the region were studied by Geological Services Branch staff, in co-operation with A.J. Anderson, a graduate student from the University of Manitoba. This investigation represents a continuation of the ongoing evaluation of Rare Element Pegmatites in the Province by the Mineral Resources Division and Dr. P. Černý of the Department of Earth Sciences, University of Manitoba.

In southeastern Manitoba, the chromite-bearing Bird River Sill was mapped in detail and a new sill stratigraphy was established in the Chrome Property. This work will be essential in the evaluation of the chromite reserves of the sill, undertaken by the Geological Services Branch as part of the Strategic Mineral Evaluation Program in co-operation with the Canada Department of Energy and Mines and Resources.

A short reconnaissance survey was carried out at Charron Lake, approximately 140 km south of Island Lake, in response to a need to obtain first-hand information of the Berens Subprovince for discussions on provincial land use guidelines.

The results of the survey confirm in large part previous mapping by the Geological Survey of Canada (Ermanovics, 1970). The rocks represent a medium crustal level comprising layered tonalitic to granodioritic gneisses with various amounts (5 - 20%) of amphibolite inclusions. The more granitic phases are the result of late kinematic regional potassium metasomatism, but there are no sharp boundaries between the various granitoid phases. With the exception of the amphibolites which probably represent mafic metavolcanic rocks, no supracrustal rocks were recognized.

Several co-operative projects with outside agencies are in progress. Students from the University of Windsor, Ontario, sampled several phases of the Bird River Sill for paleomagnetic studies, rubidium-strontium and zircon U-Pb age determinations.

A first phase of zircon dating on rocks collected in 1982 from the Island Lake belt has been completed by A. Turek, **et al.,** University of Windsor. Preliminary results indicate a 200m.y.+ long period of felsic intrusions in the belt and suggest that some volcanic rocks are at least 2880 m.y. old. Sampling for further zircon dating was continued this year, including felsic volcanic rocks.

A National Aeronautics and Space Administration (NASA) project, headed by W.C. Phinney, Houston, Texas, studying terrestrial anorthosites as part of LPI (Lunar and Planetary Institute) Early Crustal Genesis Program is presently involved in geochemical and petrological studies of plagiophyric intrusions and flows from the Cross, Atik (Utik) and Cauchon Lakes area. Fieldwork was conducted in 1982 with the assistance of personnel from the Geological Services Branch.

Samples for zircon dating were collected this summer from the Pikwitonei Granulite Domain during a field trip organized for staff of the Geological Survey of Canada. The zircon dating will be undertaken by T. Krogh, Royal Ontario Museum, Toronto. This granulite domain represents a lower crustal level. It has become increasingly important to better understand these lower levels to improve our knowledge of the development of the entire crust and its contained mineral deposits. The Pikwitonei granulite domain provides one of the best developed, exposed and accessible low crustal level cross sections in the shield. Studies from outside agencies will continue to be undertaken in the area and results of those studies will lead to a better understanding of Manitoba geology and mineral potential.

FUTURE DIRECTIONS

Short-term plans for geological mapping are strongly guided by current economic conditions. Thus easily accessible greenstone-gneiss terrains, permitting low cost fieldwork will get first priority, in particular those in the ("Nelson Front") Thompson region, to encourage exploration with the view to diversifying the mineral resource base. In addition to the low grade metamorphic rocks, medium and high grade metamorphic rocks will be examined mainly in view of possible gold mineralization and those minerals which could be economically processed in Thompson.

In order to make maximum use of recently acquired geological data in support of mineral exploration, a series of 1:250 000 scale compilations is planned for the entire northwestern sector of the Superior Province. The first will be cover the Oxford-Knee-Gods Lakes greenstone belt, and will be based on detailed work undertaken in the early seventies. Individual reports from that area will contain 1:50 000 scale maps.

Geological surveys will also continue in less accessible greenstone belts with gold potential, such as the Island Lake-Bigstone Lake-Stevenson Lake area, but on a lower priority.

Reconnaissance surveys are also planned in the Berens Subprovince, to enhance and intensify the sparse geological data base in this region. Although such projects have the lowest priority, some isolated areas in east central Manitoba are scheduled to be supplied with hydropower and/or all weather access both of which could substantially alter the economics of mineral exploration in this area.

GS-7 CROSS LAKE SUPRACRUSTAL INVESTIGATION

by M.T. Corkery

INTRODUCTION

Geological mapping of supracrustal rocks in the Cross Lake area was initiated this summer in conjunction with rare element enriched pegmatite and granitic intrusion studies (Lenton and Anderson, GS-8, this volume). Initial reconnaissance of supracrustal rocks from the Minago River through Pipestone Lake was carried out during June followed by 1:20 000 scale mapping of the area from Pipestone Lake west to the northern peninsula on Ross Island (Fig. GS-7-1).

Previous investigations disagree on the relationship of volcanic rocks, sedimentary rocks and numerous granitic intrusive phases. Alcock (1920) indicated that a gneiss complex intruded the sedimentary-volcanic sequence and found no evidence to suggest that conglomerates were unconformable upon volcanic rocks. Horwood (1934) stated that the sedimentary-volcanic sequence lay unconformably on a gneiss complex and that conglomerates overlay volcanic rocks unconformably. He subdivided the supracrustal rocks into an early sequence of volcanic-sedimentary rocks - the Hayes River series - and a later sequence of conglomeratic sediments - the Cross Lake series. Rousell (1965) found no evidence to suggest an unconformity between Horwood's Hayes River volcanic series and Cross Lake sedimentary series and assigned the name Cross Lake Group to the entire sedimentary-volcanic sequence. Rousell did not produce a comprehensive stratigraphic sequence; however, he indicated that volcanic and sedimentary rocks were interlayered. The Cross Lake area is included in Bell's (1978) 1:250 000 mapping and 1:500 000 compilation of the upper Nelson River area. Bell agreed with Rousell's interpretation of the Cross Lake Group and adds that since the conglomerates are unconformable on a granodiorite they may represent the lowermost members of the Cross Lake Group and should therefore be overlain by the volcanic members.

The objectives of this program are:

(1) to improve the subdivision and delineation of geological units providing a basis for regional volcanic-sedimentary stratigraphy with emphasis on solving the controversy involving the basement-sediment-volcanic relationships;

(2) to apply current volcanological and sedimentological concepts to the supracrustal rocks to determine their depositional environment and composition;

(3) to provide a more detailed structural and stratigraphic base in areas of rare element enriched pegmatite belts;

(4) to investigate a titanium-vanadium-bearing magnetite-ilmenite body south of Pipestone Lake which is reported to be about 10 km long ranging in width from 15 to 250 metres.

This summer's work concentrated on the metasediments, metavolcanics, and early intrusive phases in the south central portion of the area including detailed mapping in the area of "south group" rare element enriched pegmatites. During the 1984 field season mapping will continue northward to include the "north group" rare element enriched pegmatite area as well as detailed investigation of the magnetite-ilmenite body on Pipestone Lake.

Although the principal intent of this program is to provide a structural and lithological framework within which the rare element enriched pegmatites and titanium and vanadium deposits of the area can be evaluated, significant stratigraphic relationships were uncovered during the investigation. Accordingly a more comprehensive documentation of the principal lithologies is provided than would normally be entertained in a summary report of this nature. Subsequent reports will place greater emphasis on the evaluation and documentation of the economic deposits in the area.

RESULTS OF FIELDWORK

The major geological events are shown in the Table of Formations (Fig.GS-7-2) and a composite stratigraphic section in Figure GS-7-3.

Metavolcanic rocks (1) and subordinate metasedimentary rocks (2) comprise a sequence of early **supracrustal rocks** in which lithological associations suggest marine deposition. An unconformable relationship with basement rocks was not observed. Early intrusive rocks (3) intrude this sequence.

Late metasedimentary rocks unconformably overlie the **early supracrustal rocks** and a tonalite on the north tip of Cross Island. They constitute a thick sequence of subaerial-fluvial clastic sediment comprising: metaconglomerate (4). metasandstone (5), metasiltstone (6) and metashale (7). They are not interlayered with the **early supracrustal rocks.**

The contact between the two sequences is widely exposed. A regolith is developed on the mafic volcanics (1) in most locations. In two less deformed outcrops layering in the metabasalt (1) is at a high angle to, and truncated by, basal conglomerate (4a) of the overlying sequence. In most outcrops structural transposition of layering has obliterated contact relationships.

The established relationships indicate that the **early supracrustal rocks** and **late metasedimentary rocks** represent two distinct stratigraphic sequences separated by an unconformity which has been locally documented to be angular. The **late metasedimentary rocks** are equivalent to Horwood's (1934) Cross Lake series and the **early supracrustal rocks** to his Hayes River series. It is suggested that these names not be applied at this time as no correlation of the **early supracrustal rocks** and the Hayes River series can be made.

Variations in style and intensity of deformation occur within a series of blocks separated by cataclastic zones (Fig. GS-7-1). Detailed stratigraphy cannot be traced from block to block. The major block of **late metasedimentary rocks** east of the Whiskey Jack compression zone contains thick sequences of metasediments with weakly to moderately flattened, to rodded clasts. Small-scale folds are absent. To the west, in the Metis Island-Spodumene Island area the supracrustal sequence is isoclinally folded on the scale of several hundred metres with numerous small-scale folds. Clasts in the conglomerate (4) typically show pancake flattening locally in excess of 50 to 1 ratio. The relationship of large- and small-scale folding within and between blocks requires detailed analysis of structural data.

UNIT DESCRIPTIONS

All supracrustal rocks described have been metamorphosed from upper greenschist to middle amphibolite grade of metamorphism.

MAFIC VOLCANIC ROCKS (1)

Mafic volcanic rocks are exposed on the north and south shores of Pipestone Lake and extend northwest to Ross Island and Metis

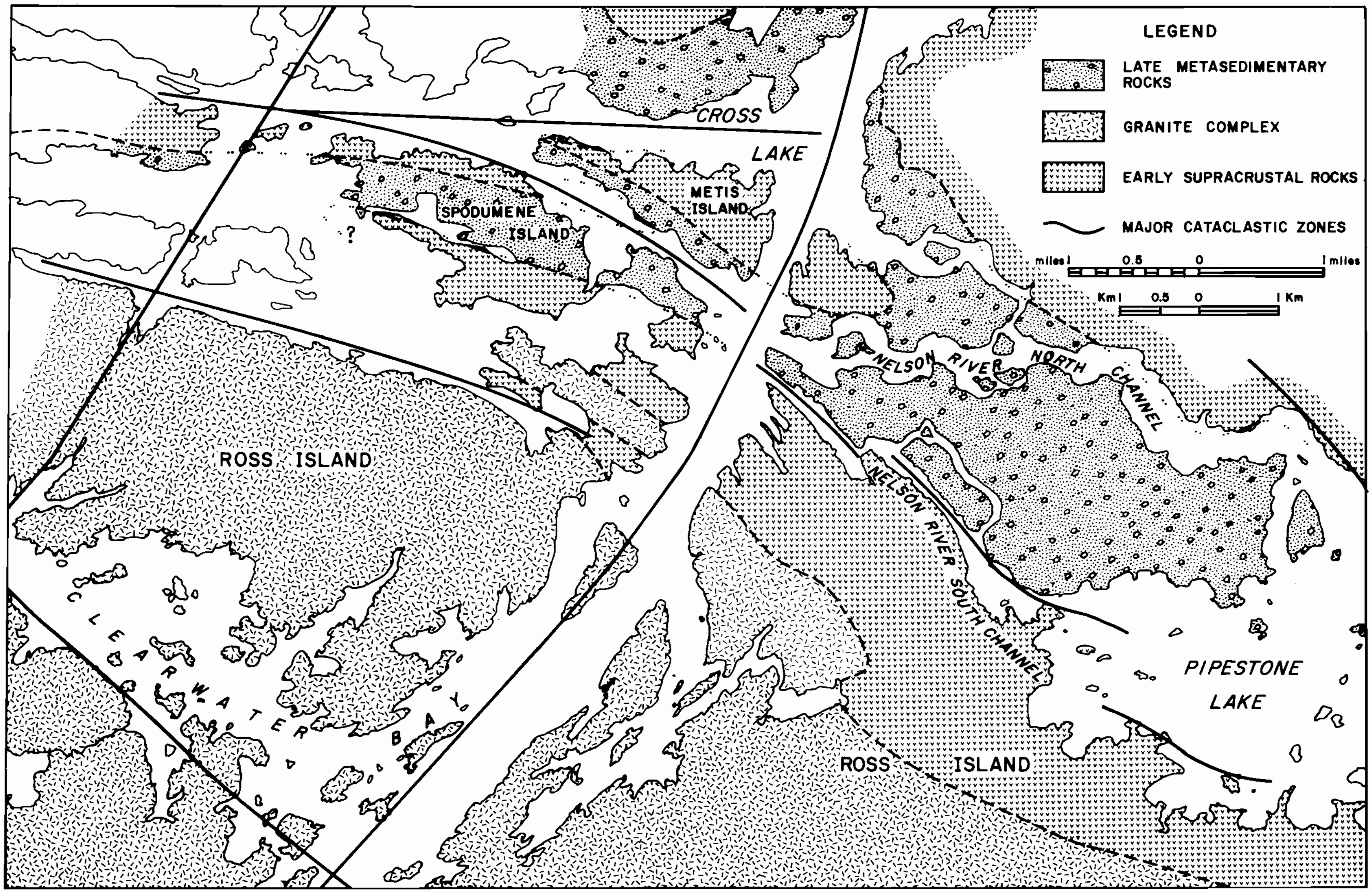

Figure GS-7-1 Simplified geological map of the southeast Cross Lake area with major block boundaries indicated.

Proterozoic		8c	Molson dykes
	Late Plutonic Rocks	8b	Rare element enriched pegmatite and associated pegmatitic granite
		8a	Quartz-feldspar porphyry
			INTRUSIVE CONTACT
		7	Shale-siltstone
	Late Metasedi-mentary Rocks	6	Siltstone- fine grained sandstone
Archean		5	Sandstone and pebbly sandstone
		4	Conglomerate
			UNCONFORMITY
		3a	Mafic dykes and sills
	Early Plutonic Rocks	3b	Anorthosite, anorthositic gabbro
		3c	Layered ultramafic sill
			INTRUSIVE CONTACT
	Early Supracrustal Rocks	2	Volcanic conglomerate and greywacke sedimentary rocks
		1	Mafic volcanic rocks

Figure GS-7-2: Table of Formations, southeast Cross Lake-east Pipestone Lake area.

Island. They are typically highly flattened and recrystallized with sporadic areas of well preserved primary structures. The thickness of this basal unit, together with subordinate sediments (2) reaches 1200 m in the west Pipestone Lake area.

Where volcanic rocks are well preserved pillowed and massive flows dominate the sequence. Greywacke sediments, mafic tuff and oligomictic flow-breccia units occur locally. The basalts are generally pillowed in flows ranging from 2 to 6 m thick, weathering olive-green-brown with interpillow material restricted to triangular interstices. Flows may be amygdaloidal or variolitic and some with 1 to 2 mm plagioclase laths, in a fine grained groundmass, may have been porphyritic. Pillows are typically 0.25 to 1.5 metres long, with rare 1.5 by 8 m pillows. Massive flows, up to 4 m thick, are subordinate to pillowed flows. Flow tops up to 70 cm thick (Fig. GS-7-4), contain amoeboid pillows and pillow fragments in a hyaloclastite matrix. A second morphologically distinct type of flow displays 1 to 2 cm of interpillow hyaloclastite (Fig. GS-7-5), consisting of fine grained plagioclase-rich matrix with 1 mm by up to 1 cm selvage fragments. These flows are pale green to grey and may represent a different composition.

Basalts typically comprise varying percentages of amphibole, plagioclase, minor chlorite and opaques (magnetite, pyrite). Where highly recrystallized, garnet-diopside or biotite-garnet-quartz assemblages may also occur.

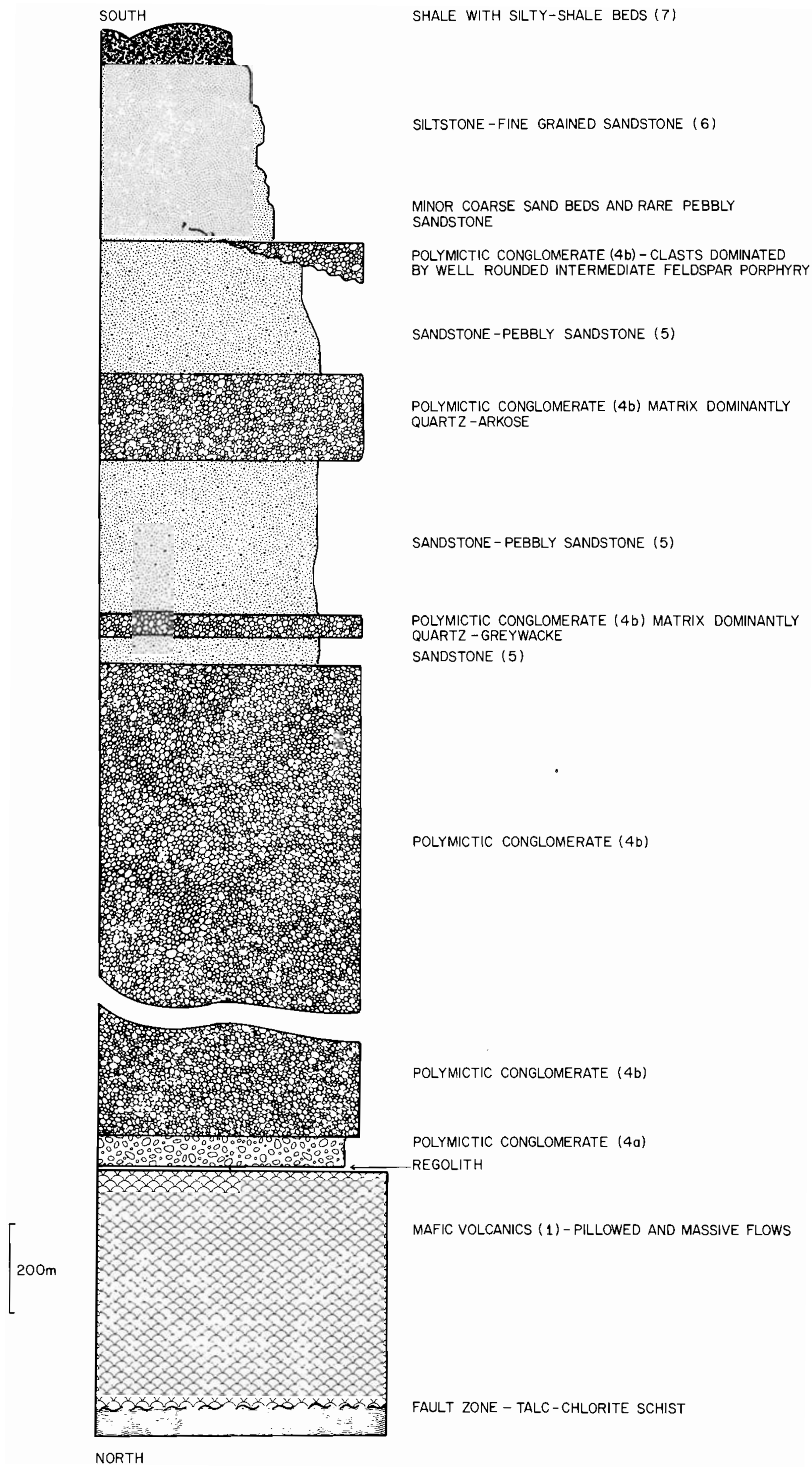

Figure GS-7-3: *Composite stratigraphic section, east Pipestone Lake area.*

Figure GS-7-4:

Pillowed basalt with recrystallized interpillow hyaloclastite.

Figure GS-7-5:

Upper portion of a massive basalt flow with amoeboid pillows in associated flow top breccia.

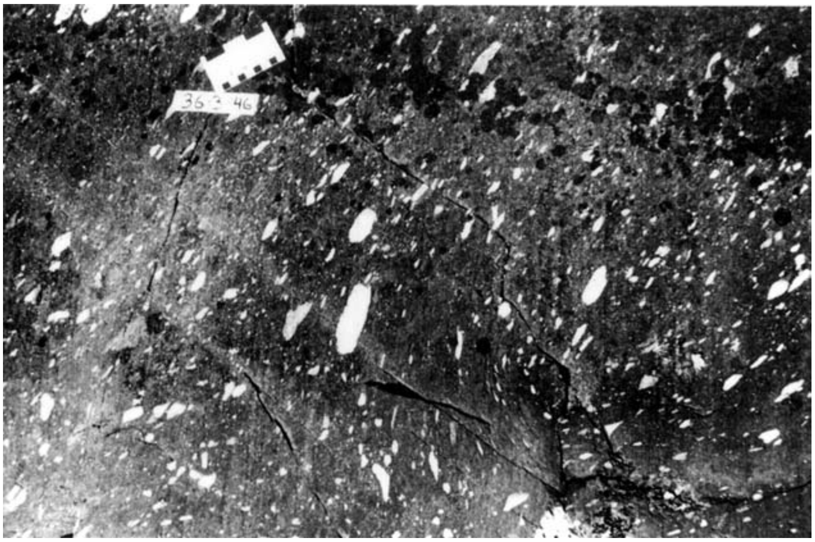

Figure GS-7-6:

Polymictic volcanic conglomerate (2).

Moderate to extreme flattening and extensive recrystallization is common in the metabasalts and generally obscures primary structures. Pillow selvages form 1 cm hornblendite layers, which are commonly garnetiferous. Flow top breccias form 5 to 15 cm layers of hornblendite with irregular hornblende-plagioclase amphibolite inclusions.

Alteration zones in the basalts from the Metis Island and Spodumene Island area (Preliminary Map 1983N-3) are of several different types:

(1) A zone up to 30 m thick, on the south-west side of Spodumene Island consists of interlayered:
- quartz-plagioclase-biotite-garnet schist;
- quartz-plagioclase-pale green amphibole-biotite-garnet schist.

Within these layers are local gossans containing pyrite.

(2) Laterally extensive layers of grey garnetiferous biotite schist up to 3 m thick occur in basalts on the north shore of Metis Island.

(3) A 300 m thick zone of muscovite schist on the east shore of Metis Island contains staurolite and andalusite concentrations in diffuse layers. A reef north of Metis Island comprises a zone of similar mineralogy which includes a gossan zone containing disseminated pyrite and pyrrhotite.

(4) Two types of alteration are associated with the rare element pegmatites of the south group. Basalts in contact with or including the pegmatites are tourmalinized. Tourmaline halos extend up to more than 100 m from the larger dykes. Holmquistite (lithium orthoamphibole) forms in basalts in zones up to 100 m from spodumene-bearing dykes.

VOLCANIC CONGLOMERATE AND GREYWACKE SEDIMENTARY ROCKS (2)

Sediments associated with mafic volcanics south of Spodumene Island consist of volcanic conglomerate, greywacke conglomerate, psammitic to pelitic greywacke - and in one location on Spodumene Island - thinly layered quartz-magnetite iron formation.

The volcanic conglomerate (Fig. GS-7-6) is typically dark green to black and massive to poorly layered. It is generally unsorted and contains a high proportion of angular (0.5 to 4 cm) clasts comprised almost entirely of dark green hornblende. Local concentrations, up to 10 per cent, of light grey-buff feldspathic clasts and rare gabbroic clasts occur.

Greywackes are typically bedded on a 2 to 5 cm scale with rare conglomeratic beds up to 1.5 m thick. They are composed of plagioclase-quartz-biotite-hornblende with minor garnet and magnetite.

EARLY INTRUSIVE ROCKS (3)

Mafic Dykes and Sills (3a)

Two major suites of early mafic dykes cut the mafic volcanic rocks and associated sedimentary rocks. The early phase consists of fine- to medium-grained equigranular gabbro dykes up to 3m thick. A later set of hornblende megacrystic dykes up to 20 m thick contain equant hornblende crystals up to 8 mm in a fine- to medium-grained plagioclase-hornblende groundmass.

Anorthosite, Anorthositic Gabbro (3b)

Layered anorthositic gabbro and anorthosite intrude the mafic volcanics on the south shore of Pipestone Lake and the south side of Spodumene Island.

Layered Ultramafic Sill (3c)

A portion of a highly altered and recrystallized layered ultramafic sill intrudes the mafic volcanics (1) on a series of islands in south-west Pipestone Lake. Metamorphosed dunite, peridotite, pyroxenite and gabbro layers are sporadically exposed over a 1 km strike length.

Clearwater Bay Gneiss Complex (3d)

A granitic intrusive complex intrudes mafic volcanics (1), volcanogenic sedimentary rocks (2) and early gabbroic intrusives (3a). See Lenton and Anderson, GS-8 , this publication.

POLYMICTIC CONGLOMERATE (4)

Basal Conglomerate (4a)

On numerous outcrops along the north channel of the Nelson River between Pipestone Lake and Cross Lake and along the shoreline of Metis Island the contact between basalt and overlying conglomerate is exposed. This basal member is variable in thickness from a maximum of 75 metres to one area where the entire unit has been removed by erosion, and sandstone (5) directly overlies the basalt.

The base of the unit commonly consists of pebble-free hornblende-biotite sediment interpreted as regolith. In three locations conglomerate with a similar mafic matrix and dominantly basaltic clasts forms the base of the sequence. Thickly bedded polymictic conglomerates overlie the regolith.

The regolith occurs as a 50 cm to 2 m thick layer of black weathering feldspar-quartz-hornblende-biotite-carbonate schist. It generally contains 2 mm to 1.5 cm garnet porphyroblasts which may constitute up to 20 per cent of the rock. Typically the unit is massive; however, in several outcrops 0.5 to 2 cm parallel beds were observed near the top and elsewhere rare pebbles occur.

Where massive pelitic regolith is absent, basal conglomerate directly overlies basalt (Fig. GS-7-7). These conglomerates are characterized by basalt clasts (75 to 95 per cent of the clast population) in a matrix similar in character to the regolith. Mafic volcanic clasts are typically angular (Fig. GS-7-7) and range in size from pebbles up to 30 cm by 1.5 m boulders. Some boulders comprise large pillow segments (Fig. GS-7-8) which show better rounding than cobble size clasts. Included in the clast population is a significant component of more rounded clasts with the same wide range of compositional variations observed in overlying polymictic conglomerates (4b).

Polymictic, clast-supported conglomerates of subunit 4b which overlie the basal members are typified by mafic-rich matrix and highly variable clast compositions. Near the base the matrix comprises plagioclase-quartz-amphibole with minor biotite-garnet-epidote and calcite. Matrix alternates from hornblende-rich to biotite-rich and biotite becomes the dominant mafic up section. Matrix composition in these layers is more pelitic and garnet-staurolite-andalusite metamorphic assemblages occur. These grade upward into sandy matrix, clast-supported conglomerates (4b).

These conglomerates are typically bedded on a scale of 1 to 3 m with no sorting or internal bedding. Clasts range in size from granule to cobbles with an average size of 5 to 6 cm. Clasts are typically well rounded, and in most areas sphericity cannot be determined due to tectonic flattening. On Pipestone Lake where deformation is less severe the granitic, quartzite, felsic volcanic and quartz clasts have high sphericity and mafic volcanic and sedimentary clasts are ellipsoidal. Variations in abundance of clast types occur from layer to layer.

Figure GS-7-7:

Mafic volcanic (1) *overlain by polymictic conglomerate (4a). Basalt* clasts *are typically angular to sub-angular.*

Figure GS-7-8:

Large clast of pillowed volcanic in polymictic conglomerate (4a).

Sand Matrix Polymictic Conglomerate (4b)

Thick sequences of clast- to matrix-supported polymictic conglomerates are exposed in relatively continuous cross-section on the west shore and nearby islands of Pipestone Lake. Deformation and recrystallization are minimal and original sedimentary characteristics are preserved. A detailed stratigraphic section through all of the units in the sedimentary sequence has not been completed due to unresolved structural complications; however, a number of partial sections have been documented and the position of conglomerates (4b) are indicated in figures GS-7-3 and 9). The most extensive sequence of conglomerate (4b) overlies basal conglomerate (4a) throughout the area and in sections up to 800 m thick. A second major sequence, in excess of 200 m thick, occurs higher in the stratigraphic section.

Three dominant large-scale variations in bedding occur:

1) massive conglomerate which appears to be bedded on a scale of 10 m to a maximum of 50 m;
2) massive and cross-bedded conglomerates, bedded on a scale of 1 to 4 m forming sets of beds up to 40 m thick;
3) cross-bedded 15 cm to 2 m conglomerate beds interbedded with sandstone and pebbly sandstone in sets of beds from 10 to 25 m thick.

Initial interpretation of structure and stratigraphy indicates that type 1 beds lie near the base of the section, type 2, the most abundant beds, are common throughout the section and type 3 are most abundant high in the section (Fig GS-7-9).

Massive type 1 conglomerate layers generally contain no internal clast organization. Clasts range in size from less than 1 cm up to 40 cm. The average of the largest clast fraction in most beds is about 30 cm. Lack of internal organization is common in most beds; however, zones up to 3 m thick, parallel to the bedding, may contain a higher percentage of randomly distributed large clasts. In other beds, 5 to 25 cm zones with a consistently higher than average sand matrix or grit-pebble fraction form layers parallel to bedding. Sporadic lenses or discontinuous quartz-wacke layers up to 30 cm thick occur between very thick beds of conglomerate.

The more common type 2 conglomerates are typically bedded on a scale of 1 to 4 m. In most beds there is no apparent organization. Clasts ranging from small pebbles up to large cobbles are randomly distributed throughout the beds. Other beds are cross-bedded. Cross-beds form at a 10° to 15° angle to bedding and range from 5 to 30 cm thick. They are defined by:

1) pebble to cobble clast-supported conglomerate;
2) sandy matrix-supported conglomerate (Fig. GS-7-10);
3) pebble conglomerate (Fig. GS-7-11).

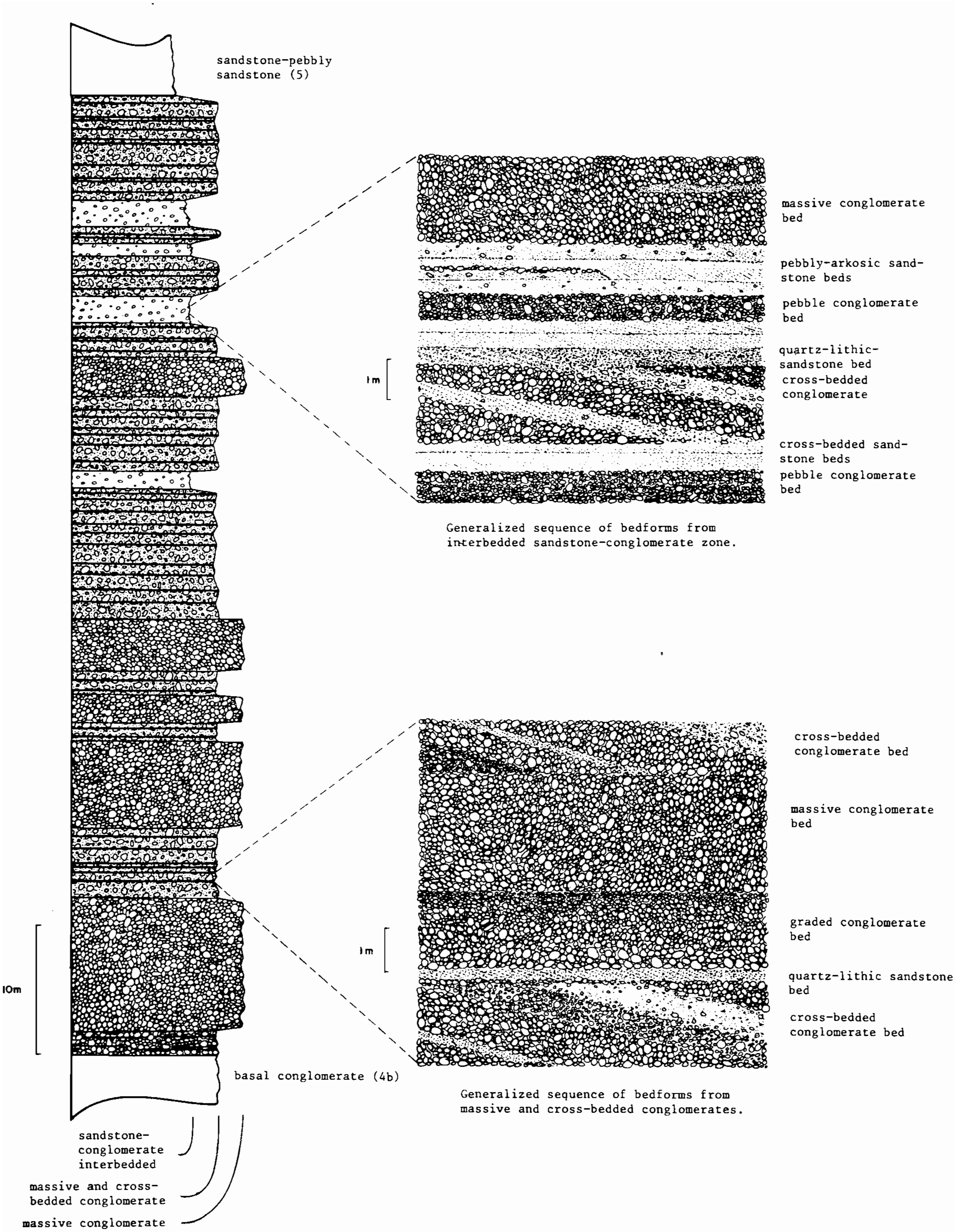

Figure GS-7-9: Stratigraphic section of conglomerate (4) - Pipestone Lake area - showing major bedforms.

Figure GS-7-10:

Sand matrix cross-beds in a 2 m thick polymictic conglomerate bed.

Figure GS-7-11:

Pebble conglomerate cross-beds in a polymictic conglomerate bed.

Within sandy matrix-supported cross-beds sands are invariably internally cross-bedded and consist of a quartz-lithic-feldspar greywacke similar to the conglomerate matrix. Rare 2 to 3 metre thick beds of clast-supported conglomerates show normal grading. Cross-bedded sand lenses 10 to 20 cm thick and up to 20 m long, occur between conglomerate beds.

Type 3 cross-bedded conglomerate-sand sequences are similar to type 2 beds in most bedforms; however, conglomerate beds are typically cross-bedded and beds are generally thinner. Thin - 15 to 50 cm - beds may contain a significant large clast fraction but generally are pebble to small cobble-bearing. Sandy interbeds, which may form up to 50 per cent of the layers, are cross-bedded with one set or up to 3 cosets and range from 10 to 50 cm thick. Thicker sand beds have been traced up to 100 m along strike. These beds range from clast-free sandstone to pebbly sandstone (Fig. GS-7-12). Two significant compositional variations occur in these sands; quartz-feldspar arkoses similar to unit 5 and quartz-lithic-feldspar greywacke similar to the matrix in the conglomerates (4b).

Clast compositions in conglomerates (4) are highly variable and more than 20 rock types have been noted on single outcrops. Common clast varieties are:

1) sedimentary clasts: psammitic to pelitic greywacke, quartzite, silicate iron formation;
2) mafic, intermediate and felsic volcanic clasts;
3) intrusive and metamorphic clasts: various tonalite to granodiorite phases, intermediate to felsic feldspar and quartz-feldspar porphyries, gabbro, diorite, anorthosite, granite gneiss and layered migmatite.

In general greywacke clasts are abundant throughout the sequence, granitic clasts are found throughout but appear to increase in abundance up section, and conversely mafic volcanic clasts occur throughout but decrease up section.

The shape of clasts varies with both size and rock type. Small clasts - granule to 2 cm pebbles - range from angular to well rounded. Clasts larger than 2 cm are typically well rounded with the degree of sphericity dependent on rock type. Intrusive, quartzite and felsic volcanic clasts are typically the most spherical and sediment and mafic volcanic clasts are elliptical.

Weathering rinds have developed on many clasts throughout this unit (Fig.GS-7-13).

Figure GS-7-12:

Interlayered sandstone and conglomerate beds.

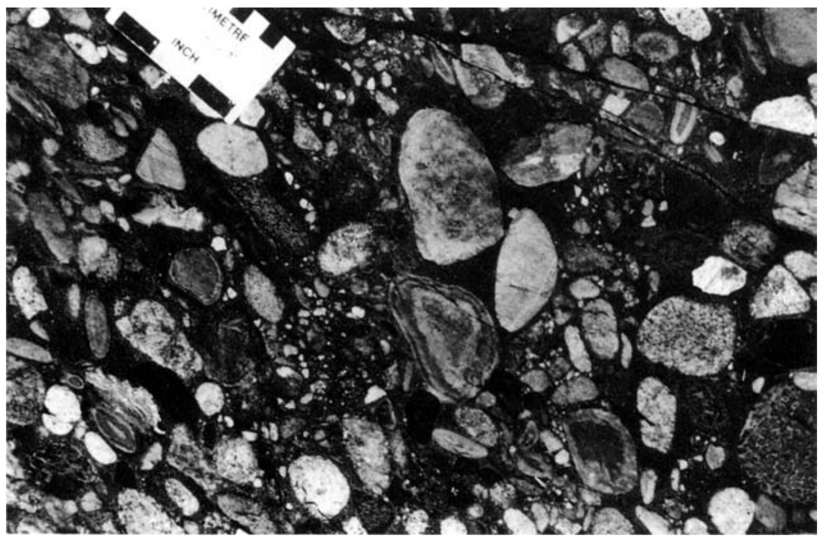

Figure GS-7-13:

Weathering rind development on clasts in polymictic conglomerate (4).

SANDSTONE AND PEBBLY SANDSTONE (5)

This unit overlies the thick basal members of unit 4 conglomerate throughout the area mapped and is interlayered, on a several hundred metre scale, with thick conglomerate (4b) sequences (Fig. GS-7-3, 14). Locally conglomerates (4a, 4b) are thin or absent and sandstone (5) directly overlies mafic volcanics (1). Sections of unit 5 up to 300 m thick are exposed on Pipestone Lake.

The rocks are composed predominantly of medium- to coarse-grained sands which are thickly bedded and invariably cross-bedded. They range from clast-free sandstone to pebble-cobble conglomeratic sandstones in which the clasts occur randomly throughout cross-beds or in discrete layers. From 45 to 70 per cent of the rock is composed of 0.5 to 1.5 mm quartz sand with an average grain size of 1 mm. Feldspar grains, which form up to 35 per cent of the rock, have a wider range of grain size from 0.1 to 4 mm grit. The remaining sand size fraction is comprised of quartzite, quartz-feldspar lithic grains and light brown mudstone. Two significant variations in composition of the sandstones occur as individual beds or series of beds within the quartz sandstone. These consist of feldspathic arkose and quartz-rich lithic sands.

A wide range of bedforms occur in the sandstone sections (Fig. GS-7-4). Major variations - from smallest to largest - are:

1) Festooned cross-beds (Fig. GS-7-15) with troughs ranging from 10 to 30 cm deep in beds up to 2 m thick. These rarely contain clasts larger than granules.

2) One to 10 metre thick beds consisting of sets of troughs or U-shaped channels. These can be subdivided into two types:

   i) co-sets with troughs up to 2 m thick containing long low angle cross-beds averaging 3 mm thick. These beds contain up to 10 per cent clasts ranging from 2 mm to 1 cm with rare 2 to 3 cm pebbles. The coarse fraction is generally randomly distributed throughout the beds;

   ii) pebbly sandstone cross-beds similar in character to type (i) except that they may form thicker beds and contain a more abundant coarse clast fraction. These cross-beds are typically defined by 3 mm thick sand laminations; however, thicker - up to 15 cm - pebble-rich horizons parallel the cross-beds. In pebble cross-beds the grain size varies from coarse sand to 3 cm pebbles with a 2 to 4 mm lithic granule matrix. A coarse clast fraction, from 10 to 20 cm, dominated by well rounded tonalite clasts, is randomly distributed throughout the beds.

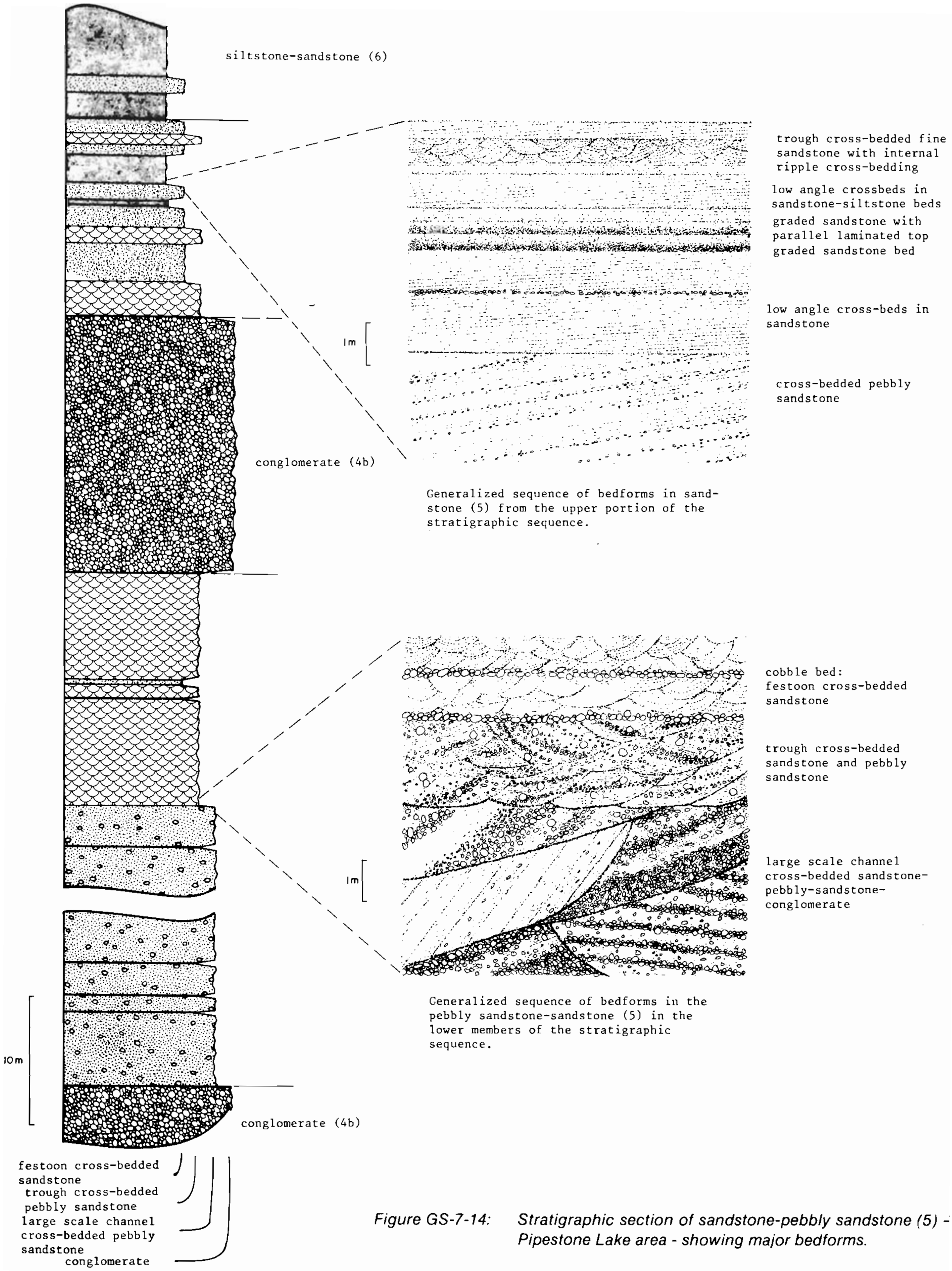

Figure GS-7-14: *Stratigraphic section of sandstone-pebbly sandstone (5) - Pipestone Lake area - showing major bedforms.*

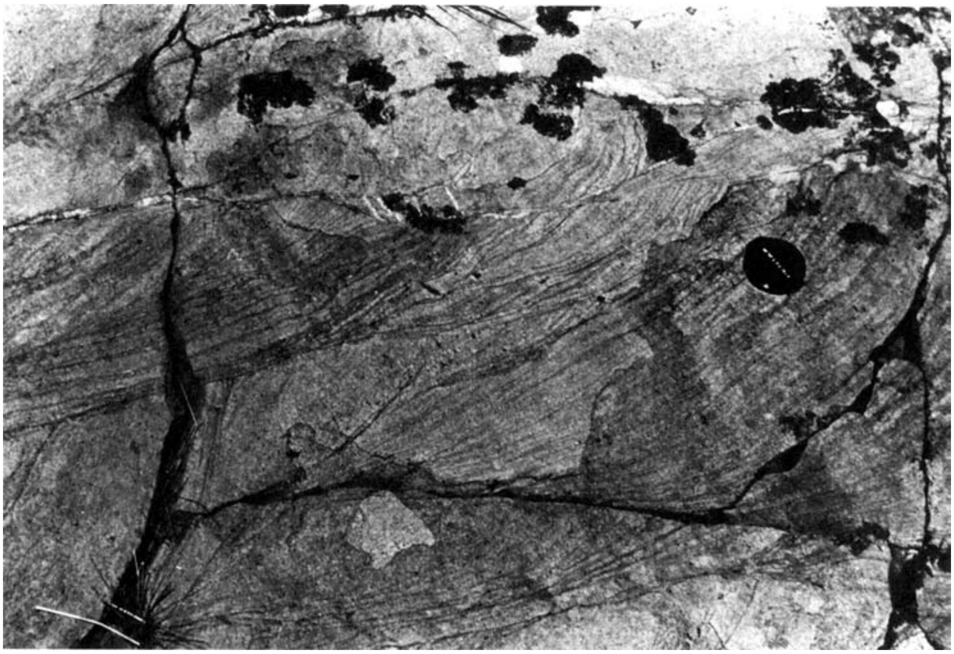

Figure GS-7-15:

Festooned cross-bedding in sandstone (5).

3) The largest bedform consists of co-sets of troughs or channels up to 30 m thick. Individual troughs ranging from 3 to 10 m thick by 15 to 20 m across, have steep angular erosional contacts with adjacent troughs (Fig. GS-7-16). Troughs contain internal cross-bedding on a scale of 5 to 25 cm (Fig. GS-7-16), consisting of sandstone, pebbly sandstone and clast-supported conglomerate layers. The sand fraction is consistently cross-bedded on a 2 to 4 mm scale.

An uncommon but distinctive feature associated with bedforms 1 and 2 is the occurrence of thin, one- to two-clast thick, coarse pebble-boulder layers between the beds (Fig. GS-7-17).

Clasts in this unit have the same range of rock types and size as in polymictic conglomerates (4). However, there are characteristic features of the clasts and their distribution in the arkosic sandstone (5). Intrusive quartzite and felsic volcanic clasts are typically well rounded, spherical and form the largest clast fraction. Sediment and mafic volcanic clasts are typically angular and appear to be portions of broken rounded clasts.

SILTSTONE-FINE GRAINED SANDSTONE (6)

Thinly bedded to laminated siltstone interbedded with medium to thinly bedded sandstone overlie the arkosic sandstone (5)-conglomerate (4) sequence on Pipestone Lake and in the south channel of the Nelson River between Pipestone and Cross Lakes. Up to 400 m of siltstone-dominant sediments are interbedded with fine grained sandstone, minor medium- to coarse-grained sandstone and argillaceous siltstone.

The contact between units 5 and 6 is gradational over about 100 m. In this zone bed thickness decreases in the sandstones and thinly bedded siltstones increase in abundance. Pebbly sandstone layers decrease upward and are absent from the top of the section. The content of lithic sand-and-silt increases. Siltstone occurs in three compositional varieties:

1) cream to beige weathering feldspathic siltstone;
2) light brown-buff feldspar-lithic greywacke siltstone;
3) argillaceous siltstone.

Sandstone beds are similar in composition to unit 5 arkosic sand. However, local increases in the lithic sand fraction occur in many beds.

Figure GS-7-16: Large-scale trough structure with internal bedding and cross-bedding.

Figure GS-7-17:

Cobble-boulder lag deposits in sandstone (5).

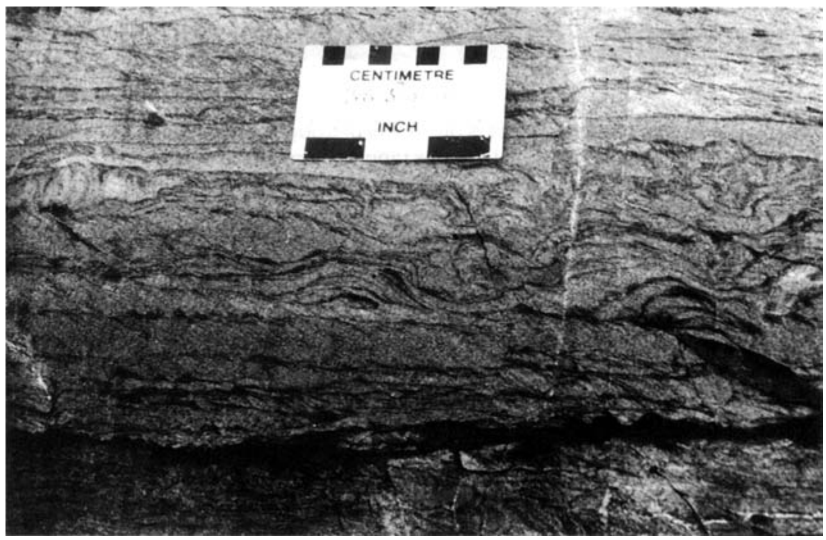

Figure GS-7-18:

Ripples in fine grained sandstone.

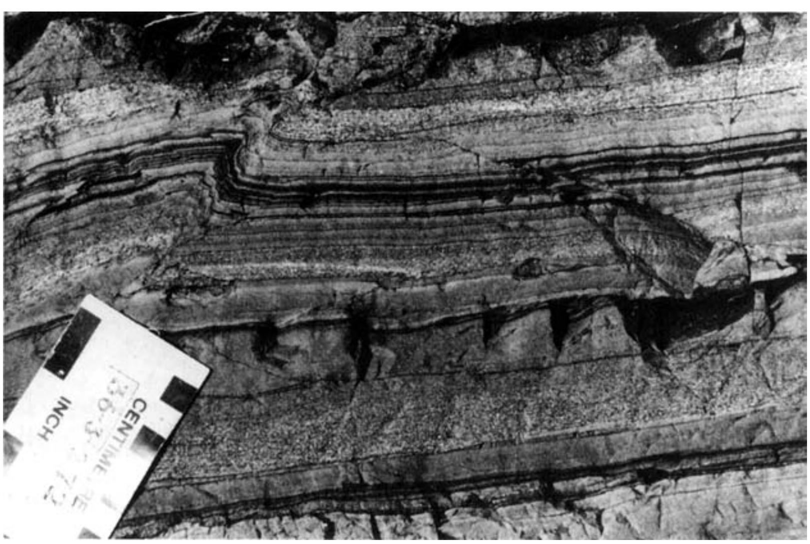

Figure GS-7-19:

Graded bedding in siltstone-sandstone (6).

Primary sedimentary structures are abundant. In coarse to fine sands, tabular cross-beds, small-scale trough crossbeds and graded beds are common. In thin beds ripples are preserved (Fig. GS-7-18). In silt layers graded (Fig. GS-7-19), cross-bedded and ripple-bedded layers are common.

SHALE-SILTSTONE (7)

The uppermost unit in the stratigraphic section consists of 80 m of highly recrystallized biotite schist, exposed in the south channel of the Nelson River between Pipestone Lake and Cross Lake. Metamorphic recrystallization has destroyed most primary features. The rock contains quartz-feldspar-biotite with minor staurolite, garnet and andalusite. Variations in mineral components define layering indicative of primary bedding. Layers range from millimetre shale partings up to 20 to 25 cm beds of silty shale and siltstone. Silt-dominant beds are typically laminated and in one outcrop appear to be cross-bedded.

LATE INTRUSIVE ROCKS (8)

Three late intrusive phases occur.

Unit 8a consists of a fine grained light grey quartz-feldspar porphyry.

Unit 8b consists of rare element enriched pegmatites and associated pegmatitic granite - See Lenton and Anderson (GS-8) this publication.

Unit 8c consists of numerous mafic dykes of the Molson dyke swarm.

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GS-8 GRANITE-PEGMATITE INVESTIGATION,

CROSS LAKE

by P.G. Lenton and A.J. Anderson[1]

INTRODUCTION

Detailed studies of plutonic rocks and rare element enriched pegmatites in central Cross Lake region were undertaken in conjunction with regional and detailed mapping programs initiated by M.T. Corkery and J.J. Macek (reports GS-7 and GS-9, this volume). The pegmatite evaluation is being conducted as a co-operative program between the Mineral Resources Division and the University of Manitoba under the Federal-Provincial Interim Mineral Agreement (1983-85). A.J. Anderson is currently completing a M.Sc. thesis project on the rare element pegmatites of Cross Lake which involved two months of field studies in 1982 and one month in 1983.

Rare element pegmatite dykes in the Cross Lake area were reported by Bell (1962), Rousell (1965) and Bannatyne (1973). Subsequent discovery of Ta-Nb oxide mineralization in pegmatites by Tantalum Corporation of Canada in 1979 indicated a need for detailed investigation of the pegmatite field. Anderson examined 99 pegmatites and 25 pegmatitic granite bodies (Fig. GS-8-1). They were sampled for minerals containing fractionation-sensitive pairs of elements. Where possible the structural position and metasomatic effect on country rocks of the pegmatites was documented.

Detailed mapping of all intrusive phases was undertaken to determine a complete intrusive history of the area. Initial work was concentrated on the area south of Cross Island.

GENERAL GEOLOGY

Central Cross Lake is dominated by east- and northeast-trending arms of a bifurcated greenstone belt (see Corkery, GS-7, this publication). The greenstone belt is intruded by a variety of complex granitoid bodies that exhibit several distinct phases and an extended structural history. The supracrustal belt comprises two major subdivisions; an old, dominantly volcanic section that predates all granitoid plutonism and a younger coarse clastic sedimentary section that postdates all but the youngest of granitic bodies (see Table GS-8-1).

Units 1 to 8 form multi-component gneiss complexes. As any exposure may comprise several phases the units have been grouped according to dominant phase and relative age as follows (see Fig. GS-8-1):

Pipestone Lake mafic complex; unit 1 with varying proportions of units 3,4,6 and 8
Northern complex; units 2 and 4 dominant
Whiskey Jack complex; unit 3 extensively intruded by units 4, 5, 6 and 7
Clearwater Bay complex; unit 4 extensively intruded by units 5 to 9
Eves Rapids complex; units 4 and 5

Units 10 and 11 are the only intrusive units that cut the upper sedimentary section of coarse clastic rocks.

Two intrusive bodies are lumped into unit 10.They are contemporaneous with, and probably the source of the rare element enriched pegmatites. The body south of Cross Island (unit 10b) is a pegmatitic granite comprising a two mica-garnet leucogranite and a pegmatitic leucogranite. The source of this pegmatitic granite body has not been identified and may exist only at depth. The northern body (unit 10a) is a one kilometre wide near circular plug of fine grained feldspar porphyritic magnetiferous biotite-muscovite granite. No pegmatic granite body has been directly associated with this body. Although the two intrusions differ in texture, mineralogy and composition their position in the structural and plutonic history of the region indicates they are contemporaneous in origin.

Metamorphic grade in the Cross Lake area ranges from upper greenschist facies at Pipestone Lake to hypersthene granulite grade in the gneissic terrane northwest of Cross Lake. Highly fractionated pegmatites occur in regions of middle amphibolite grade, generally at or near the first appearance of sillimanite in pelitic greywacke.

Structural investigations in the central Cross Lake area (Report GS-7, this volume) indicate a predominantly isoclinal fold style with a west trend and ENE plunge at 60°. Pegmatites form tabular to podiform bodies intrusive into the axial surfaces of antiformal folds. Dips are variable but predominantly to the north. Elongation in podiform dykes generally parallels the ENE regional plunge. Shearing, minor offsets and boudinage at 230° are common features in the pegmatites related to a single post-intrusion deformation. In the Pipestone Lake region block faulting is the major structural feature. The change from tight folding to block faulting occurs at the NE-trending channel between Cross Lake and Pipestone Lake. This also marks the eastern limit of rare element enriched pegmatites, although molybdenite, fluorite and ilmenite-bearing quartz veins with similar attitudes to the pegmatites are common in eastern Pipestone Lake.

Rare element pegmatite dykes comprise two linear belts; an east-trending "south group" and northeast trending "north group". Although the attitude of individual dykes is controlled by the west trending fold pattern, the orientation of the belts appears to be controlled by linear zones of cataclasis (see Fig. GS-8-1). These zones are long-lived features characterized by both multiple shearing events and the presence of many minor intrusive phases. Mylonite zones and pseudotachylite veining are common features in these compressive deformation zones that both predate and postdate intrusion of the pegmatite dykes. The pegmatitic granite that is the probable source of the south group dykes is intruded over several kilometres as a series of elongate sheets in a major west-trending zone of cataclastic deformation.

For a discussion of the metasomatic effects on country rocks produced by the intrusion of rare-element enriched pegmatites see Report GS-7, this volume, by Corkery.

RARE ELEMENT ENRICHED PEGMATITE DYKES

Highly fractionated dykes have been separated into two groups based on mineralogy, texture and available geochemistry. They appear to be derived from different source granites. Highly fractionated dykes of the south group typically comprise: quartz, microcline (pink to mottled pink and grey), pale green spodumene, tourmaline, pale green muscovite, white beryl, Mn-rich garnet, blue apatite and traces of Nb-Ta oxides, cassiterite, loellingite ($FeAs_2$) and sicklerite

[1] A.J Anderson is currently undertaking graduate studies at the Department of Earth Sciences, University of Manitoba.

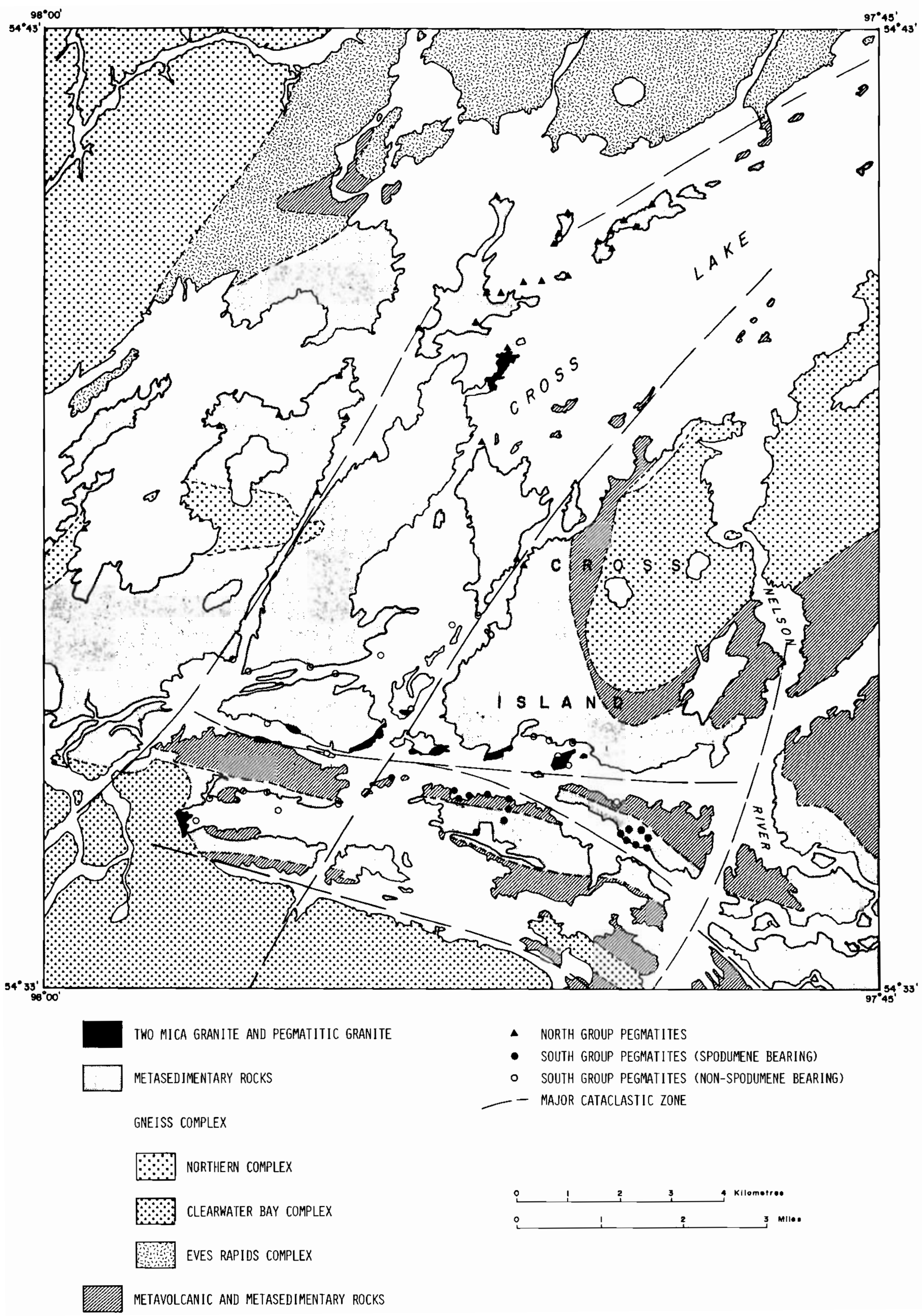

Figure GS-8-1: Simplified geological map of the Cross Lake area showing maior structural features and the distribution of pegmatite dykes.

TABLE GS-8-1
INTRUSIVE HISTORY OF THE CENTRAL CROSS LAKE AREA

11	Mafic dykes (Molson swarm)	
deformation		
10	Two mica granites	
	10a	Feldspar porphyritic magnetiferous biotite-muscovite muscovite granite (North Group pegmatites)
	10b	Pegmatitic granite comprising leucocratic biotite-muscovite-garnet granite and pegmatitic leucogranite (South group pegmatites)
deformation		
9	pegmatite: simple pegmatites, may contain xenotime	
cataclastic deformation (local)		
8	pegmatite and aplite	
	deposition of upper coarse clastic sedimentary sequence(?)	
7	massive grey granodiorite; occurs as dyke swarm	
cataclastic deformation		
6	grey porphyritic granodiorite; small plug-like bodies and extensive dyke swarms	
cataclastic deformation (local)		
5	pegmatite; extensive **lit-par-lit** injection in older gneisses	
4	tonalite; grey leucocratic biotite gneiss	
3	augen granodiorite; porphyritic grey to white leucocratic biotite granodiorite	
2	granodiorite; plagioclase megacrystic hornblende granodiorite	
1	mafic complex; gabbro, anorthositic gabbro, anorthosite, pyroxenite, diorite	

($Li(Mn,Fe)PO_4$). North group dykes lack spodumene, have less potassium feldspar (locally a brown monoclinic variety occurs), are generally richer in blue apatite, garnet, coarse albite, beryl (in diverse colours of pale yellow, pale green, deep yellow-green and colourless) and contain triplite ($(Mn,Fe,Mg,Ca_{12}(PO_4)(F,OH))$) rather than sicklerite.

Textural and paragenetic features of individual pegmatites vary across the field. Dykes found at the western end of the belts are typically of simple mineralogy and homogeneous texture whereas eastern pegmatites are concentrically zoned bodies of diversified mineralogy. Zonal distribution of different pegmatite types suggests the pegmatites are progressively more fractionated in an easterly direction.

At the present time a small percentage of mineral samples have been chemically analyzed. Mineral geochemical data may verify and clarify regional fractionation trends inferred from field observations. It will also narrow the search area and provide a semi-quantitative estimate of mineralization potential for the pegmatites. Existing chemical analyses of blocky potassium feldspar samples from core-margins of pegmatites suggest that some spodumene-bearing dykes have attained a level of fractionation comparable to the Bernic Lake group of southeastern Manitoba (Fig. GS-8-2).

Ta-Nb oxide minerals were found at nine localities in the Cross Lake pegmatite field. Columbite-tantalite occurs as tabular and wedge-shaped grains, between 0.1 and 5.0 cm in length, in cleavelandite and fine grained albite. Mn/Fe and Ta/Nb ratios in columbite-tantalite increase with progressive pegmatite fractionation. Unit cell dimensions were determined from powder X-ray diffraction patterns and the chemistry was determined by energy-dispersive electron microprobe analyses. Figure GS-8-3 is a plot of **a-c** unit cell dimensions for columbite-tantalites from the Cross Lake pegmatite field. Komkov (1970) has shown that the **a** cell edge increases with increasing Mn/Fe ratio. The **a-c** plot also illustrates relative order-disorder in columbite-tantalites which affects mainly **c** dimensions. Cross Lake columbite-tantalites display a wide range in Mn/Fe ratios and intermediate structural state.

Figure GS-8-4 illustrates columbite-tantalites from Cross Lake in the $FeNb_2O_6$-$FeTa_2O_6$-$MnNb_2O_6$-$MnTa_2O_6$ (mol%) diagram. The Mn and Ta contents are lowest at the western end and highest at the eastern ends of the pegmatite belts.

Columbite-tantalite from the highly fractionated pegmatites from Cross Lake have fractionation-sensitive element contents similar to the Tanco pegmatite. These initial chemical results indicate that the eastern groups of pegmatites are of considerable economic interest and therefore deserve detailed exploration.

The work remaining in the Cross Lake pegmatite study involves additional detailed mapping, sampling, and whole rock analyses of the pegmatitic granites and the continuation of the chemical analyses of K-feldspars, muscovite, beryl, spodumene, garnet, and Ta-Nb-Sn oxide minerals.

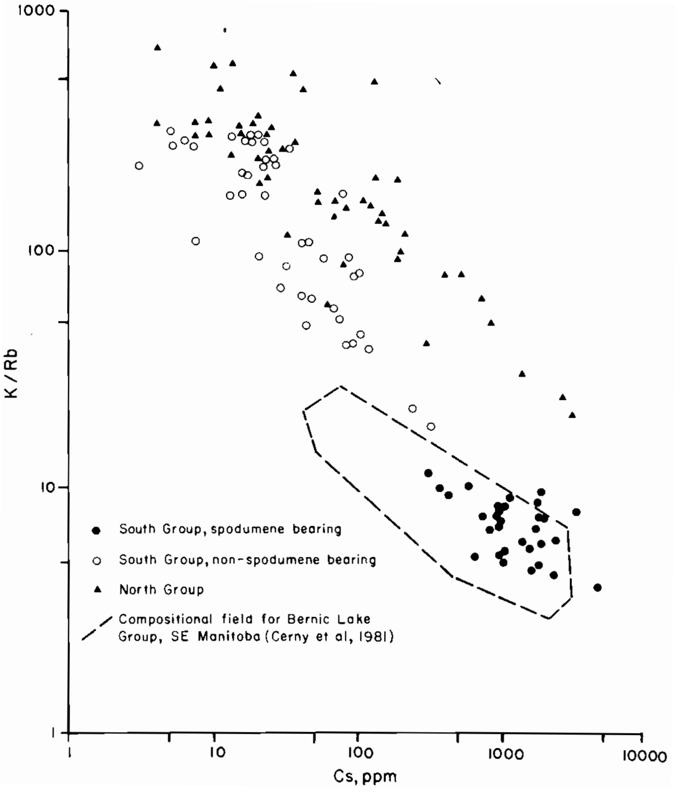

Figure GS-8-2: K/Rb vs. Cs plot of potassium feldspars from pegmatites of the Cross Lake area.

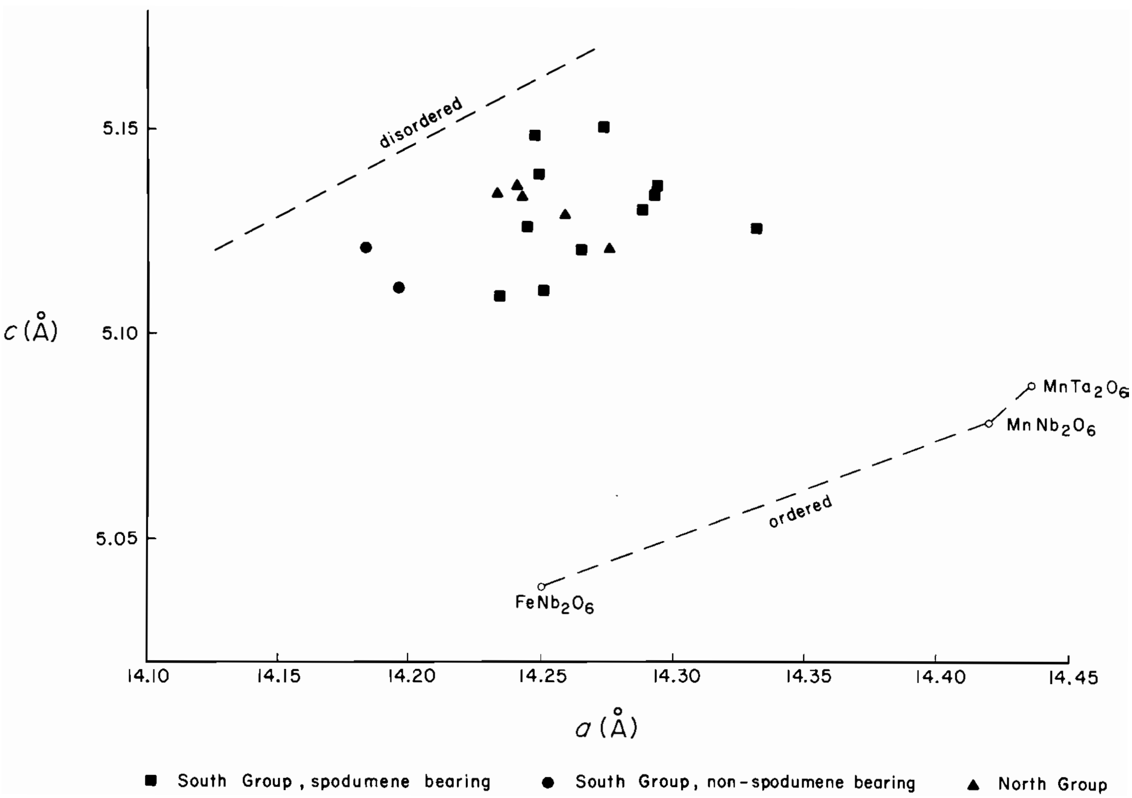

Figure GS-8-3: Columbite-tantalite minerals from the Cross Lake pegmatite field plotted in the a-c unit cell dimension diagram.

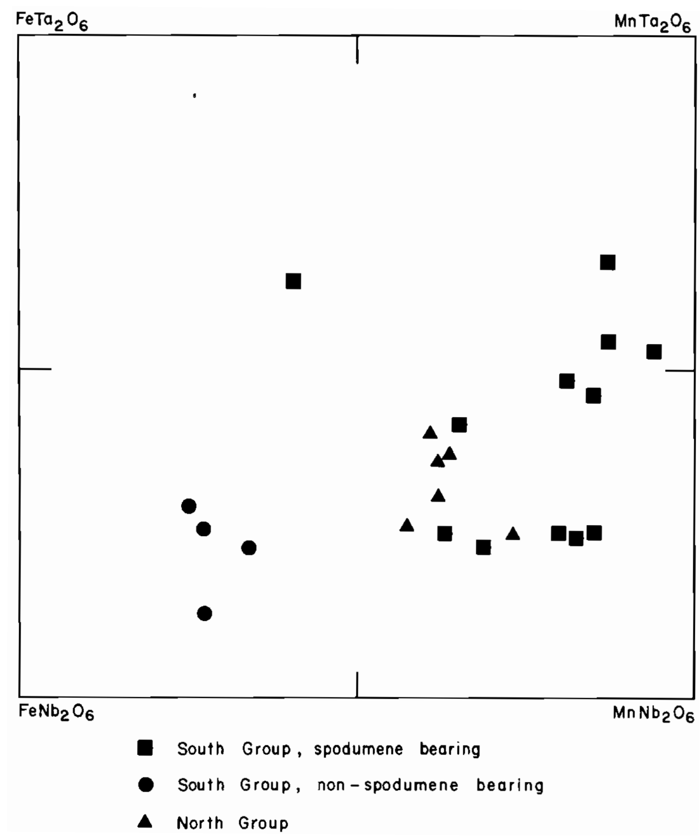

Figure GS-8-4: Columbite-tantalite minerals of the Cross Lake pegmatite field in the $NeNb_2O_6$ - $FeTa_2O_6$ - $MnNb_2O$ - $MnTa_2O_6$ (mol.%) diagram.

FUTURE WORK

Numerous samples collected from all pegmatites in the area are currently being analyzed to refine the geochemical trends described above. These will be supplemented with geochemical analyses of the major plutonic masses. Further detailed structural investigations are planned, particularly on the north group and the eastern end of south group where it terminates abruptly on a NE-trending cataclastic zone. The granite sampling program will be extended into the northern gneiss complexes and south toward Playgreen Lake.

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GS-9 WALKER LAKE PROJECT

(parts of 63 1/7, 9, 10, 14, 15)

by K.C. Albino and J.J. Macek

INTRODUCTION

Regional geological mapping (1:50 000) was extended from Walker Lake (Macek and Zimmer, 1982) into Lawford Lake (southeast of Walker Lake) and also north into northeastern Cross Lake in order to obtain:

(a) basic lithological and structural data in the Lawford Lake area and to investigate the cause of several aeromagnetic anomalies occurring in this area;

(b) similar data for Cross Lake, and to investigate the lithological and structural character of the northeastern termination of the Cross Lake greenstone belt.

GEOLOGY OF THE LAWFORD LAKE AREA

Outcrops in the Lawford Lake area are very poor, and only a discontinuous band of clean shoreline exposure, 10-30 cm wide, was available for geological observation. Other outcrop is lichen- and moss-covered with the exception of a few, small burned areas.

Ninety to ninety-five per cent of rocks occurring in the Lawford Lake area belong to a gneiss-migmatite complex. The remaining rocks -exposed as inclusions, rafts or tectonic blocks - belong either to supracrustal or mafic-ultramafic associations. Few diabase dykes of the Molson dyke swarm were encountered.

GNEISS-MIGMATITE COMPLEX

Rocks of the gneiss-migmatite complex vary considerably in megascopic structure and mineralogic composition. Both variations were utilized simultaneously and form the basis of the legend in Lawford Lake.

The megascopic structures vary from almost homogeneous, weakly to strongly foliated gneiss (Fig. GS-9-1) to typical stromatic and/or folded migmatites and nebulitic migmatites. Transitional structural types such as schlieric, faintly stromatic and stromatic gneiss or migmatitic gneiss may occur on one outcrop with gradational contacts.

The petrographic composition of gneiss or major gneissic components in migmatite varies from melanocratic hornblende tonalite to leucocratic biotite granodiorite-granite. Tonalitic rocks are dominant over granodiorite and granite. The decrease of mafic index in general and decrease of the hornblende/biotite ratio is inversely proportional to potash feldspar content in the Lawford Lake area. This correlation was checked by staining of the samples in the field (approx. 100) since direct identification of potash feldspar is often very difficult. Staining showed that assignment of rock names on the basis of mafic mineral content in the rock series: tonalite-granodiorite-granite was correct in more than ninety per cent of cases in the Lawford Lake area.

Pegmatite, aplite and leucogranite mobilizate are ubiquitous on every outcrop as intrusives or segregations or both.

The spatial relationship between tonalite, granodiorite and granite is gradational and often observed on a single outcrop. No simple contacts which would permit definition of discrete, petrographically distinct bodies are possible to establish; however, in a certain area one rock unit usually prevails.

Thus Lawford Lake area is viewed as a section through the crustal level where the bodies were transformed into lense-shaped masses and modified by partial melting and various degrees of homogenization into flame-shaped zones with diffuse, and often mutually penetrating boundaries.

SUPRACRUSTAL ROCKS

Supracrustal rocks occur as inclusions and rafts often arranged in linear zones forming agmatites or schollen migmatites. Primary textures are seldom preserved. Some amphibolites of basaltic composition show relicts of pillow structures.

Fine grained, light grey, thinly layered metasediments were encountered only on one inland outcrop in association with metabasalts.

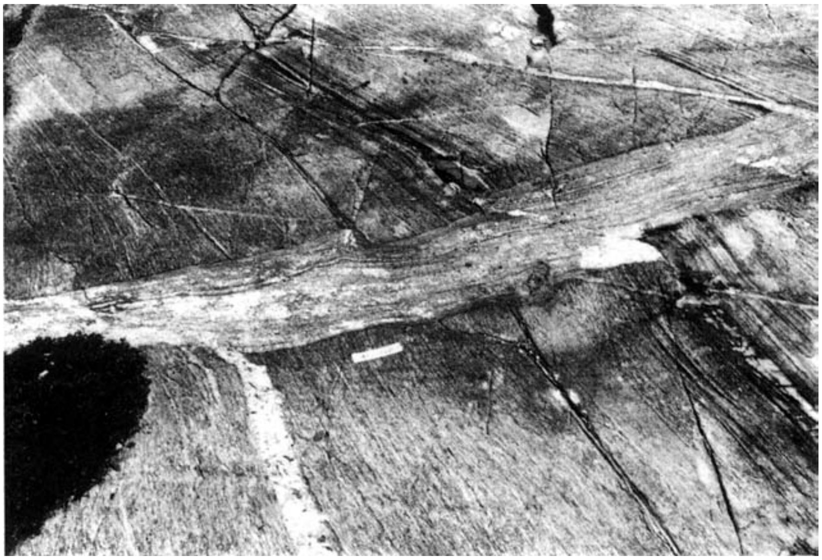


Figure GS-9-1:

Medium grained, biotite-hornblende-tonalite gneiss with S_1-S_2 foliations.

MAFIC-ULTRAMAFIC COMPLEX

Isolated inclusions and rafts of metagabbro/diorite, metapyroxenite and metaperidotite occur in gneiss-migmatite complex. Rafts larger than 5 m are very rare.

AEROMAGNETIC SIGNATURE OF THE LAWFORD LAKE AREA

Two broad aeromagnetic anomalies in the northern part of the Lawford Lake are underlain by tonalite gneiss-migmatite with increased magnetite content (3-7%).

A linear east-trending belt of isolated aeromagnetic anomalies, cuts through the northern part of the map area, and coincides with the occurrence of supracrustal rocks.

GEOLOGY OF CROSS LAKE (N-E PART)

Accessibility of outcrops, and quality of exposure varies considerably from year to year due to drastic fluctuation of water level influenced by Hydro. Existing topographic maps are obsolete.

The northeastern flank of the Cross Lake area is underlain by five distinct rock groups, listed in decreasing order of abundance:

1. Gneiss complex
2. Migmatite
3. Supracrustal rocks and their tectonometamorphic derivatives
4. Molson dykes
5. Rocks of mafic-ultramafic complex and their tectonometamorphic derivatives.

GNEISS COMPLEX

The gneiss complex consists of light beige weathering, grey, weakly to strongly foliated, schlieric to nebulitic - in places stromatic- biotite-quartz-feldspargneiss with local concentrations of hornblende. Potash feldspar content is highly variable (0-40%) even on the scale of a single outcrop. It is unevenly distributed, parts of the outcrop are biotite tonalite gneiss, others biotite granite gneiss. Average composition of the gneiss is biotite granodiorite with a medium grained texture.

Zones of schlieren, nebulitic bands and highly absorbed inclusions indicate a high degree of anatexis and homogenization. Simple pegmatite and aplite veins and segregations occur on every outcrop. Trails of amphibolite inclusions of uncertain origin are common in some areas.

MIGMATITES

Migmatites (agmatite, schollen, stromatic, folded and opthalmic) are developed as zones of variable width in gneiss with gradational contacts. Migmatites close to faults are modified by an intense brittle deformation.

SUPRACRUSTAL ROCKS

Supracrustal rocks form a continuous belt in the western part of the map area. The belt loses its continuity and is progressively and increasingly segmented towards the northeast resulting in large-scale schollen migmatites.

In the northeastern termination of the Cross Lake greenstone belt metavolcanic rocks are closely associated with metasedimentary rocks and also a significant volume of mafic-ultramafic rocks. Areas where primary textures are well preserved can be traced gradationally into linear tectometamorphic zones in which primary textures are partially or completely eliminated. A number of these zones segregate the area into a series of elongated blocks, where the central part of each block may contain relatively unaffected primary textures and structural attitudes. Towards the outer boundaries of these blocks original attitudes are often progressively transposed into long limbs of asymmetric Z-folds. Along these long limbs primary textures are eliminated due to intense deformation (shearing, faults) and recrystallization.

METAVOLCANIC ROCKS

Metavolcanic rocks occur as interlayered pillowed and massive flows of basaltic composition.

Pillows (Fig. GS-9-2) vary from 0.2 to 2 m in size. Different pillowed flows contain variable amount of interpillow calc-silicate material (Fig. GS-9-3), which commonly weathers out giving outcrops a pitted surface. Photographs of preserved pillows (GS-9-2,3) are examples from the central part of a tectonic block. (short limb of large-scale asymmetrical Z-fold where transposition is least intense). However, penetrative deformation is substantial as demonstrated by detailed folding of selvage surface (Fig. GS-9-4). Some pillowed flows have cores of pillows replaced by calc-silicates (Fig. GS-9-5).

Massive flows may be featureless but commonly display a polygonal pattern (Fig. GS-9-6) which might be interpreted as alteration along fractures. Massive flows may display an abrupt contact with pillowed flows or may be separated from them by layered, calc-silicate rock zone 0.5 - 2 m thick. In some instances, the presence of fragments, suggests that these zones are altered flow top breccias. In other places regular layering of calc-silicates may be interpreted as interflow chemical precipitates.

Figure GS-9-2:

Deformed pillowed flows with sporadic intrapillow calc-silicate material.

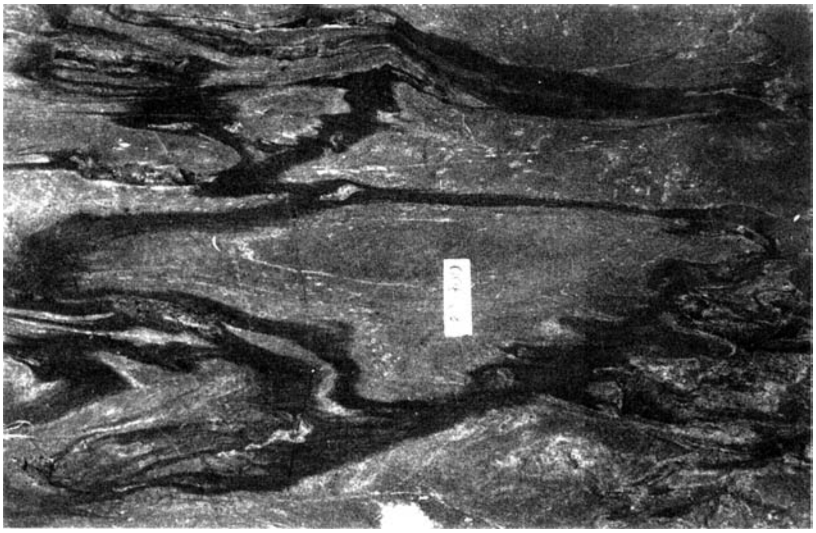
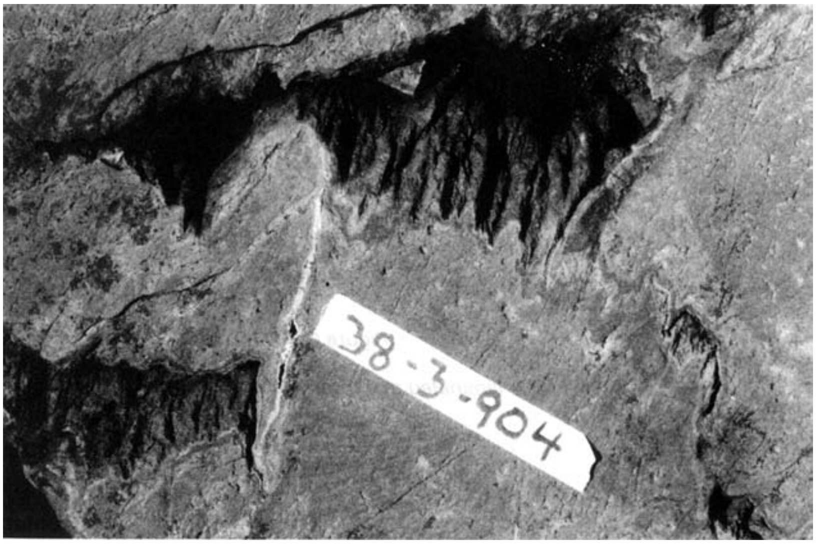


Figure GS-9-3:

Strongly deformed pillowed flow with abundant intrapillow calc-silicates.

Figure GS-9-4:

Pillow selvage folded by intense penetrative deformation.



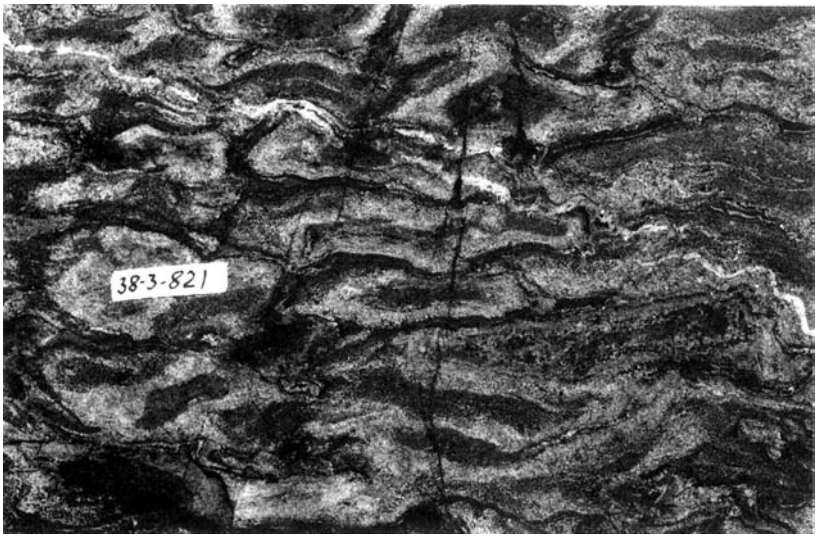


Figure GS-9-5:

Pillows with zoned cores of calc-silicates.

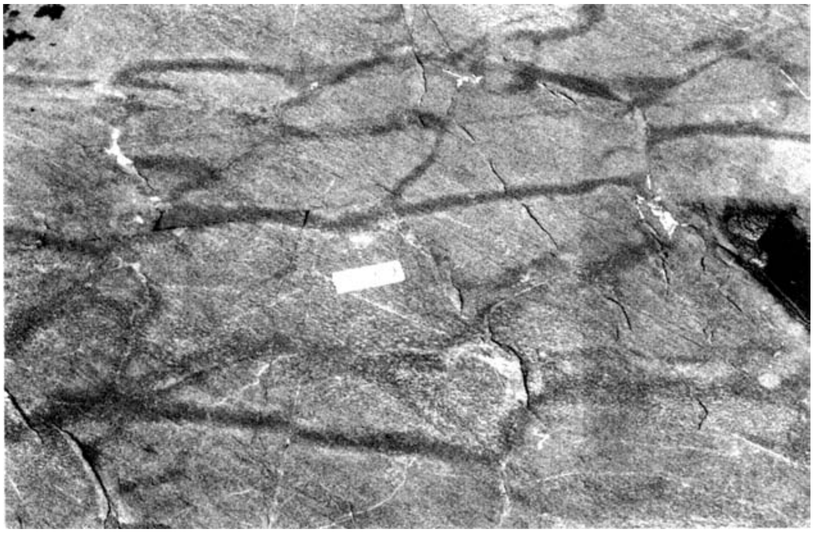


Figure GS-9-6:

Polygonal pattern of a massive flow near the contact with a pillowed flow.

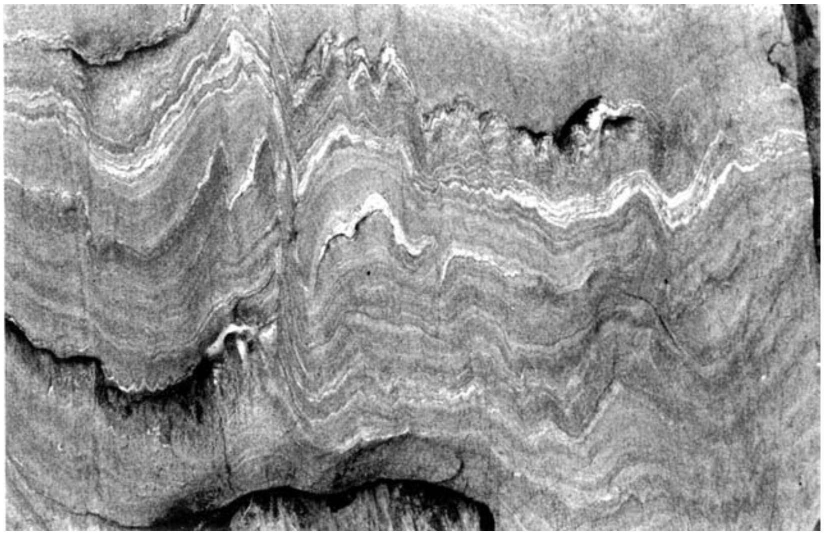


Figure GS-9-7:

Finely laminated mafic siltstones.

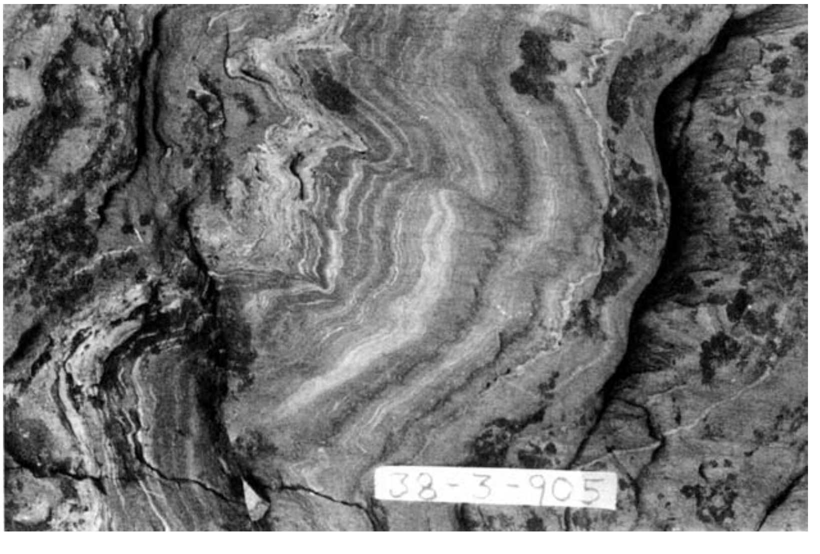


Figure GS-9-8:

Finely laminated mafic siltstones with calc-silicate layers.

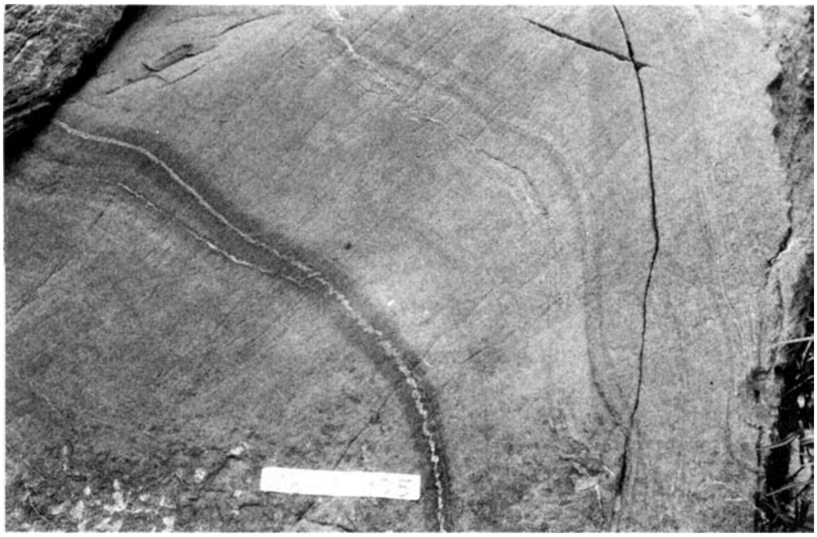


Figure GS-9-9:

Thickly layered to massive mafic siltstones with sporadic laminae.

Figure GS-9-10:

Calc-silicate rock, layered siltstones.

METASEDIMENTARY ROCKS

Metasedimentary rocks are closely related to metavolcanic rocks in space and in composition. They occur as a 200 m thick (minimum) interlayered sequence of:

a) finely laminated to thinly layered, fine grained, dark grey, mafic siltstones (Fig. GS-S-7) with variable amounts of calc-silicate layers (Fig. GS-S-8) and sporadic stratiform sulphide gossans;
b) thickly layered to massive, dark grey, mafic siltstones with sporadic laminae (Fig. GS-9-9);
c) finely laminated to thinly layered siltstones rich in calc-silicate layers 0.5 - 2 m thick (Fig GS-9-10).

Average composition of this sequence is estimated to be very close to basaltic. The lack of coarse grained clastic sediments, lack of any fraction of more felsic composition and close spatial association with volcanics, suggest the laminated shales were derived from a source material entirely composed of metabasaltic rocks (or possibly rocks of mafic-ultramafic complex). They are tentatively interpreted as fine grained volcanogenic sediments of dominantly basaltic composition interlayered with minor carbonate precipitates in the same basin.

Banded magnetite iron formations 10-50 cm thick on average are relatively common.

MAFIC-ULTRAMAFIC COMPLEX

Layered intrusions, found in close spatial association with volcano-sedimentary sequence belong to the mafic-ultramafic complex. However, the exact stratigraphic position is unknown.

There are three types of layered intrusions:

a) Intrusions with rhythmic repetition of meta- pyroxenite-metagabbro layers (10 cm thick on average (Figs. GS-9-11).
b) Intrusions with irregular repetition and thickness of meta-pyroxenite-metagabbro-meta-anorthosite layers (Figs. GS-9-12).
c) Isolated outcrops of magnetic, dark green metapicrite occur as interlayered fine grained and porphyritic varieties in outcrops near layered metapyroxenite-metagabbro- meta-anorthosite intrusion.

The inter-relationships of these intrusives is not exposed and contacts with volcano-sedimentary sequence are tectonically overprinted or tectonically imposed, therefore their stratigraphic positions are uncertain. Also, it cannot be determined if all three types are parts of a larger differentiated intrusion or not.

Figure GS-9-11:

Layered metapyroxenite-metagabbro intrusion.

Figure GS-9-12:

Layered metapyroxenite-metagabbro-meta-anorthosite intrusion.

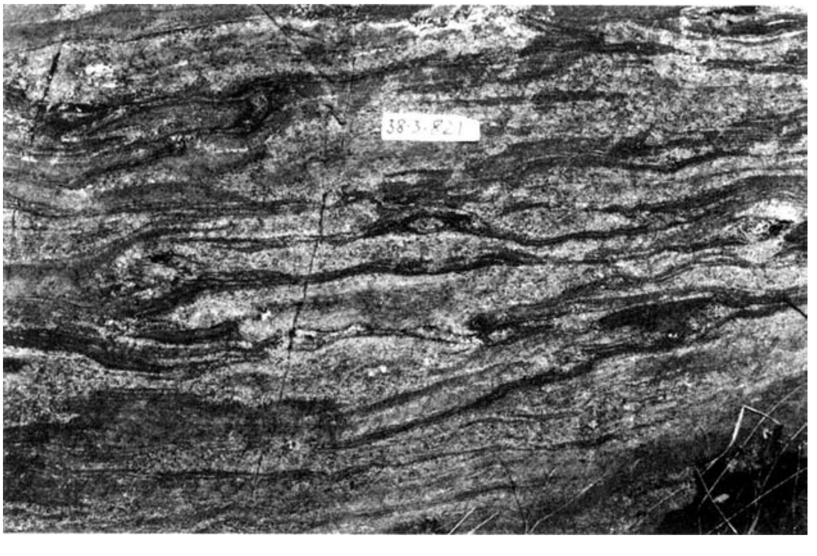


Figure GS-9-13:

Strongly deformed pillow structures.

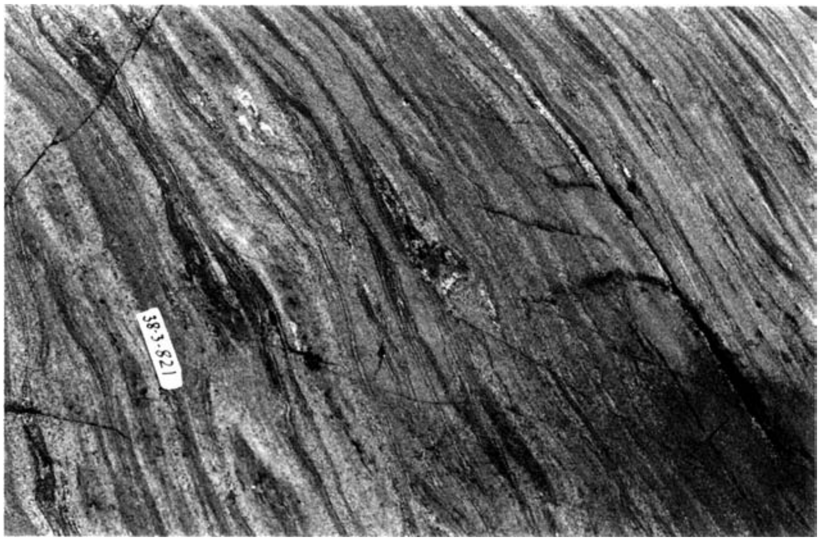


Figure GS-9-14:

Relicts of pillow structures.

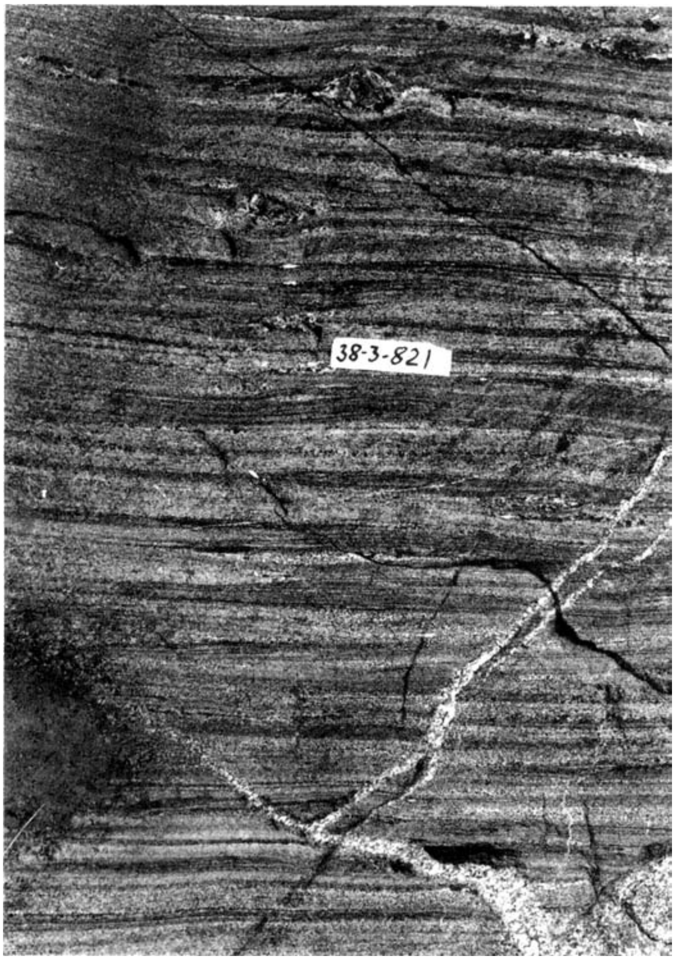


Figure GS-9-15: Layered amphibolite derived from pillow flow.

TECTONOMETAMORPHIC ROCKS

These rocks originated from the volcano-sedimentary sequence and mafic-ultramafic complex by additional recrystallization in broad tectonic zones. In these rocks it is characteristic that all primary megascopic structures were obliterated except for a few remnants of uncertain origin.

The following photographs demonstrate the effect of tectonism and recrystallization.

Fig. G8-9-5 displays relatively well preserved pillows with large, zoned calc-silicate cores. Effects of progressive deformation are shown in Figs. G8-9-13,14,15. Photos were taken on the same outcrop and the maximum distance from Fig. G8-9-5 to G8-9-15 is 20 m.

Fig. G8-9-16a represents typical mafic, finely laminated to thinly layered volcanogenic sediment. Figs. G8-9-16b, 17a,b demonstrate the effect of deformation along one limb of a fold (notice the north arrows on the pictures for orientation). Since composition of these sediments is close to basaltic, new structures of Figs. G8-9-17a,b could be mistaken for remnants of pillows on isolated outcrops whereas structures of Fig. G8-9-15 could be mistaken for sedimentary structures on isolated outcrops.

Another, textural feature of many rocks recrystallized during late deformation is the presence of discrete plagioclase aggregates (checked by staining) in the form of streaks, lenses, angular or rounded fragment-like bodies 0.5 - 10 cm long (Figs. G8-9-18a,b).

Clues to the origin of such aggregates has been obtained from outcrops of the layered intrusion which contain shear zones of varying intensity. Fig. G8-9-19a shows the texture of the relatively undeformed boundary metapyroxenite-metagabbro. No original megacrysts of plagioclase are present. During shearing (Fig. G8-9-19b), the original texture is destroyed (mineralogical re-equilibration takes place) and porphyroblasts of plagioclase grow. With further shearing, single porphyroblasts are progressively broken (Figs. G8-9-20a,b) into aggregates of plagioclase grains. With progressive deformation these may be stretched into streaks and lenses (Fig. G8-9-21a) or preferentially into the crests of the folds (Fig. G8-9-21b).

These aggregates may appear in pillowed flows, massive flows, layered intrusions, or volcanogenic sediments where the composition is close to basaltic and appropriate deformation occurs. It is stressed that the presence of original megacrysts is not a pre-requisite for formation of plagioclase aggregates and no evidence of original megacrysts was found, in relatively undeformed fine grained rocks with primary structures preserved.

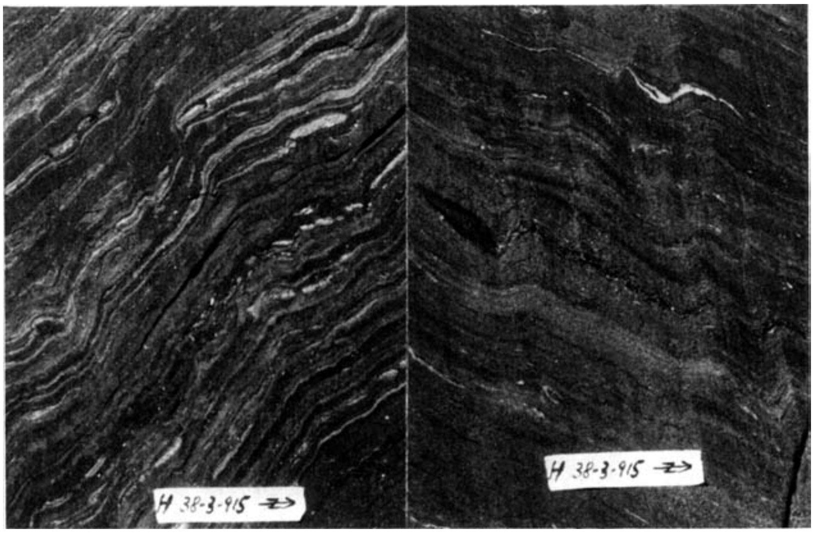


Figure GS-9-16a:

Laminated mafic siltstone.

Figure GS-9-16b:

Laminated mafic siltstone, weakly deformed.

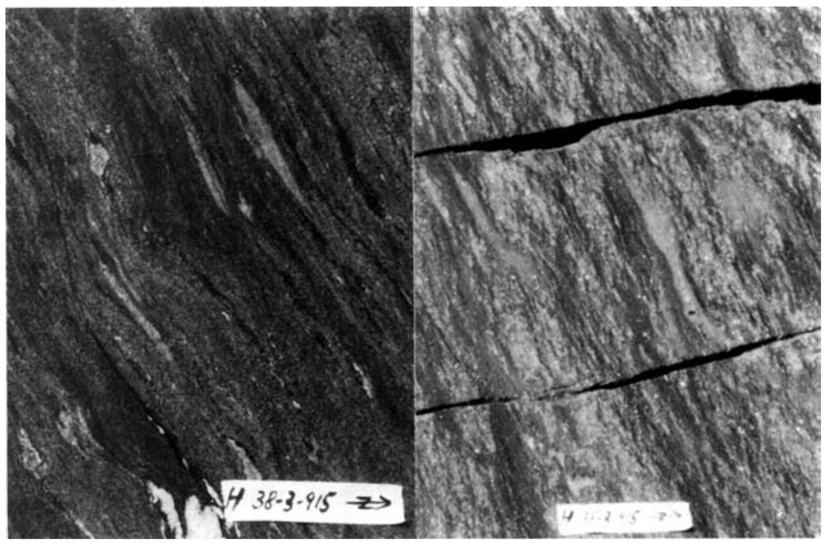


Figure GS-9-17a:

Strongly deformed, laminated mafic siltstone.

Figure GS-9-17b:

Very strongly deformed mafic siltstone.

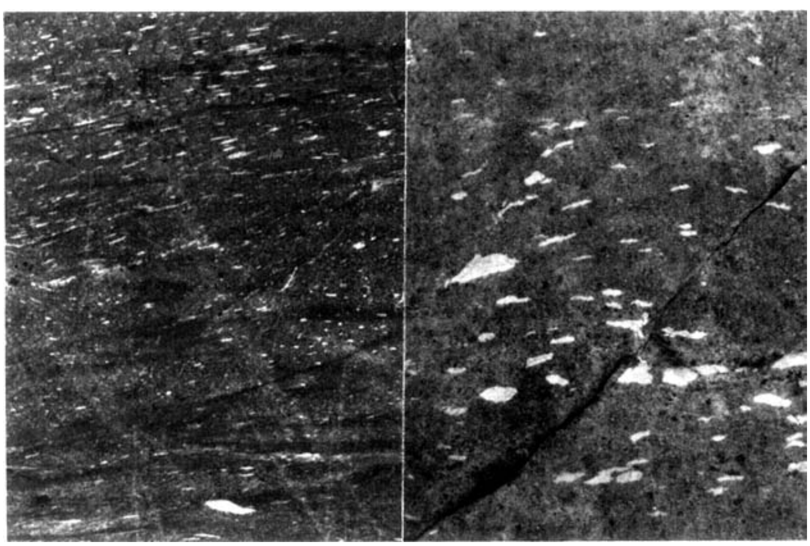


Figure GS-9-18a:

Plagioclase aggregates in pillowed flow.

Figure GS-9-18b:

Plagioclase aggregates in amphibolites of uncertain age.

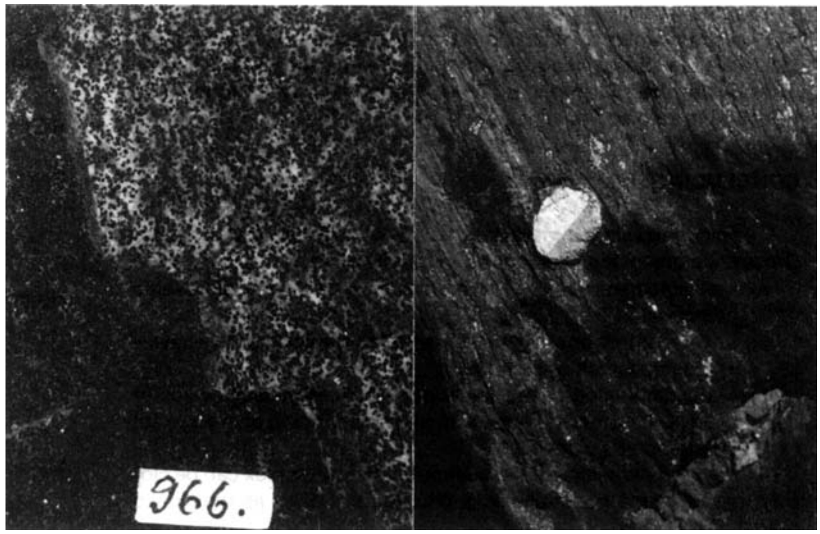


Figure GS-9-19a:

Texture of metapyroxenite-metagabbro layer.

Figure GS-9-19b:

Plagioclase porphyroblast (15 mm long) in sheared layered intrusion.

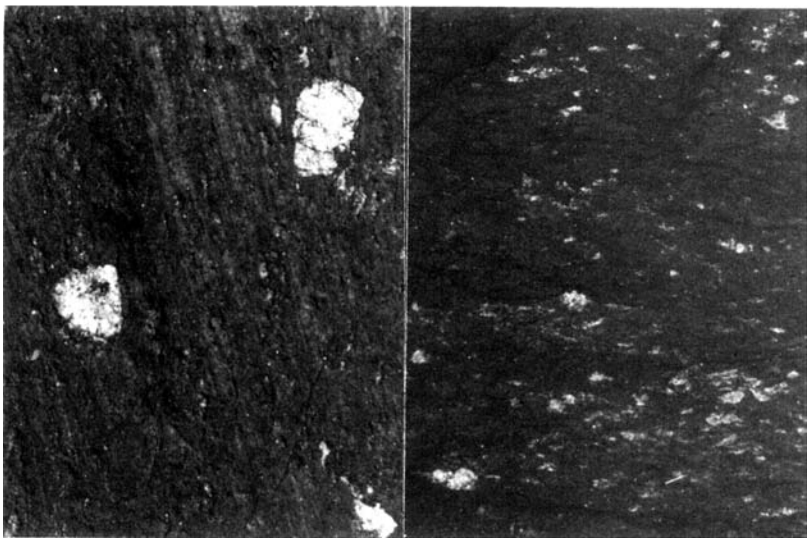


Figure GS-9-20a:

Fractured plagioclase porphyroblasts in sheared layered intrusion.

Figure GS-9-20b:

Disintegration of plagioclase porphyroblasts into aggregates.

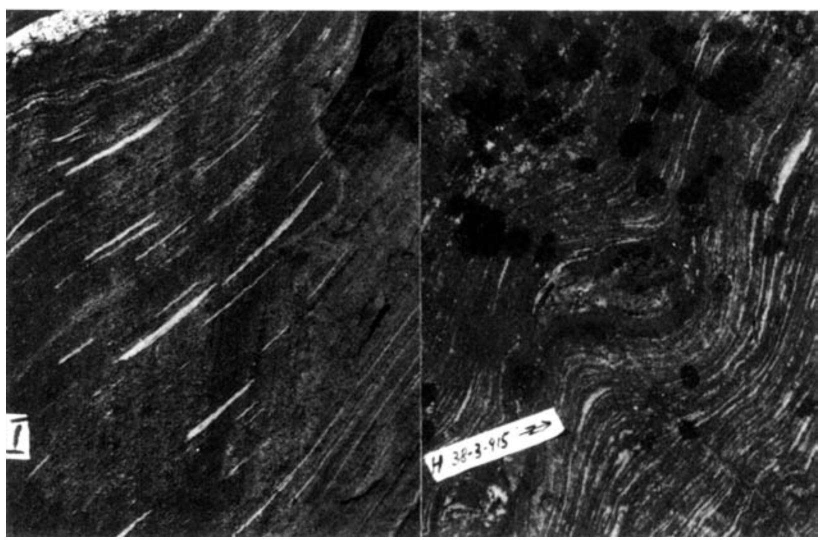


Figure GS-9-21a:

Streaks and lenses of plagioclase aggregates.

MOLSON DYKES

Several gabbro-diabase dykes of the Molson Dyke swarm are located in the Cross Lake area. Although the average width is 5-10m, dykes wider than 50 m occur. These are marked by a pronounced signature in aeromagnetic maps.

CONCLUDING REMARKS

Recognizable supracrustal rocks at the NE termination of the Cross Lake greenstone belt consist primarily of:

a) Metavolcanic rocks (pillowed and massive flows) of basaltic composition.
b) Layered intrusions of mafic-ultramafic complex having an average composition of gabbro.
c) Mafic, laminated shales likely derived from metavolcanics or even partially from layered intrusions depending on their exact stratigraphic position.

Layered intrusions of the mafic-ultramafic complex can be closely related to metabasaltic rocks (Hubregtse, 1980) as their deep seated equivalents.

The lack of Late Metasedimentary rocks, in the northeastern termination of the Cross Lake greenstone belt, may reflect a lower level of the depositional basin in its initial stages of development. This contrasts with the higher levels preserved in the central part of the Cross Lake greenstone belt (Corkery, report GS-7, this volume).

The authors are grateful for the assistance of N. Barr, L. Doig, A. Grossjean and L. Posthumus for excellent support during the field season. N. Barr and A. Grossjean mapped part of Cross Lake.

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GS-10 THE SAPPHIRINE PROJECT

(Part of 63P/4)

by J.J. Macek

Hubregtse (1978) reported the first occurrence of sapphirine-bearing rocks in the Superior Province (Sipiwesk Lake). Eight localities were known in Canada at that time, five in Grenville Province, three in Churchill Province (Herd, 1975) and two dozen or so in the rest of the world.

Sapphirine, ideally $(Mg,Fe)_2Al_4O_6[SiO_4]$, occurs in high grade metamorphic rocks of basic composition relatively high in aluminum and poor in silicon (Deer, Howie and Zussman, 1966). Rocks with such chemical constraints are unusual to start with and are very rarely subjected to high pressure-high temperature metamorphism. Where such circumstances are brought together a complex and unique mineralogical assemblage is generated. This warrants special attention for it records within well defined P & T limits the conditions and sequence of high grade metamorphic events for that region.

On Sipiwesk Lake (Pikwitonei granulite domain, Hubregtse 1980) sapphirine occurs in segmented and boudinaged basic to ultrabasic layers hosted by acidic granulite gneiss in a zone approximately 1.5 km long. Samples of several types of sapphirine-bearing assemblages were collected and studied microscopically. Some samples showed various complex reaction coronas among co-existing minerals (spinel, sapphirine, orthopyroxene, clinopyroxene, sillimanite, cordierite, garnet, plagioclase, potash feldspar, amphibole and phlogopite).

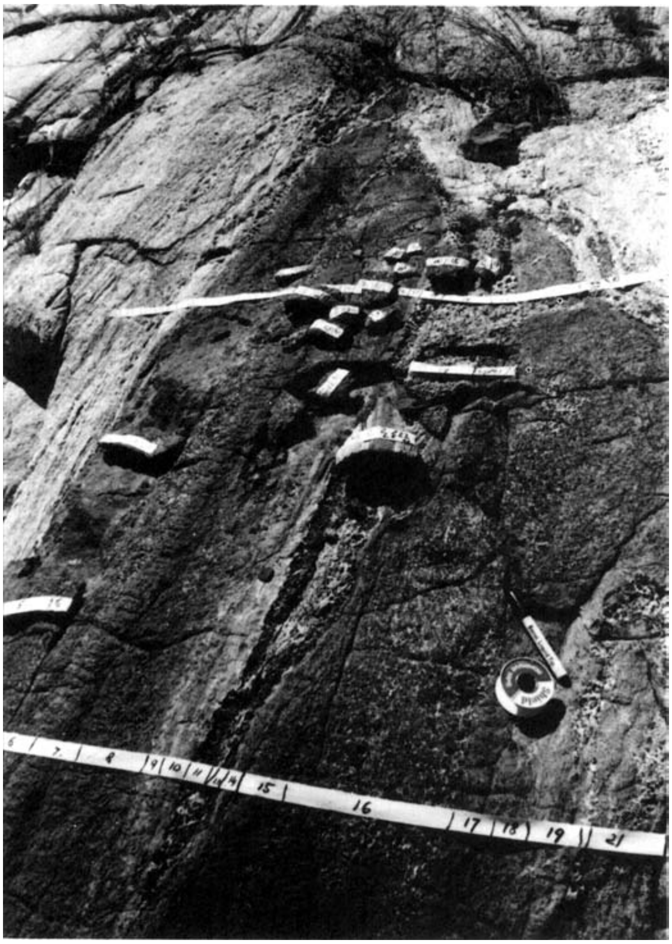

Figure GS-10-1: A *boudinaged sapphirine-bearing layer with leucocratic mobilizates.*

Figure GS-10-2:

As *detailed.*

In co-operation with the University of Manitoba, 62 microprobe analyses were conducted on various paragenetic combinations of minerals in mutual contact in order to establish governing metamorphic reactions. Microscopic observation of coronas and other textures has not resolved the equilibrium relationships and P & T characteristics of the sapphirine-bearing assemblages (especially those in less basic rock types).

Accordingly the study has been extended to incorporate an investigation and comparison with other assemblages in various associated segregations and mobilizates, their composition, spatial distribution, and relation to the sapphirine-bearing assemblages (Fig. GS-1 0-1), and host granulite gneiss.

The Sipiwesk sapphirine locality was revisited this summer and additional detailed sampling conducted (Fig. GS-10-2).

The results of this study will be ready for publication within a year.

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GS-11 ISLAND LAKE PROJECT

(parts of 53E/15, and 16)

by H.P. Gilbert and W. Weber

INTRODUCTION

The objectives of six weeks' field work were completion of mapping of the central part of the Island Lake Greenstone Belt and investigations of

(a) felsic to intermediate volcanic rocks in the vicinity of Henderson Island, and

(b) mineralization in part of the basaltic section just north of Henderson Island (Island Lake, Preliminary Map 19831-1).

The eastward extension of mapping into the York Lake area (53E/16) has been published as an addition to the revised preliminary map of the Island Lake area. Narrow belts of supracrustal rocks related to the main greenstone belt were also mapped in several small lakes north of Island Lake. Conglomerate and associated wacke in these belts are younger than the enclosing tonalite, but are locally intruded by pegmatitic rocks. These metasediments are stratigraphically equivalent to the Late Metasedimentary Rocks ("Island Lake Group") in the western part of the main belt (Weber **et al.,** 1982).

GEOLOGY OF THE ISLAND LAKE AREA (53E/15SE)

STRUCTURE

The major structures identified last year have been confirmed, with minor adjustments to the locations of the axial zones of the two folds flanking the main channel of Island Lake southwest of Meegeesi Bay. The synclinal axis extending through conglomerate (unit 5, Fig. GS-11-1) at the northern margin of the greenstone belt may continue through this unit at the north shore of Meegeesi Bay; however, no structural data was found which would change the original interpretation in which the axial zone of this fold passes obliquely out of unit 5 into unit 4 at Meegeesi Bay. The section from the southern margin of the greenstone belt at Henderson Island to the north shore of Confederation Island is essentially north facing; a syncline-anticline pair within this section just north of the west end of Henderson Island is based on limited structural data (Fig. GS-11-2). Folds are largely confined to sedimentary parts of the succession (Fig. GS-11-3), whereas volcanic sections are generally monoclinal.

Strike-slip faulting is widespread throughout the Hayes River Group in the Island Lake area, associated with alteration of basalt (1) to amphibolitic schist, and felsic to intermediate sedimentary rocks (3,4) to sericitic schist. Relatively more competent gabbroic rocks (8) and some basaltic units have developed a cataclastic foliation and local breccia in response to strike-slip movement. Tectonic breccia occurs in the core of the major syncline extending along the north side of Confederation Island; this breccia, which post-dates the regional foliation, is attributed to movement localized along the axial zone of the fold.

Relatively late NE- to NW-trending faults are commonly observed at a mesoscopic scale, and several faults of greater displacement (10's of m) are locally indicated by lateral discontinuities in the stratigraphy (e.g., at the west and east ends of Henderson Island).

STRATIGRAPHY

Mapping in the vicinity of Henderson Island has resulted in considerable revision of the lower part of the Hayes River Group as described last year (section GH, Fig. GS-7-5, Report of Field Activities, 1982). The basal 2 km of the section in that area includes mafic and intermediate to felsic flows, intermediate to felsic volcanic breccias and fine-grained sedimentary rocks (Fig. GS-11-4). The mafic flows (1) are locally plagioclase-phyric in contrast to those in the area further northwest at Jubilee Island, where porphyritic flows are absent. The plagioclase is generally medium grained (up to 5 mm) but several flows contain phenocrysts up to 2cm across. Amygdaloidal and (less common) variolitic units are present and thin (1 - 2 m) flow-breccia units occur sporadically. Inter-flow gabbro sills (1 - 5 m thick) are widespread. The mafic flows are commonly strongly foliated and attenuated. One mafic section (at least 130m) approximately 500 m north of Ministik Mine is dark green and hornblenditic, but elsewhere the basaltic rocks are pale to medium green or grey.

Intermediate to felsic volcanic rocks (2) - the Henderson Island felsic volcanics - comprise a section at least 850 m thick extending from the north shores of Henderson and Holdstock Islands north into the archipelago southeast of Confederation Island (Fig. GS-11-2). The Henderson Island felsic volcanics occur within a section of mafic to intermediate flows, which also occur as minor interlayers together with rare sedimentary intercalations within the intermediate to felsic volcanics. The latter include massive flows and/or sills which are generally aphyric (locally plagioclase-phyric) and contain accessory lenticular mafic aggregates (1 - 3 mm). The massive rocks are interlayered with related volcanic breccias containing clasts up to 1.2 m x 20 cm; the breccias are moderately to strongly attenuated or altered to layered gneissic rocks. Minor sulphide mineralization, which is common within the mafic volcanic sections in the Island Lake area, is not conspicuous in the Henderson Island felsic volcanics.

A section (150 m) of felsic to intermediate greywacke and siltstone (3) underlies the small island close to the narrows between Confederation and Henderson Islands. Minor sedimentary interlayers (generally 50 cm - 2 m thick) are common within the mafic to intermediate flows north and south of the Henderson Island felsic volcanics; the sedimentary rocks include feldspathic greywacke, intermediate and siliceous siltstone, minor chert and rare argillite. These units are commonly mineralized with pyrite and pyrrhotite (± chalcopyrite ± sphalerite) but the sulphides are generally largely or completely oxidized. Traces of gold and galena also occur in several units. Some mineralized zones are associated with felsitic intrusives, and others represent narrow shear zones within the mafic volcanics. Mineralized zones are particularly abundant close to the top of the mafic volcanic section where it is in contact with the overlying sedimentary rocks which occupy the northern part of Confederation Island. A moderate aeromagnetic anomaly is associated with this uppermost part of the mafic volcanic section (Map 4041G, Island Lake, Federal-Provincial Aeromagnetic Series). A very strong anomaly is related to iron formation within the mafic volcanic rocks at the east end of Henderson Island and at Bouchard Island (Fig. GS-11-2); at least 4 iron formations have been mapped, and several consist of 2 or 3 units, generally 50 cm to 5 m thick (up to 11 m). The extent of possible structural repetition is unknown; the iron formations are locally isoclinally folded and disrupted. The formations consist of thin laminae (2 mm - 2 cm) of massive magnetite and chert, and occur within basalt or gabbro sills; massive garnetite is locally developed at the contact between iron formation and gabbro.

PROTEROZOIC		16	Molson dykes
ARCHEAN	Post-Tectonic Plutonic Rocks	15	Granites (intruding Chapin Bay tonalite)
		14	Plagioclase + quartz porphyry dykes
		13	Mafic dykes, metamorphosed
	Late Plutonic Rocks	12	Tonalite, quartz diorite, felsic to intermediate dykes
			INTRUSIVE CONTACT
	Late Metasedimentary Rocks "ISLAND LAKE GROUP"	11	Turbidity current deposits: wacke, siltstone, argillite
		10	Regolith: wacke, breccia (on unit 6); fluvial deposits: tonalite- and volcanic-derived conglomerate, cross-bedded wacke, siltstone, argillite
			UNCONFORMITY
	Early Plutonic Rocks	9	Felsic metavolcanic rocks, related metasedimentary rocks, subvolcanic porphyries
		8	Mafic intrusive rocks, minor related felsic phases
		7	Ultramafic intrusive, subvolcanic or flow rocks
		6	Tonalite batholiths (Bella Lake, Waasagomach, Chapin Bay, Bunny Island), related rocks
			INTRUSIVE CONTACT
	Early Supracrustal Rocks HAYES RIVER GROUP	5	Conglomerate, mainly sediment-derived, minor arkosic wacke
		4	Wacke, siltstone, argillite, conglomerate, chert, iron formation, carbonate
		3	Wacke, conglomerate, derived from felsic to intermediate pyroclastic deposits, interlayered with siltstone and argillite; iron formation
		2	Felsic to intermediate metavolcanic rocks; flows, pyroclastics, related subvolcanic porphyries
		1	Mafic to intermediate metavolcanic rocks: flows, tuffs, breccias, related subvolcanic gabbro sills

Figure GS-11-1: Table of Formations

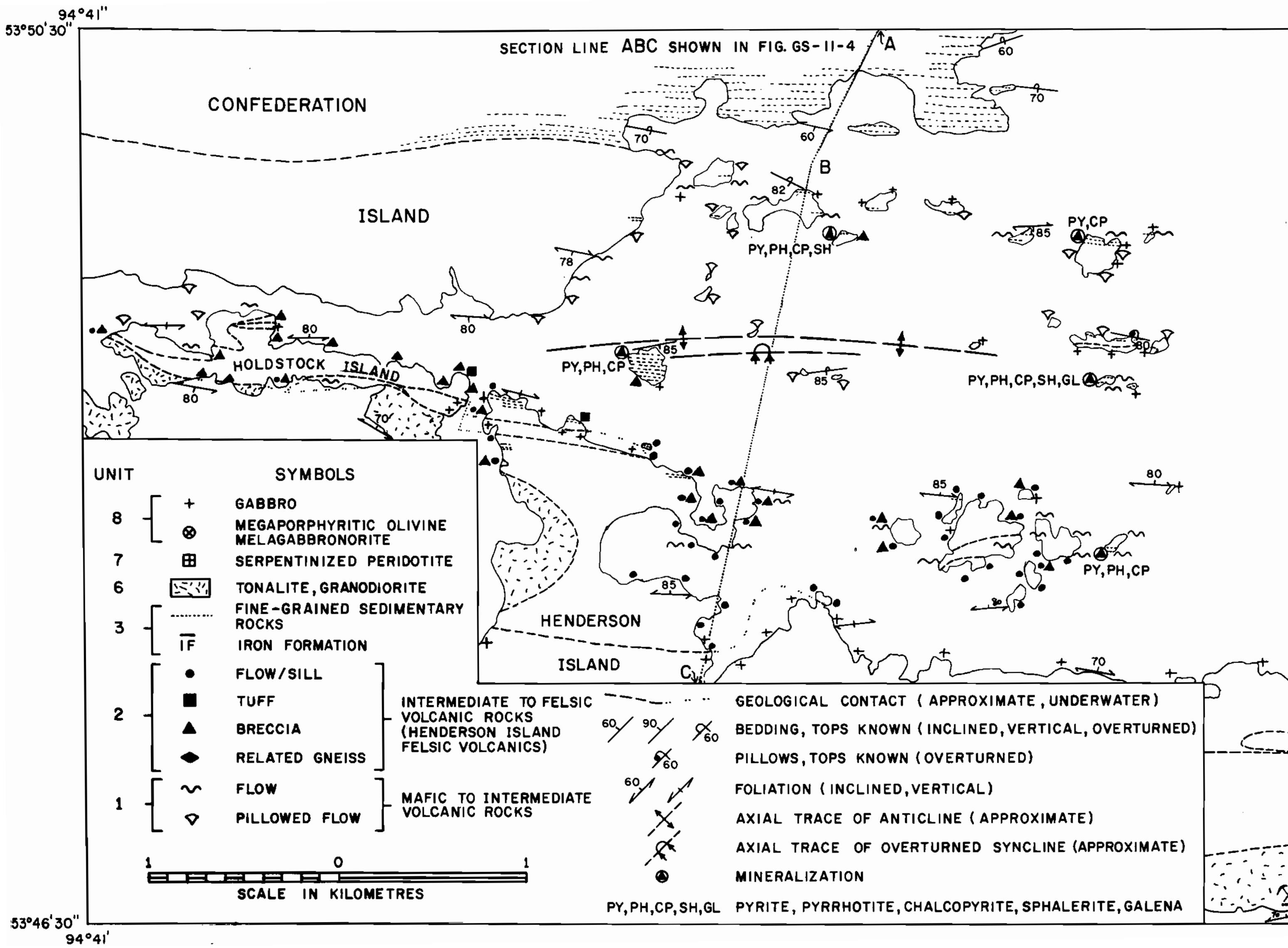

Figure GS-11-2: Geology of the area south and east of Confederation Island, Island Lake.

A complete version of Figure GS-11-2 is included at the end of this file.

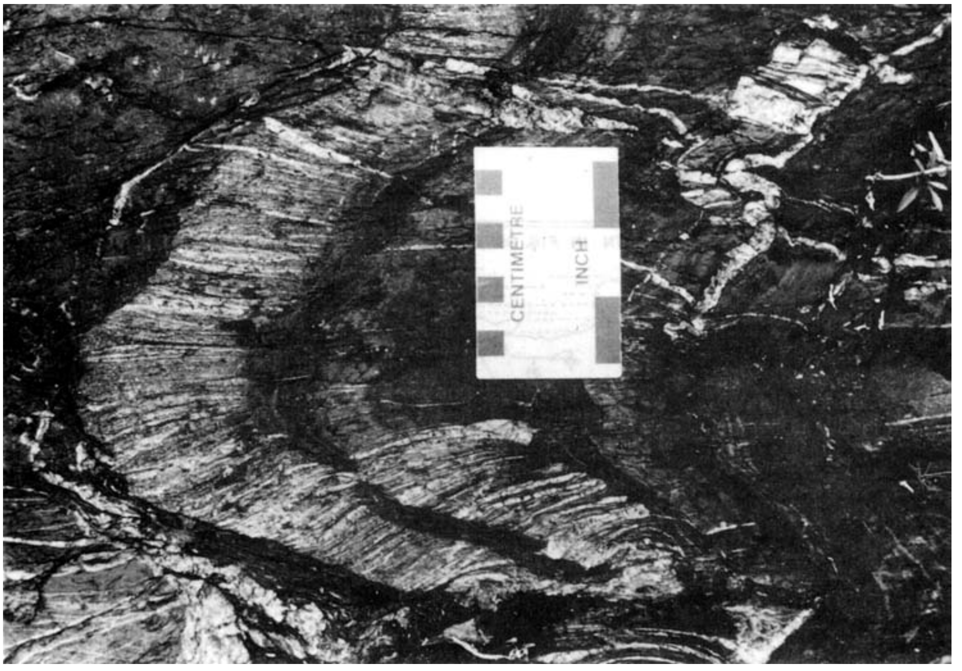

Figure GS-11-3:

Early fold in greywacke-siltstone (4) with quartz-filled axial-planar cleavage.

INTRUSIVE ROCKS

Minor intrusions of gabbro are widespread in both volcanic and sedimentary rocks (1 - 4) excluding the Garden Hill conglomerate (5). The extent of two major gabbro sills at Confederation Island and between Jubilee and Richardson Islands has been defined. The latter sill (at least 13.5 km long and 870 m thick) contains sporadic supracrustal enclaves and minor phases of hornblendite and (at one locality) serpentinized peridotite; a minor zone of quartz diorite within this sill at the southwest corner of Richardson Island, and sporadic leucocratic tonalite dykes within or close to the gabbro sills are interpreted as cogenetic with the mafic intrusions. An irregular fascicular to plumose texture of green hornblende occurs locally in the gabbro (Fig. GS-11-5).

Megaporphyritic olivine melagabbronorite comprises an elongate body (at least 700 m x 100 m) between a gabbro sill (to the north) and hornblenditic basalt (to the south) 600 m north of Ministik Mine (Fig. GS-11-2). Minor serpentinized peridotite occurs at the north margin of the melagabbronorite, which may itself be ultramafic; the latter is completely altered and consists largely of antigorite, tremolite, chlorite, magnetite and minor carbonate; plagioclase and quartz are absent. The melagabbronorite (Fig. GS-11-6) is distinguished from ultramafic sills further north (e.g., southwest and west of Meegeesi Bay) by:

(a) zoned olivine pseudomorphs, ovoid to subhedral, up to 3 cm long (up to 70% of the rock),
(b) chlorite with green-brown, anomalous birefringence, possibly after plagioclase (up to 15%), and
(c) relatively lower carbonate content (up to 15%).

The altered olivines are locally vaguely stratified (at a scale of 10 cm - 3m) by variations in size and abundance; a regenerated, metamorphic origin is considered likely (J. Scoates, pers. comm.). The melagabbronorite sill is less than 500 m from the south margin of the greenstone belt, where it is intruded by a major tonalite-granodiorite intrusion (6); the relative ages of the melagabbronorite and the granitoid intrusion are not established. The latter has locally resulted in development of garnet in greywacke (3) at the margin of the greenstone belt.

Quartz-plagioclase porphyries, interpreted as part of the granitoid suite (6), are widespread in the Island Lake area; these commonly contain minor pyrite and pyrrhotite, and one dyke at the isthmus of Richardson Island contains native copper, chalcopyrite and malachite. Late plutonic mafic dykes (13, Fig. GS-11-7) also contain accessory sulphides but significant mineralization has not been observed.

GEOLOGY OF THE McGOWAN LAKE AND KROLMAN LAKE AREAS (53E/16NE and NW)

The metasediments at McGowan and Krolman Lakes comprise polymictic pebble-cobble conglomerate with tonalite as the dominant clast type, some interlayered wacke and rare cordierite-bearing argillite a facies similar to metasediments in the northern part of Cochrane Bay (Cochrane Island conglomerate, unit 10n, and associated rocks). Top indications are not sufficient to delineate the structure. Strong shearing along the north margin of the supracrustals at McGowan Lake suggests uplift of the tonalite to the north relative to the metasediments.

Lack of tonalite dykes and intrusive relationships between the tonalite and the metasediments suggests that the tonalite is older. Sporadic white pegmatite dykes in the metasediments are interpreted as part of a younger, post-tectonic event.

Metasediments at Irving Lake form a monoclinal southwest-facing sequence and are lithologically similar to some units of the Late Metasedimentary Rocks ("Island Lake Group") in Cochrane Bay. The lithological succession indicates a general coarsening upward from massive, thickly bedded sandstone to pebbly sandstone to conglomerate interlayered with pebbly sandstone suggesting a transition from mid-fan deposits to inner fan channel fill deposits (after Walker, 1979). This sequence is overlain by finer grained sandstone and siltstone, possibly representing overbank deposits. Facing directions and the conglomerate facies (similar to the Cochrane Island conglomerate, unit 10n, Weber **et al,** op. cit.) suggests transport from the north.

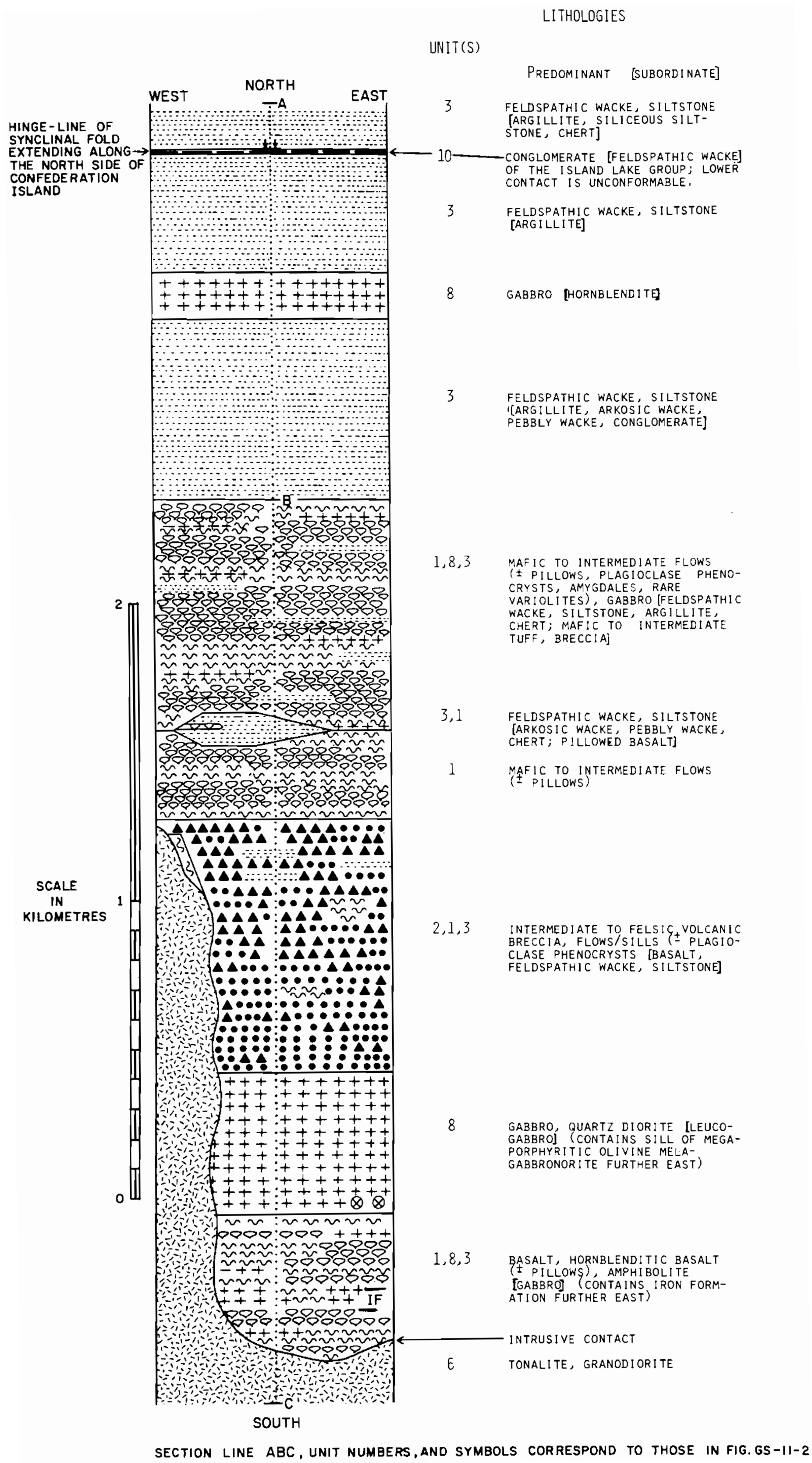

Figure GS-11-4: *Stratigraphic section (north-south) through the Island Lake Greenstone Belt east of Confederation Island.*

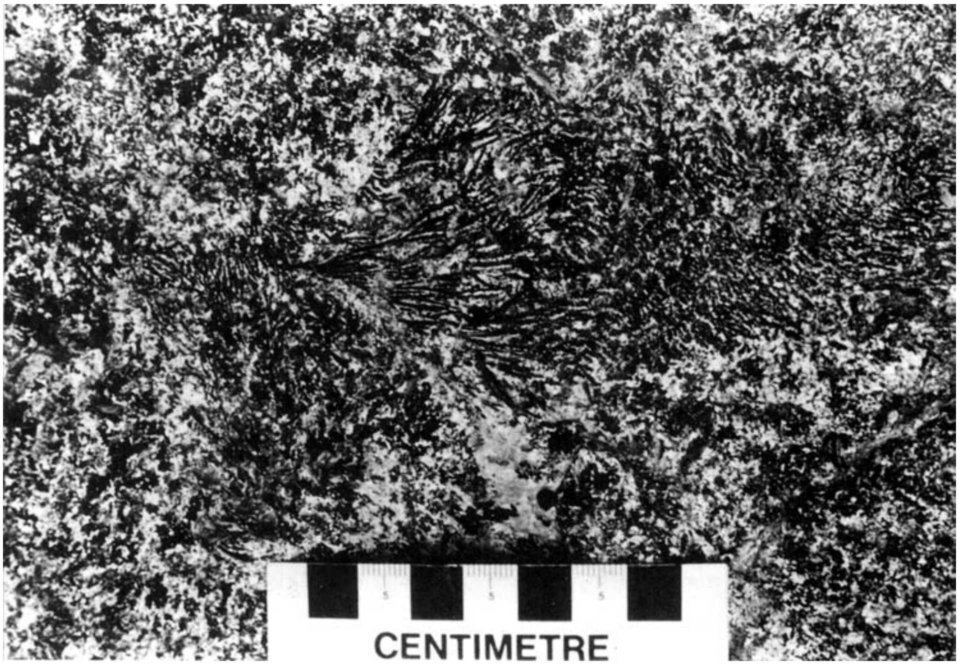

Figure GS-11-5:

Plumose texture of green hornblende in gabbro (8).

Figure GS-11-6:

Megaporphyritic olivine melagabbronorite (8) with prominent ovoid to subhedral olivine phenocrysts.

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1983: McGowan Lake; Manitoba Mineral Resources Division, Preliminary Map 1983 I-2.
1983 Krolman Lake; Manitoba Mineral Resources Division, Preliminary Map 1983 I-3.

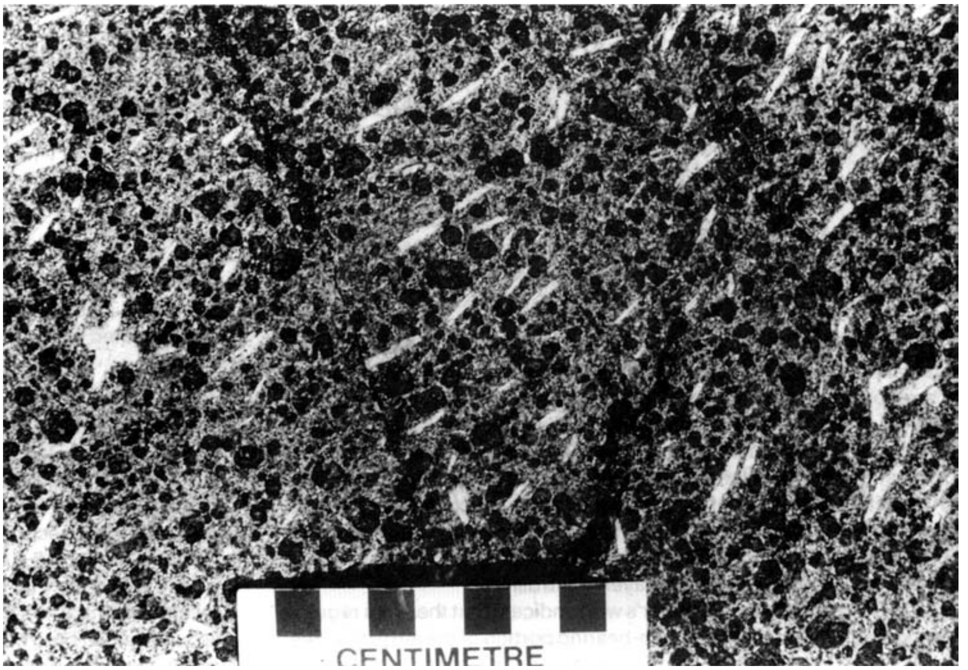


Figure GS-11-7:

Plagioclase-hornblende-phyric amphibolite from a late plutonic mafic dyke (13).

GS-12 A PRELIMINARY STRATIGRAPHIC EXAMINATION OF THE ULTRAMAFIC ZONE OF THE BIRD RIVER SILL (part of 52L/5NE)

by R.F.J. Scoates

INTRODUCTION

A stratigraphic approach was utilized during the 1983 re-evaluation of the Bird River Sill. This approach was taken to determine if a regular stratigraphy exists, particularly in the chromitite-bearing portion of the Ultramafic zone of the intrusion. The relatively clean outcrops of the Chrome property area were examined, so that details of the stratigraphic relationships could be evaluated. The lower, non-chromitite-bearing part of the Ultramafic zone was examined as well as rocks of the Gabbro zone of the intrusion. These rocks were examined to evaluate their potential for chromitite as well as to gain insight into crystallization processes of the layered intrusion.

The results of this summer's work indicate that there is a regular stratigraphy within the chromitite-bearing portion of the intrusion. The stratigraphic relationships are remarkably consistent along the length of the Chrome property area, a distance of approximately 1.5 km. The same stratigraphic elements have been observed on the Page property, some 3 km east of the east end of the Chrome property, implying that the stratigraphy within the chromitite-bearing portion of the Ultramafic zone of the intrusion is consistent along a strike length of approximately 4.5 km.

Chromitite horizons are of two types, dense chromitites and diffuse chromites. Dense chromitites, which represent layers with the greatest concentration of fine grained (<0.5 mm) chromite octahedra, contain from 60 to 90 percent chromite in a featureless, whitish cream groundmass. The groundmass is composed of a mixture of chlorite and grossular garnet that is interpreted to represent rodingite-type alteration of original postcumulus plagioclase. Dense chromitite layers possess sharp contacts with olivine cumulate layers. Diffuse chromite layers, which consist of heavy disseminations of fine grained (<0.5 mm) chromite octahedra, contain from 15 to 60 percent chromite in an olivine cumulate groundmass. They have diffuse, gradational contacts with olivine cumulate layers. Volume percentages of constituent minerals are estimates based on field megascopic examination of outcrops.

Six distinctive suites of chromitite seams have been defined, each suite possessing specific detailed stratigraphic relationships that have lateral continuity. Some of the intervening olivine cumulate layers also possess distinctive compositional and/or textural characteristics that likewise possess lateral continuity.

The six distinctive chromitite suites are, from the lowest stratigraphic level upward, lower chromitites, disrupted layer suite, lower main suite, banded layer-diffuse layer suite, upper main chromitite, and upper chromitites (Fig.GS-12-1).

CHROMITE-BEARING PORTION OF THE ULTRAMAFIC ZONE

LOWER CHROMITITES

The lower chromitites consist of two or three layers that are partly discontinuous along strike. The layers are distinguished by abundant olivine cumulate inclusions (Fig.GS-12-2) and by a gently folded, partly disrupted character. Individual layers range from 1 to 7 cm in thickness and are composed of fine grained chromite octahedra (<0.25 mm) in a featureless, whitish cream matrix. The lower chromitites are separated from the disrupted layer by a medium- to fine-grained olivine cumulate (olivine 1-2 mm) that contains 1-2 per cent disseminated chromite. The olivine cumulate layer ranges from 5 to 7 m thick.

DISRUPTED LAYER SUITE

The disrupted layer suite consists of a continuous, lower bounding dense chromitite layer (25 cm thick), that is distinguished by numerous olivine cumulate inclusions. In places, this lower chromitite is overlain by a second dense chromitite (12 to 20 cm thick) that also contains numerous inclusions. This in turn is overlain by 3 to 6 m of olivine cumulate that contains numerous, disrupted chromitite segments (Fig. GS-12-3). Many of these segments appear to define disrupted chromitite horizons (Figs.GS-12-4 and 12-5). This sequence is capped by a dense chromitite layer (20-25 cm thick) that is characterized by an entrainment of elongate silicate inclusions along the medial portion of the layer. The overall nature of this sequence suggests soft sediment disruption of a partly consolidated suite of alternating chromitite and olivine cumulate layers.

The disrupted layer suite is separated from the base of the lower main suite by medium grained olivine cumulate (olivine 1-4 mm), that contains 15-20 per cent dark greenish black hornblende after original postcumulus clinopyroxene. The olivine cumulate layer, which ranges from 17 to 19 m thick contains from 1-3 per cent disseminated chromite.

LOWER MAIN SUITE

The lower main suite is composed of a lower 4-15 cm, dense chromitite layer (Fig.GS-12-6) overlain by 2-5 m of coarse grained to pegmatitic peridotite, that in turn is overlain by the lower main chromItite (50-100 cm thick). The lower chromitite of this sequence pinches out at the west end of the Chrome property. The upper and lower contacts of the lower chromitite are locally sheared and there is a dramatic change in grain size across the upper contact from fine grained chromitite to coarse grained peridotite.

The lower chromitite is overlain by a coarse grained to locally pegmatitic peridotite (Fig.GS-12-7), that represents the most unique olivine-rich layer of the Ultramafic zone of the intrusion. Variations in grain size and textural relations, sporadic inclusions of disrupted dense chromitite, mm-scale discontinuous chromitite layers, and the presence of 2-5 cm pegmatitic clinopyroxene inclusions contribute to the overall heterogeneous character of the layer, which ranges from 1.7 to 5 m thick. The rock is composed of coarse grained subhedral to euhedral olivine crystals (up to 2 cm long), some of which possess hollow cores. Coarse grained hornblende after original pyroxene, which occupies the interstitial areas constitutes 5-15 per cent of the rock. Disseminated chromite, up to 1 mm in size, ranges from 2-4 per cent. In portions of a number of outcrops, elongate olivine crystals are oriented at right angles to the direction of layering, producing a pseudo-harrisitic pattern on the ourcrop surface. Large patches of finer grained peridotite (olivine 1-3 mm) are common in some exposures, and in one area, discontinuous chromitite layers (1-3 mm thick) separate coarse grained peridotite from medium to fine grained peridotite (Fig.GS-12-8).

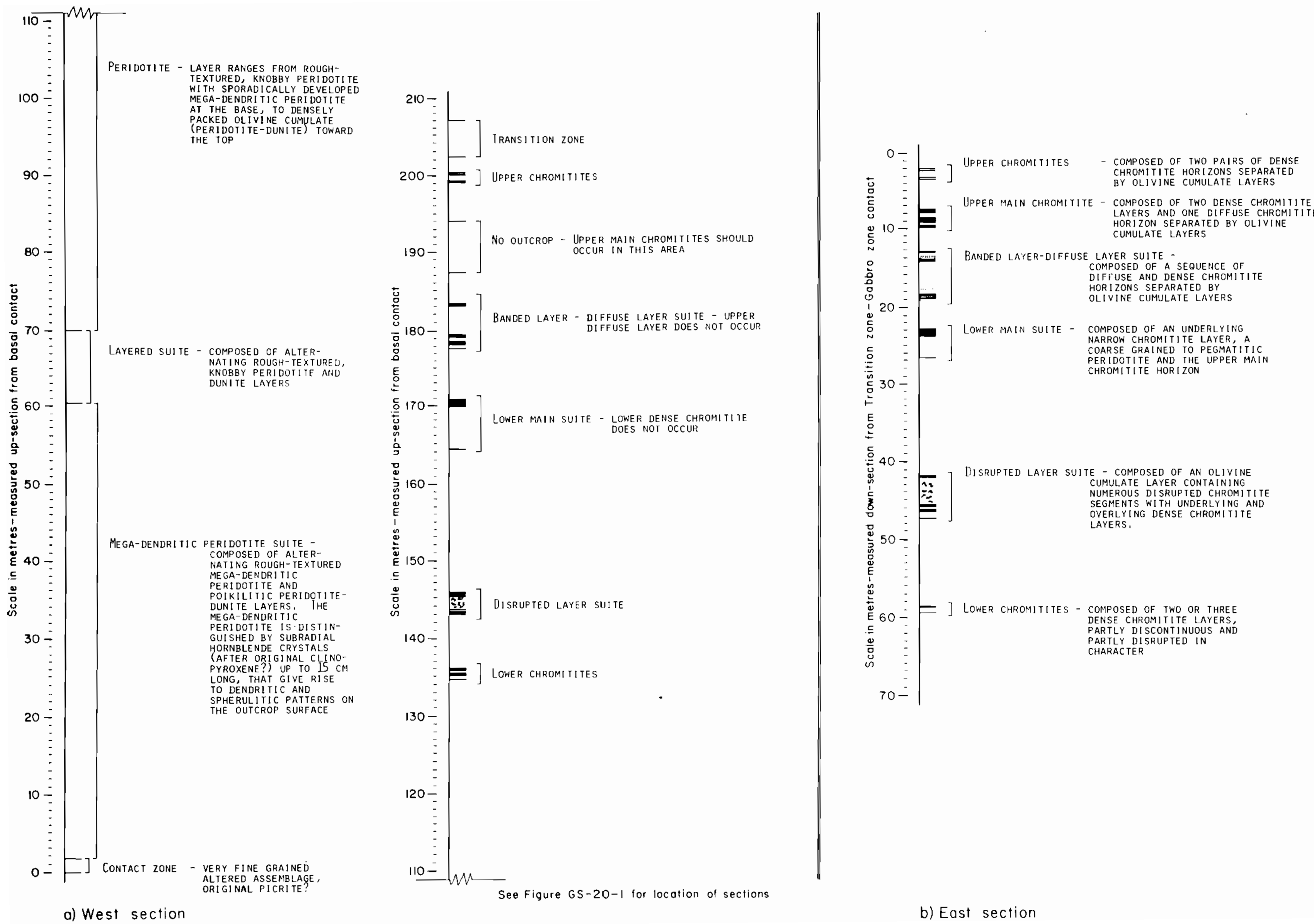
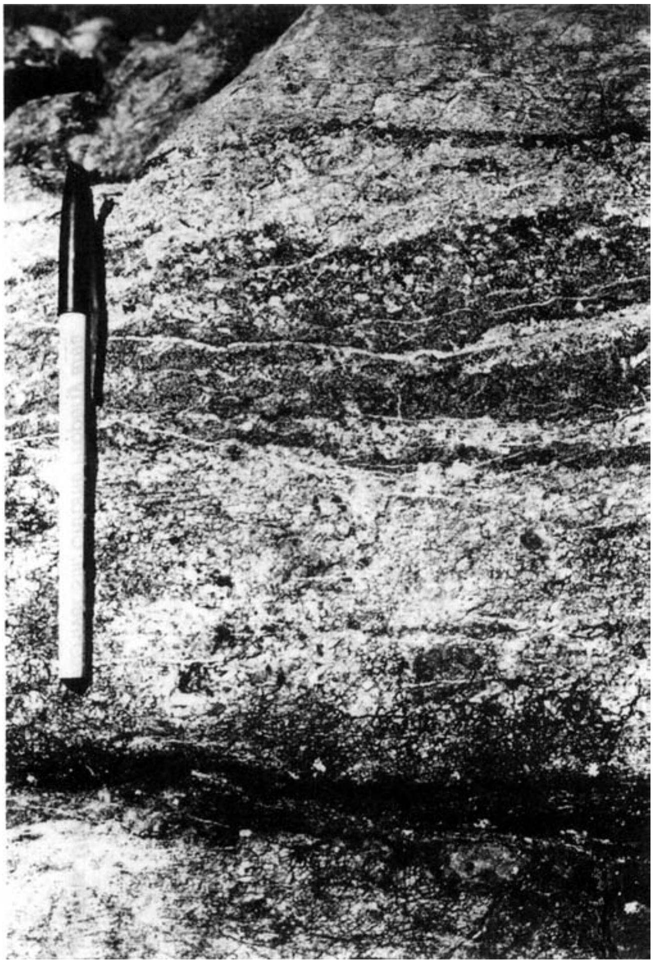


Figure GS-12-1: Composite stratigraphic sections, Ultramafic zone, Bird River Sill. Chrome Property area.



The lower main chromitite (Fig.GS-12-9), which overlies the coarse grained peridotite, ranges in thickness from 50 -100 cm, and is the thickest individual chromitite horizon. The lowermost 5.0 to 10.0 cm of the layer is commonly composed of alternating dense and diffuse chromitite layers, layer thickness ranging from several mm to several cm. The diffuse chromitite layers contain individual and clusters of individual olivine crystals. Dense chromitite composed 50 to 70 per cent of fine grained (0.25 - 0.50 mm) chromite octahedra in a featureless whitish cream matrix, overlies the lower layered portion of the layer. Vague layering, in a few locations, is caused by variations in grain size of chromite crystals.

The olivine cumulate that separates the lower main suite from the banded layer-diffuse layer suite ranges in thickness from 3.1 m to 6.8 m.

BANDED LAYER-DIFFUSE LAYER SUITE

The banded layer-diffuse layer suite comprises a sequence of diffuse and dense chromitite layers that constitute an integral part of approximately 6.0 m of stratigraphy. This sequence is very distinctive and individual elements have been observed throughout the Chrome property and have been observed on the Page property. A dense chromitite that ranges from 6 to 15 cm thick forms the basal chromitite of this sequence. The chromitite is composed of 60 to 70 per cent fine grained (<0.5 mm) chromite octahedra in a whitish cream groundmass. Rounded to irregularly-shaped silicate inclusions are sporadically distributed along the layer in a few exposures. The lower dense chromitite is overlain by a medium grained, oikocryst-bearing olivine cumulate (olivine 2-4 mm), that contains from 7 to 10 per cent chromite. The layer ranges in thickness from 23 to 33 cm. A sharply defined 5mm chromitite that occurs within the olivine cumulate at a position that ranges from 5 to 10 cm above the underlying dense chromitite, has been observed in a number of areas.

Figure GS-12-2:

Chromitite of lower chromitites. This is the uppermost layer of two layers at this location. Note bifurcation of chromitite and olivine cumulate inclusions. Pen, which points up section, is 16 cm *long.*

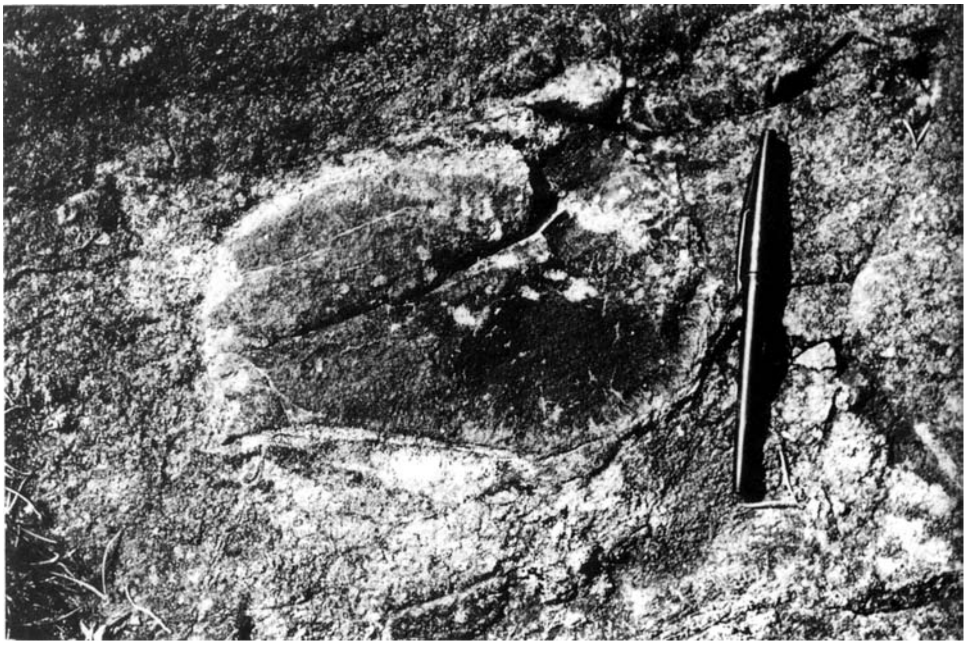


Figure GS-12-3:

Rounded inclusion of dense chromitite surrounded by olivine cumulate. Disrupted layer. Pen, which points up section, is 15 cm *long.*

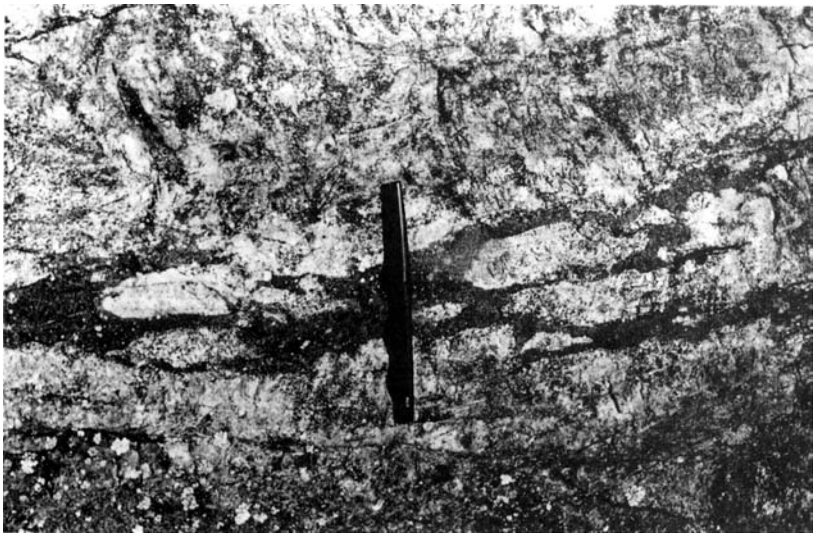


Figure GS-12-4:

Disrupted chromitite of disrupted chromitite layer. Pen 15 cm.

Figure GS-12-5:

Disrupted chromitite of disrupted chromite layer. Pen 15 cm.

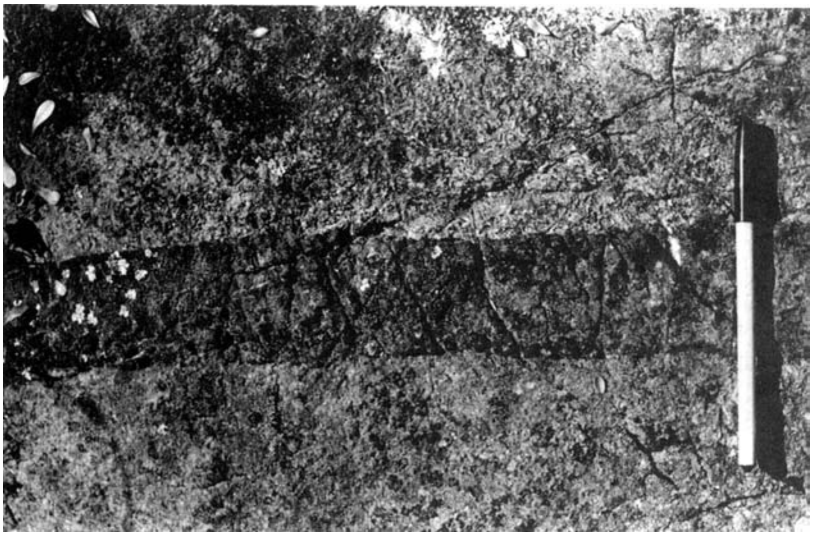


Figure GS-12-6:

Dense chromitite underlying coarse gralned peridotite of lower main suite. Pen 16 cm.

The banded layer, which is consistently 20 to 25 cm thick is composed of 10 chromitite layers that range from 3 mm to 2 cm thick (Fig.GS-12-10). The chromitite horizons alternate with fine grained olivine cumulate layers (olivine 1-2 mm). All chromitite layers except the uppermost layer are diffuse chromitites (15 to 40 per cent chromite), the uppermost layer being a 5 to 10 mm dense chromitite. In a few areas, the banded layer displays soft sediment-type contortion and partial disruption. A large rounded inclusion observed in one area has depressed underlying layers and overlying layers are draped over the inclusion.

A medium grained, oikocryst-bearing olivine cumulate (olivine 2-4 mm), that separates the banded layer from the lower diffuse layer, ranges from 40 to 60 cm thick. The oikocrysts, which are hornblende after pyroxene are abundant and large (3-4 cm). A 5mm chromitite seam occurs in the oikocryst-bearing olivine cumulate 10 cm above the banded layer in a number *ot* exposures.

The lower diffuse chromitite, which ranges from 20 to 30 cm thick is composed of three diffuse chromitite layers separated by medium grained olivine cumulate layers. It has not been observed everywhere. and thus is not as continuous as the other elements of the banded layer-diffuse layer suite. The lower diffuse chromitite is overlain by an oikocryst-bearing, medium grained olivine cumulate that ranges in thickness from 2.6 to 3.5 m. The grain size of olivine ranges from 2 to 4 mm, increasing to 6 mm near the top of the layer.

The middle diffuse chromitite layer, which ranges from 20 to 25 cm thick, is distinguished by a central 2 cm thick olivine cumulate layer. It is separated from the overlying upper diffuse layer by a medium grained, oikocryst-bearing olivine cumulate (olivine 2-3 mm) that is approximately 70 cm thick. This olivine cumulate is distinguished by mm-scale (1-6 mm) chromitite seams, 2 to 5 seams being present in different locations along strike.

The upper diffuse chromitite layer (Fig.GS-12-11) ranges from 12 to 25 cm thick and is distinguished by numerous inclusions of

Figure GS-12-7:

Coarse grained peridotite of lower main suite. Some olivine crystals are 2 cm *long. Pen 15 cm.*

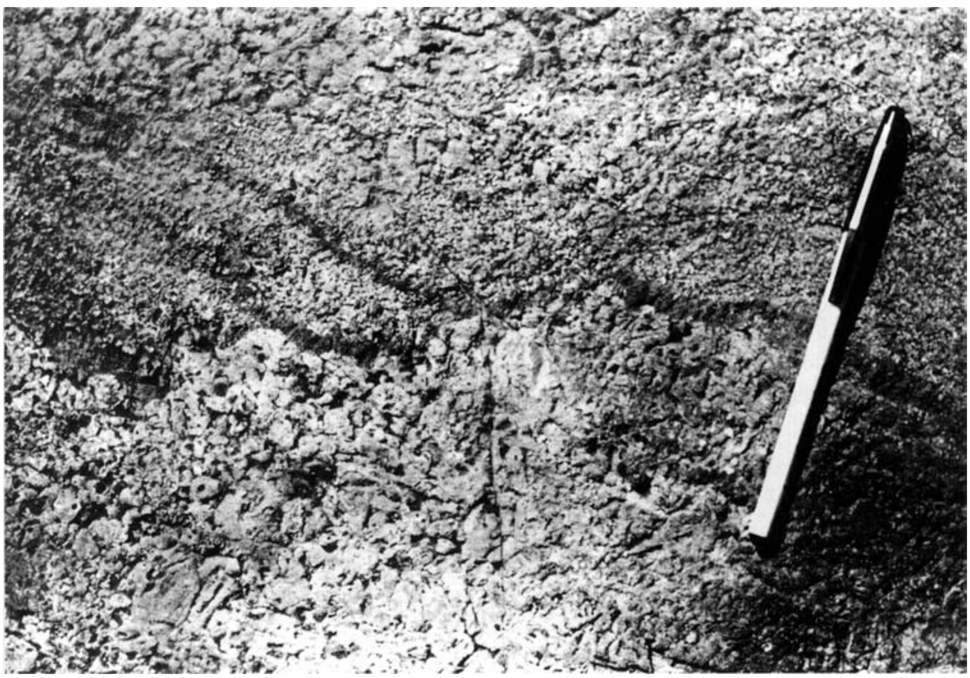


Figure GS-12-8:

Bifurcated mm-seale ehromitite layers in coarse grained peridotite of lower main suite. Pen 16 cm.

Figure GS-12-9:

Lower main chromitite (under hammer handle). Hammer head rests on overlying olivine cumulate.

olivine cumulate. It is separated from the base of the overlying upper main chromitite by medium grained, oikocryst-bearing olivine cumulate (Fig.GS-12-11) that ranges in thickness from 2 to 2.5 m.

UPPER MAIN CHROMITITE

The upper main chromitite, which consists of three chromitite horizons separated by olivine cumulate layers is remarkably consistent in total thickness averaging 2.5 m on the Chrome property (Fig.GS-12-12). It is composed of a lower dense fine grained chromitite (50-60 cm thick) overlain by a medium grained, oikocryst-bearing olivine cumulate (olivine 2-3 mm), the upper 7 cm of which contains wispy layers of fine grained chromitite. This oikocryst-bearing olivine cumulate (30-42 cm thick) is overlain by a dense, fine grained chromitite (50-60 cm thick), the upper 20 cm of which is diffuse chromitite. This chromitite is overlain by a medium grained olivine cumulate (50-55 cm thick) that lacks oikocrysts and possesses diffuse chromitite layers. The uppermost layer is a diffuse, fine grained chromitite (50-65 cm thick) with abundant cumulus olivine. The lower 7-10 cm of the layer is a dense fine grained chromitite.

The upper main chromitite is separated from the upper chromitites by fine grained olivine cumulate (olivine 1-2 mm) that contains sporadic, 1-2 cm poikilitic hornblende crystals (after original clinopyroxene?) and 1-2 cm whitish green to cream poikilitic crystals (after original orthopyroxene?). The layer, which ranges from 4 to 5 m thick, contains 2-4 per cent disseminated chromite and may contain a small percentage of original cumulus plagioclase. In one exposure, rare discontinuous dunite layers (4-5 cm thick) were observed.

UPPER CHROMITITES

On the Chrome property the upper chromitites are composed of two sets of paired chromitite layers separated by olivine cumulate layers. A 1-2 cm thick fine grained, dense chromitite constitutes the

Figure GS-12-10:

Banded layer of banded layer-diffuse layer suite. All chromitite layers except the uppermost layer are diffuse chromitites, the uppermost layer being dense chromitite. Pen 15 cm.

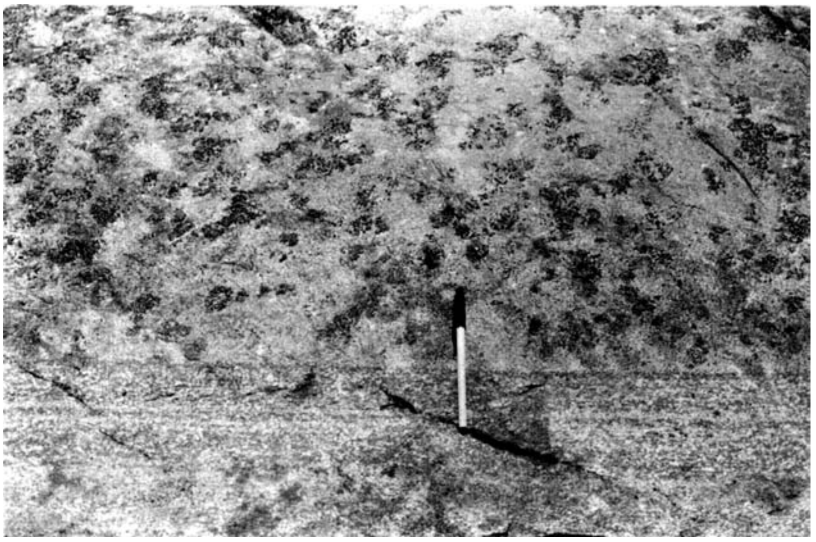


Figure GS-12-11:

Upper diffuse chromitite (under lower part of pen) and overlying oikocryst-bearing olivine cumulate. Pen 16 cm.

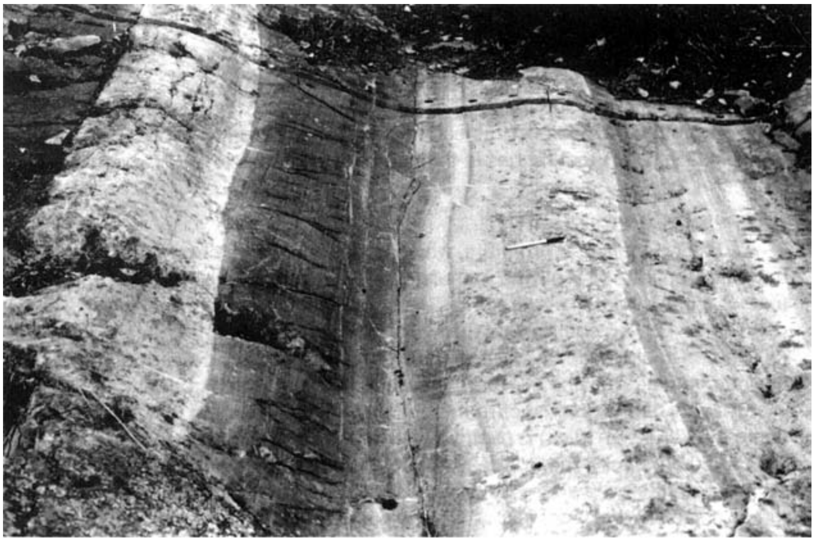


Figure GS-12-12:

Upper main chromitite. From left to right, lower dense chromitite, oikocryst-bearing olivine cumulate, middle dense chromitite, olivine cumulate (pen location), and upper diffuse chromitite. The upper main chromitite is *2.67* m *thick at this location. Pen 16 cm.*

Figure GS-12-13:

Mega-dendritic peridotite. Resistant ridges are horn-blende (after original clinopyroxene) which form curved branching crystals that produce a dendritic pattern. Recessive areas between hornblendes are composed of fine grained olivine and hornblende +disseminated chromite. Pen 16 cm.

base of the lower pair. It is overlain by 15-20 cm of fine grained olivine cumulate that is similar to the olivine cumulate that separates the upper main chromitite from the upper chromitites, but that contains 5-10 per cent disseminated chromite. A 5-10 mm chromitite seam overlies the fine grained olivine cumulate and forms the upper layer of the lower pair. The lower chromitite pair is separated from the upper chromitite pair by 78-85 cm of fine grained olivine cumulate similar to the olivine cumulate that separates the lower chromitite horizons. The upper chromitite pair consists of an 8-10 cm basal, fine grained, dense chromitite, overlain by a 10-17 cm oikocryst-free medium grained olivine cumulate that is close to dunite in original composition. The upper chromitite pair is capped by a 2 cm fine grained, dense chromitite.

The upper chromitites are overlain by a 2 m thick, medium grained olivine cumulate that contains abundant poikilitic crystals, dark greenish black hornblende (after original clinopyroxene?) and whitish green amphibole (after original orthopyroxene?). This unit, which possesses a pronounced fabric is overlain by the Transition zone that separates the Ultramafic zone from the overlying Gabbro zone of the intrusion.

SUMMARY OF SIGNIFICANT OBSERVATIONS CONCERNING THE CHROMITITE-BEARING PART OF THE ULTRAMAFIC ZONE

The chromitite-bearing portion of the Ultramafic zone of the intrusion represents approximately 60 m of stratigraphic section (Fig.GS-12-1) Within this section, 13 chromitite seams, 10 cm or more thick are present (including the disrupted layer). In addition, there is a minimum of 12 chromitite seams that range from several millimetres to several centimetres in thickness. Several other mm-scale layers have a sporadic distribution along strike.

One of the most significant observations made this summer concerns the fact that some olivine-rich layers contain localized inclusions of chromitite. Rounded, ball-like to elliptical chromitite inclusions have been observed in the upper 5 m of the olivine cumulate layers that underlie the lower chromitites and the disrupted layer suite. These inclusions, which range up to 5 x 10 cm in size have a sporadic rather than regular or consistent distribution along strike. Significant concentrations of chromitite inclusions, as ball-like disrupted masses, and as mm-scale layers, have been observed in the coarse grained peridotite layer that underlies the lower main chromitite. In addition, small, isolated concentrations of chromitite have been noted in other areas. These observations suggest that future work should be directed to evaluating the economic significance of these other chromite concentrations in terms of adding to the known chromite resources of the intrusion.

A discontinuous 3 mm thick chromitite layer was observed at one location in medium grained gabbro, approximately 15 m stratigraphically above the Transition zone. This suggests that the gabbro immediately above the Transition zone can host chromitite concentrations.

Disseminated chromite occurs throughout the olivine cumulate rocks of the Ultramafic zone of the intrusion. The abundance of disseminated chromite is variable from layer to layer, ranging from 2 to 6 per cent. The abundance of disseminated chromite is variable within within individual layers on outcrop scale. Future work will be directed toward determining the range in abundance of disseminated chromite in olivine cumulate layers, particularly those within the chromitite-bearing portion of the Ultramafic zone.

The establishment of a defined stratigraphy within the chromitite-bearing portion of the Ultramafic zone of the intrusion should make correlation possible with other fault segments of the intrusion. It may be possible to fit isolated chromitite-bearing outcrops into the stratigraphic section established for the Chrome property area. Although there are large tracts of non-descript olivine cumulate rocks, there are layers of olivine-rich rocks that possess unique characteristics, that may permit correlation of these rocks with olivine-rich rocks in other fault segments of the intrusion.

LOWER, NON-CHROMITITE-BEARING PORTION OF ULTRAMAFIC ZONE

A number of outcrops in the western part of the Chrome property illustrate the stratigraphic relationships of the lower, non-chromitite-bearing portion of the Ultramafic zone of the intrusion, This lower portion consists of 4 stratigraphic elements. From the base of the intrusion upward these elements are: contact zone; mega-dentritic peridotite suite; layered suite; and peridotite.

CONTACT ZONE

The basal contact and contact zone rocks of the intrusion are exposed in an isolated small rubbly outcrop. The contact is sharp and unsheared. At this location the Sill is in contact with a fine grained, dark greenish grey gabbro that is part of the mafic volcanic suite that underlies the intrusion. The Sill rocks at the contact are very fine grained and olivine-bearing (olivine 1 mm); over the 2 m width of the zone olivine increases in grain size to 1 mm. The original composition of the zone is difficult to determine because of its fine grain size and alteration; however, plagioclase may have been present and the original rock may have been picritic in composition. Millimetre-scale, cross-fibre serpentine veinlets fill fractures in the contact zone.

MEGA-DENDRITIC PERIDOTITE SUITE

Overlying the contact zone is a peridotite that possesses a distinct knobby appearance on the outcrop surface. This is caused by coarse grained (5 mm - 2 cm) hornblende crystals (after original clinopyroxene?). Over the next 60 m, this peridotite is interlayered with poikilitic peridotite that possesses smoothly rounded weathered surfaces. Olivine is very fine grained throughout this suite, forming rounded crystals that seldom exceed 1 mm in size. Disseminated chromite ranges from 3 to 6 per cent, and sporadically distributed, fine grained (<.5 mm), disseminated chromite that form rounded clusters up to 1 cm in size were observed.

Large portions of this suite are distinguished by organization of the resistant hornblende segments into long curving and branching crystals. Many of these crystals emanate from a point source and form dendritic to spherulitic masses up to 15 cm long (Figs.GS-12-13 and 12-14). Concentration of these dendritic masses gives rise to spectacular patterns on the outcrop surface. The recessive weathered areas between the branching hornblende (clinopyroxene?) crystals are composed of fine grained rounded olivine crystals (up to 1 mm), fine grained hornblende (clinopyroxene?) crystals (up to 1 mm) and finely disseminated chromite. Close inspection of the hornblende crystals reveals that they poikilitically enclose fine grained olivine. The poikilitic character of the original clinopyroxene(?) crystals implies that they formed by late stage crystallization of interstitial liquid. Their dendritic character suggests that they crystallized under unusual conditions of nucleation and crystallization. The textural pattern appears to be a coarse grained analogue to similar, but much finer clinopyroxene textures reported from mafic and ultramafic volcanic rocks of the Fox River area of northeastern Manitoba (Scoates, 1981). The term mega-dendritic peridotite has been assigned to rocks possessing this unusual textural pattern.

The curved, branching hornblende crystals are similar to feldspars in comb-layered rocks described from the Willow Lake intrusion in Oregon (Taubeneck and Poldervaart, 1960). On the basis of cooling

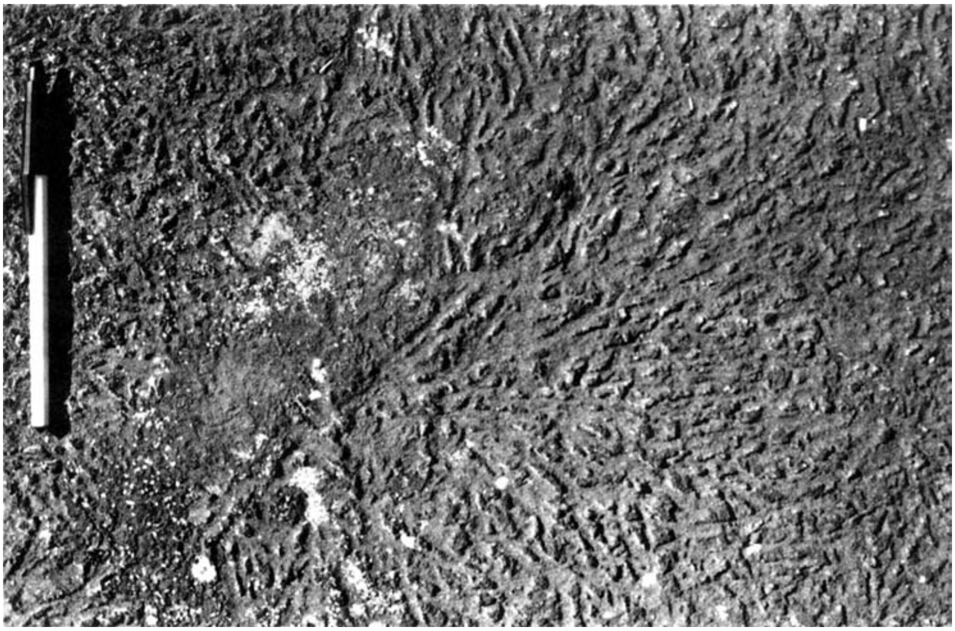


Figure GS-12-14:

Detail of mega-dendritic peridotite. Pen 16 cm.

experiments, it has been suggested that the branching crystal shapes, typical of feldspars in comb-layered rocks, grew only in a more supercooled or supersaturated environment than did tabular feldspars found in rock that encloses the comb-layered material (Lofgren and Donaldson, 1975). The curved, branching hornblende (after clinopyroxene) crystals of the mega-dendritic peridotite may reflect conditions of crystallization similar to those suggested for feldspars of comb-layered rocks.

The grey brown weathering, rough textured mega-dendritic peridotite is interlayered with peridotite that possesses a smooth, buff to reddish brown weathered surface. This peridotite is distinguished by 1-2 cm, equidimensional, pale whitish green amphiboles (after original orthopyroxene?) that poikilitically enclose rounded fine grained olivine crystals. Disseminated chromite constitutes 3-6 per cent of the rock.

A 1 m thick peridotite, distinguished by elongate hornblende (after clinopyroxene?) crystals that are oriented approximately at right angles to layering, possesses a harrisitic-like pattern on the outcrop surface.

LAYERED SUITE

The layered suite is composed of alternating dunite-peridotite layers that range from 10 cm to 1.6 m thick (Figs. GS-12-15 and 12-16). The peridotite layers possess a rough textured, knobby surface similar to the peridotite of the underlying mega-dendritic suite but lacking the curved, branching crystals that distinguish the latter. The dunite layers have smooth, recessive weathered surfaces and many possess a fabric that makes an acute angle with the layering direction. Delicate mm-scale layering is locally developed (Fig.GS-12-17). Circular to elliptical dunite inclusions occur singly or in groups (Fig.GS-12-18) in some peridotite layers. An irregular inclusion of whitish, fine grained, dense material with a chlorite selvage (Fig.GS-12-19) is interpreted to represent rodingite-type alteration of an original plagioclase-rich rock similar to that described by Trueman (in prep.).

The layering in the layered suite, which represents the only layering defined by differences in silicate mineralogy observed in the Ultramafic zone of the intrusion, is caused by the presence or absence of original postcumulus clinopyroxene. This in turn reflects original differences in composition of interstitial magma from layer to layer.

PERIDOTITE

The peridotite that overlies the layered suite is approximately 60 m thick and ranges in composition upward from rought textured, knobby peridotite to dense packed olivine-rich rocks that have a smooth weathered surface. This unit separates the layered suite from the lowerchromitites of the chromitite-bearing portion of the Ultramafic zone. Olivine is fine grained (1 mm) through most of the unit and disseminated chromite constitutes from 1 to 4 per cent of the rock. Poikilitic crystals composed of hornblende (after original clinopyroxene?) and whitish green amphibole (after original orthopyroxene?) distinguish portions of the rough textured knobby peridotite that locally contains curved branching hornblende crystals that form dendritic masses. The upper portion of the unit is composed of densely packed fine grained olivine, the poikilitic hornblende crystals giving way to widely dispersed oikocrysts. Within 5 m of the lower chromitites, wispy concentrations of chromitite form discontinuous 1-2 cm thick layers. Coarse grained (olivine 2-6 mm), sulphide-bearing peridotite distinguishes the uppermost metre of the unit.

SUMMARY OF OBSERVATIONS ON NON-CHROMITE-BEARING PORTION OF ULTRAMAFIC ZONE

The lower non-chromite bearing portion of the Ultramafic zone is distinguished by fine grained olivine (1 mm) and the lower part is further distinguished by rocks possessing unique textures suggesting unusual conditions of crystallization. Repetitive cycles involving the disappearance and reappearance of cumulus phases are absent, repetitive layering of the layered suite being caused by the presence of absence of original postcumulus pyroxene. Structures that suggest magmatic current activity are lacking, although the presence of dunite inclusions in peridotite layers suggests redeposition of previously consolidated rocks. Disseminated chromite occurs throughout, and rare local concentations of more heavily disseminated chromite (up to 10 per cent) have been noted. Apart from the discontinuous wispy chromite concentrations noted immediately below the lower chromitites, chromitite layers were not observed.

Figure GS-12-15:

Alternating dunite (smooth weathered surface) and peridotite (rough, knobbly weathered surface) layers, layered suite, Pen 16 cm.

Figure GS-12-16:

Alternating dunite (smooth weathered surface) and peridotite (rough, knobbly weathered surface) layers, layered suite, Pen 16 cm.

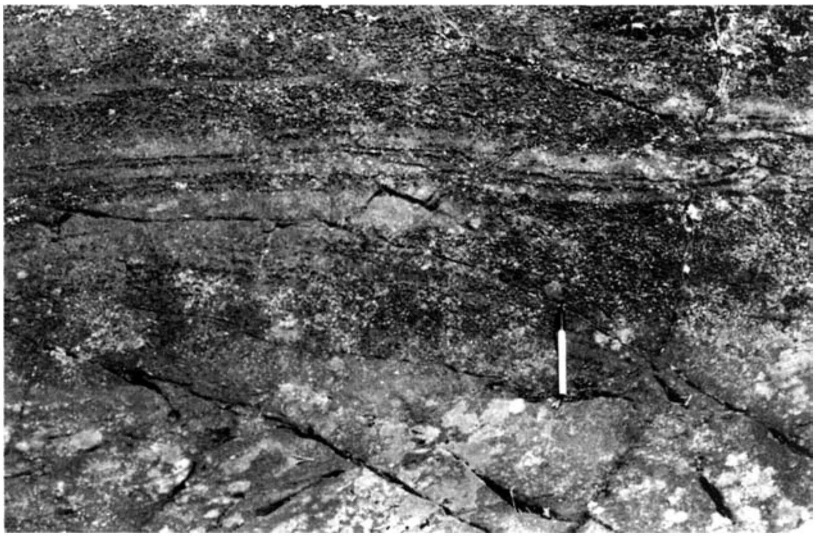


Figure GS-12-17:

Delicate, mm-scale layering between dunite and peridotite in layered suite rocks. Pen 16 cm.

Figure GS-12-18:

Circular to elliptical dunite inclusions in peridotite of the layered suite. Pen 16 cm.

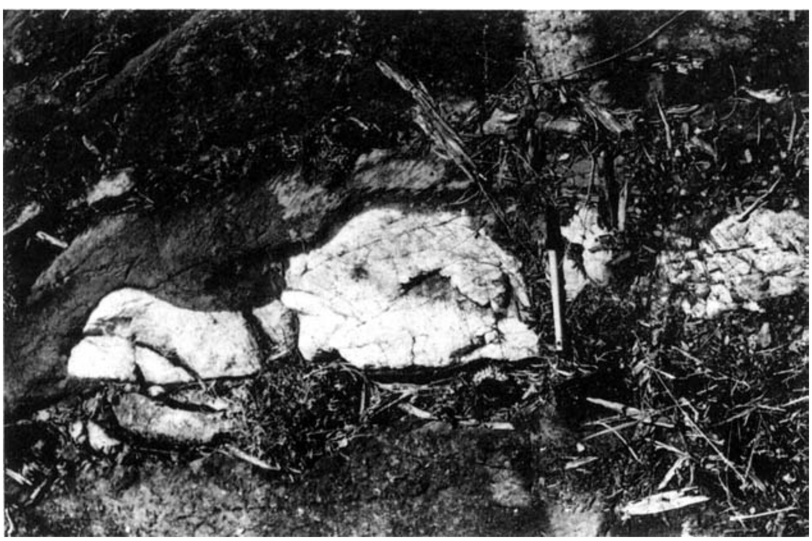


Figure GS-12-19:

Rodingite inclusion with foliated chlorite selvage in layered suite rocks. Pen 16 cm.

LAYERING AND REPETITIVE CYCLES IN THE ULTRAMAFIC ZONE

The Ultramafic zone of the Bird River Sill is composed almost entirely of olivine + chromite cumulates. The rock types range from dunite and peridotite to chromitite. There is a distinct lack of repetitive cyclic units based on the disappearance and reappearance of cumulus silicate phases. Layering in the silicate portion of the intrusion is based on the presence or absence of postcumulus pyroxene. Textural layers in peridotite are defined by concentrations of original pyroxene oikocrysts. Alternating peridotite-chromitite layers in the chromitite-bearing portion of the intrusion may reflect repetitive cycles. Dense chromitites contain a fine grained featureless matrix composed of a mixture of chlorite and grossular garnet, which is interpreted as representing rodingite-type alteration of original plagioclase. The dense packed nature of the chromite suggests that if plagioclase was the original silicate phase, it likely formed as a postcumulus mineral. Thus, chromitites originally may have been composed of cumulus chromite and postcumulus plagioclase.

Alternating peridotite-chromitite layers in the chromite-bearing portion of the intrusion reflect dramatic changes in the abundance of cumulus phases. In dense chromitites, individual cumulus olivine crystals are rare or entirely absent. The changes across peridotite-chromitite contacts thus involve a dramatic increase in the abundance of cumulus chromite, a dramatic decrease in the abundance of cumulus olivine, and a change in the postcumulus phases from pyroxene(s) in the peridotite to plagioclase in the chromitite. The change of the postcumulus phase from pyroxene to plagioclase suggests that if peridotite-chromitite layers are considered as representing cyclic units, chromitite layers likely form the upper units of individual cycles.

FAULTS IN THE ULTRAMAFIC ZONE

Within the Ultramafic zone there are numerous faults with displacements from several centimetres to tens of metres. Repetition of portions of the stratigraphy by faults has been recognized in a number of areas. The lack of marker horizons in olivine cumulate layers that separate chromitite-bearing horizons suggests that changing thickness of some of these layers along strike may be the result of movement along faults. The definition of a regular stratigraphy within the chromitite-bearing portion of the Ultramafic zone permits recognition of significant fault displacements. Rotation of some fault blocks has been documented (Trueman, 1971) and although layer dips are not readily measureable, substantial changes in dip have been recognized. Future chromite resource studies should include a critical evaluation of fault block rotation and fault offsets.

TRANSITION ZONE

The Transition zone is a narrow (1.5 - 4.9 m) layer that separates the Ultramafic zone from the overlying Gabbro zone. It is distinguished by a well-developed fabric that is approximately parallel with layering, and by gradational changes in the proportions of cumulus olivine and plagioclase. It has a smooth, brownish buff weathered surface and contains 1-2 cm hornblende oikocrysts (after original clinopyroxene?), and 2-3 cm ovoid, whitish green poikilitic amphibole crystals (after original orthopyroxene?). Cumulus olivine decreases in abundance upward and original cumulus plagioclase increases in abundance upward. The contact with overlying oikocryst-bearing gabbro is gradational over 1 to 3 m, although in one area this contact is a fault. A large (1 x 5 m) rodingite inclusion comprising massive prehnite (Trueman, in prep.) and possessing a continuous chlorite selvage was observed in Transition zone rocks on the Chrome property.

GABBRO ZONE ROCKS

A number of traverses were made across Gabbro zone outcrops, although time did not permit for a rigorous stratigraphic treatment to be applied to the zone. The following represent the most significant observations made as a result of these preliminary traverses.

The lower anorthositic gabbro layer (Trueman, 1970, 1971 and in prep.) was seen to be in part xenolith-bearing. The xenolith-bearing zone, which is approximately 60 m thick, appears to be continuous along the length of the Chrome property. It is composed of angular to rounded blocks of coarse grained to pegmatitic anorthositic gabbro in a medium grained gabbro matrix (Fig. GS-12-20). Rounded, cobble-sized fragments of coarse grained anorthosite give rise to areas of "football" gabbro within the xenolith zone. The larger fragments range

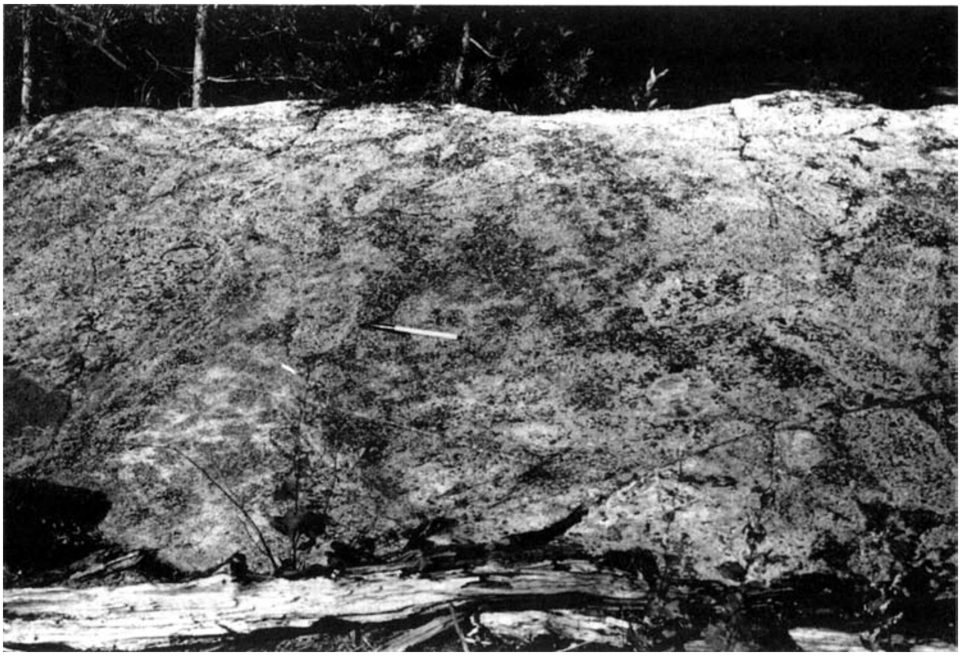


Figure G5-12-20:

General view of xenolith zone outcrop illustrating population of xenoliths of different shapes and sizes. Pen 16 cm.

Figure GS-12-21: Large (1.5 x 0.5 m) *rectangular anorthositic gabbro xenolith in medium gained gabbro. Xenolith zone. Pen 16 cm. See sketch Fig. GS-12-22.*

from metre-sized rectangular blocks with sharply angular corners (Figs.GS-12-21 and 12-22) to slab-like (Fig.GS-12-23), and irregularly-shaped masses with smoothly curving outlines. Some xenoliths possess internal layering. There does not appear to be any stratigraphic organization in terms of size and/or shape distribution.

The xenolith zone must represent a significant event in the history of the intrusion. The fragments represent disruption and redeposition of previously consolidated material. They presumably descended from above, and they may represent rocks that originally crystallized near the intrusion roof. Trueman (1971, and in prep.) suggested the concept of crystallization from the roof downward on the basis of cryptic variation of plagioclase compositions. The presence of xenoliths in the lower anorthositic gabbro layer supports this concept.

Large portions of the anorthositic gabbro layer that underlie the xenolith zone are distinguished by patches of coarse grained to pegmatitic anorthositic gabbro in a medium grained, even textured gabbro matrix. The contacts between the coarse grained patches and matrix gabbro are vaguely defined. The heterogeneous nature of the rocks suggests that much of the anorthositic gabbro layer underlying the xenolith zone originally may have been composed of anorthositic gabbro xenoliths that were partially resorbed through reaction with surrounding magma.

Rodingite inclusions in the underlying Ultramafic and Transition zones are interpreted to represent original plagioclase-rich inclusions, and these may be the result of earlier events of disruption of previously consolidated gabbro. This, in turn, suggests that gabbro may have been crystallizing elsewhere in the intrusion at the time of formation of the Ultramafic zone-Transition zone sequence.

QUARTZ-BEARING ROCKS

Quartz-bearing rocks may be more widespread than previously indicated. At the base of the porphyritic gabbro layer, quartz crystals are widely distributed, constituting approximately 1 per cent of the rock. From this point upward, the quartz content of the rocks displays a progressive increase. This gives rise to a succession of quartz-bearing rocks that range in composition from quartz gabbro to tonalite. Contacts within the quartz-bearing assemblage are gradational, although rare cm-scale layers have been observed. Within the tonalite zone, quartz stringers and veins are common, and the core of the tonalite zone contains discontinuous veins and lenses of aplite. Progressing up section from the core of the tonalite zone, the quartz content of the rocks decreases and the succession of rocks progresses through tonalite to quartz gabbro. The quartz gabbro is in fault contact with medium grained anorthositic gabbro that becomes coarser grained upward (southward). Outcrops of medium to coarse grained anorthositic gabbro represent the uppermost Sill rocks exposed on the Chrome property.

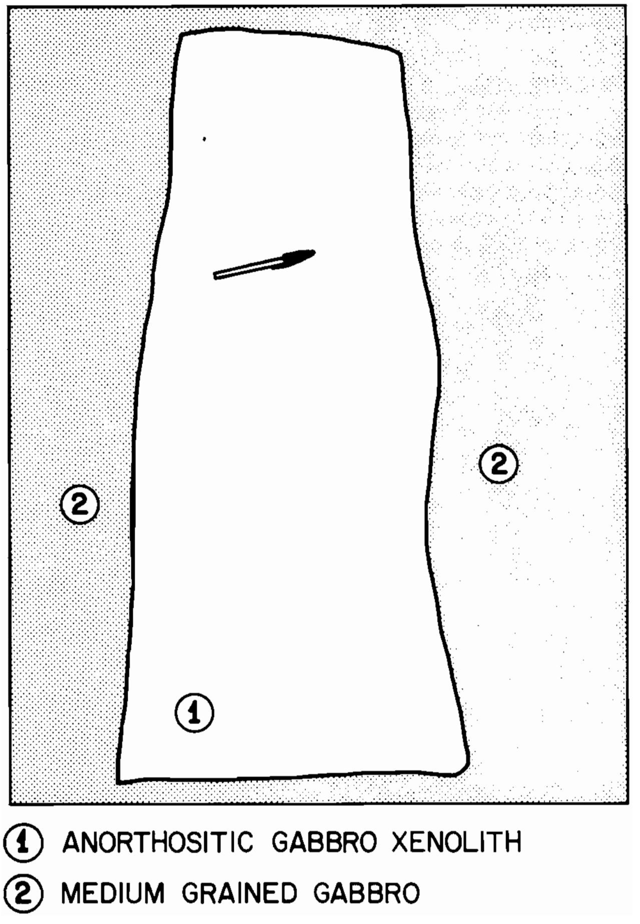


Figure GS-12-22: Sketch of Fig. GS-12-21 with xenolith border outlined.

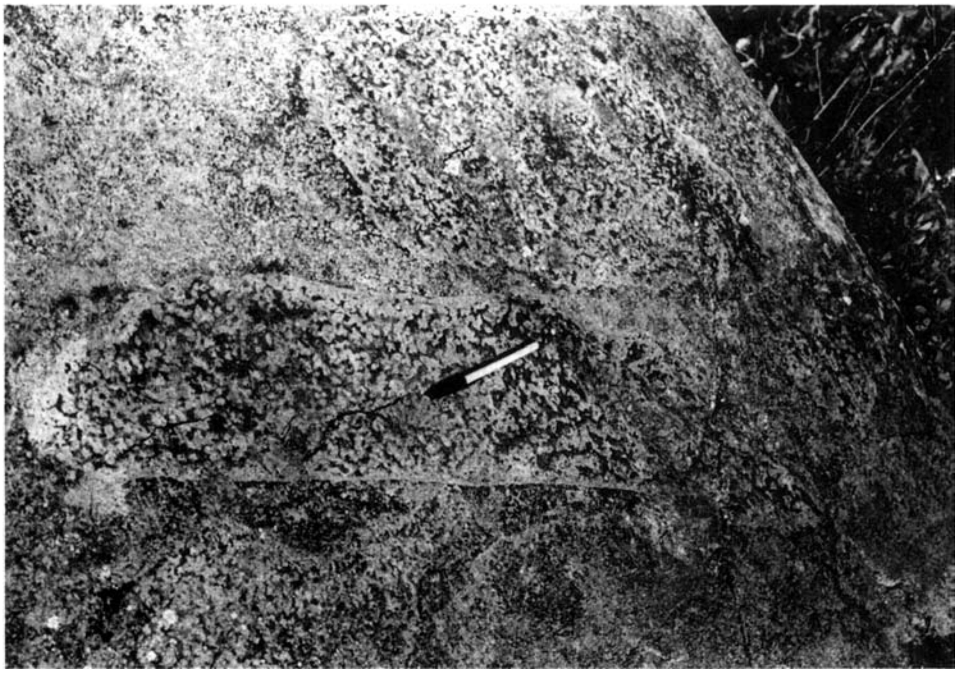


Figure GS-12-23:

Slab-like coarse grained gabbro xenolith in medium grained gabbro. Xenolith zone. Pen 16 cm.

INCLUSIONS

Rare inclusions of fine grained felsic tuff have been noted in the quartz-bearing assemblage. The largest inclusion (5x40 m) is light buff brown to beige weathering, and is composed of a fine grained (<1 mm) assemblage of quartz, feldspar and biotite. Euhedral, lath-shaped feldspar crystals (2 x 5 mm) are sporadically distributed, and in places the rock possesses a delicate, ribbon-like fabric. These inclusions likely represent stoped fragments of the intrusion roof.

COMMENT ON CRYSTALLIZATION

In the ultramafic portion of the intrusion the rocks are predominantly olivine + chromite cumulates, with clinopyroxene (±orthopyroxene) being the original postcumulus phase. Dense chromitites are chromite cumulates, with plagioclase being interpreted to have been the original postcumulus phase. In the upper part of the Ultramafic zone and in the Transition zone olivine + plagioclase + chromite were original cumulus phases and clinopyroxene ± orthopyroxene were original postcumulus phases. Gabbro zone rocks were original plagioclase cumulates with clinopyroxene being the original postcumulus phase. In the upper part of the Gabbro zone acicular plagioclase crystals and ophitic hornblende (after clinopyroxene?) suggest **in-situ** crystallization, and quartz becomes an increasingly important constituent.

Thus, from the base of the intrusion upward there is a regular progression from olivine + chromite cumulates and chromite cumulates, to olivine + plagioclase + chromite cumulates to plagioclase cumulates. In the upper part of the gabbro zone there is textural evidence of **in-situ** crystallization and quartz becomes a prominent phase. There is significant evidence that the Bird River Sill represents fractional crystallization of a single pulse of magma. This is supported further by a general lack of repetitive cycles.

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GS-13 MINERAL DEPOSIT INVESTIGATIONS IN THE LYNN LAKE AREA

by G.H. Gale

INTRODUCTION

The major portion of this year's mineral deposit studies were conducted in the Lynn Lake region. Field work included the continuation of programs initiated in 1982 (Fedikow and Gale, 1982) and consisted mainly of studies into: a)the nature of gold mineralization along the Agassiz-Arbour Lake mineral belt (Fedikow, 1983); b) internal stratigraphy of felsic volcanic rocks associated with mineral occurrences (Baldwin, 1983): c) the genesis of copper-zinc sulphide and related porphyroblastic schist occurrences; and d) the nature of gold mineralization along the Johnson Shear Zone.

LAKE SEDIMENT SAMPLING

A joint Federal-Provincial program was undertaken in 1983 to investigate the geochemistry of lake sediments and waters in the Lynn Lake area. Contract sampling of map sheet 64C (Fig.GS-1) has been completed. The analyses are being carried out under contract at several analytical labs and the results will be released as an open file report in the spring of 1984 .

PORPHYROBLASTIC SCHISTS

BOILEY-COUNSELL LAKE AREA

Prospecting and follow-up drilling by Sherritt Gordon Mines Ltd. have indicated the presence of copper mineralization in volcaniclastic metasedimentary rocks in the Boiley Lake and Counsell Lake areas. Magnetite-bearing garnet-chlorite schist and chlorite schist are exposed in a number of places (Fig.GS-13-2). Examination of drill core and detailed mapping of portions of the Boiley Lake area (Fig.GS-13-3) revealed that: a) the chloritic and garnetiferous schists transect the volcanic stratigraphy; b) a number of the geophysical anomalies in the area were confined to the cross-cutting alteration zone; c) the alteration was associated with a stratum containing muscovite, kyanite, cordierite, pyrite, pyrrhotite and silicic rocks that are interpreted as cherty sedimentary rocks of probable exhalative origin; d) the relative positions of the silicic rocks and chloritic schists indicate that stratigraphic tops are towards the south in this area; and e) the presence of quartz-muscovite-biotite-kyanite-pyrrhotite schists south of the identified exhalite stratum suggests that a stratigraphically higher exhalative (mineralized) stratum may be present in the unexposed terrain immediately to the south.

Porphyroblastic chlorite-garnet schists are exposed in small outcrops along and south of a tractor trail between Counsell and Boiley Lakes (Fig.GS-13-2). The magnetite-bearing chlorite-garnet schists resemble those at Boiley Lake; however, the alteration is not as intensive as that at Boiley Lake. A one-metre thick pyritic silicic rock with less than 10 percent sulphide stratigraphically overlies the chloritic schists and occurs at approximately the same stratigraphic position as the exhalative stratum delineated at Boiley Lake.

South of Counsell Lake (Fig.GS-13-2) drilling of geophysical conductors by Sherritt Gordon Mines has intersected chalcopyrite-pyrite-pyrrhotite mineralization. Sparce exposures in the area consist predominantly of intrusive rocks and layered mafic volcanic rocks. Small lenses and patches of coarse grained hornblendite with trace sulphide and chlorite observed in the eastern part of the area may be part of a massive sulphide alteration zone; however, derivation of the alteration from the nearby intrusions cannot be ruled out.

The disseminated sulphide mineralization observed in drill core occurs in layers of silicic (cherty?) sedimentary rocks containing quartz, muscovite, biotite, garnet, anthophyllite, kyanite and cordierite that appear to be stratabound. Locally, the amphibolitic host rocks are bleached by epidotization that postdates the amphibolite grade regional metamorphism and may be related to the igneous intrusions.

The sulphide mineralization at Counsell Lake occurs within a few metres of well-layered fine grained clastic quartzofeldspathic rocks that resemble Sickle metasedimentary rocks. The contact between the two rock types appears to be conformable and there is no evidence of conglomeratic rocks in the cores examined. Sickle-type rocks are also present south of the Boiley Lake exhalative stratum (Gilbert **et al.,** 1980). The presence of stratabound exhalative mineralization adjacent to the Wasekwan-Sickle contact and the recognition of porphyroblastic schists and iron formation (Gilbert **et al.,** 1980) in the volcanic rocks near the contact indicate that the contact may be a significant marker in the exploration for massive sulphide deposits.

LAURIE LAKE AREA

Coarse grained quartz-anthophyllite-chlorite ± biotite ± muscovite ± magnetite ± cordierite schists occur in at least three localities (Fig .GS-13-1) on the north side of Lau rie Lake (G ilbert **et al.,** 1980; J. Chornaby, pers. comm., 1980). At the Lar deposit and the New Fox occurrence these rocks are associated with known sulphide mineralization.

At the Lar Deposit the schists are associated with and stratigraphically underlie the Cu-Zn massive sulphide mineralization and forms part of the alteration zone. The two other occurrences can be traced for considerable distances adjacent to the margins of granitic intrusions; however, the stratigraphic positions and genesis of these porphyroblastic schists have not been determined.

JOHNSON SHEAR

Selected mineral occurrences along the Johnson Shear (Bateman, 1945) were examined. The mineral occurrences were described in detail by Bateman (1945) and are considered to be an adequate property description; most of the old trenches described by Bateman are still recognizable.

Gold mineralization occurs in association with minor sulphides in a fine grained albite dyke that cuts across folded volcanic rocks (the Central Manitoba showing). in quartz veins (Ace Group) and in quartz veins cutting volcanic and sedimentary rocks (siltstones) on the Johnson claims. Although the gold mineralization at the Johnson and Ace showings may have been mobilized from the surrounding volcanic and sedimentary rocks there is no apparent evidence of a shear zone controlling the deposition of the mineralization and a distinct "shear zone" was not observed in the rocks containing the gold mineralization; however, strongly deformed rocks are present in the general area.

Since gold mineralization is associated with intrusive rocks in the Cartwright Lake area (Milligan, 1960; Baldwin, 1983) at the Central Manitoba showing and in veins cutting the syenite and volcanic rocks on McVeigh Lake, a lithogeochemical survey of intrusive rocks in the vicinity of the Johnson Shear will be undertaken to establish if a metal-rich plutonic source is present in the area.

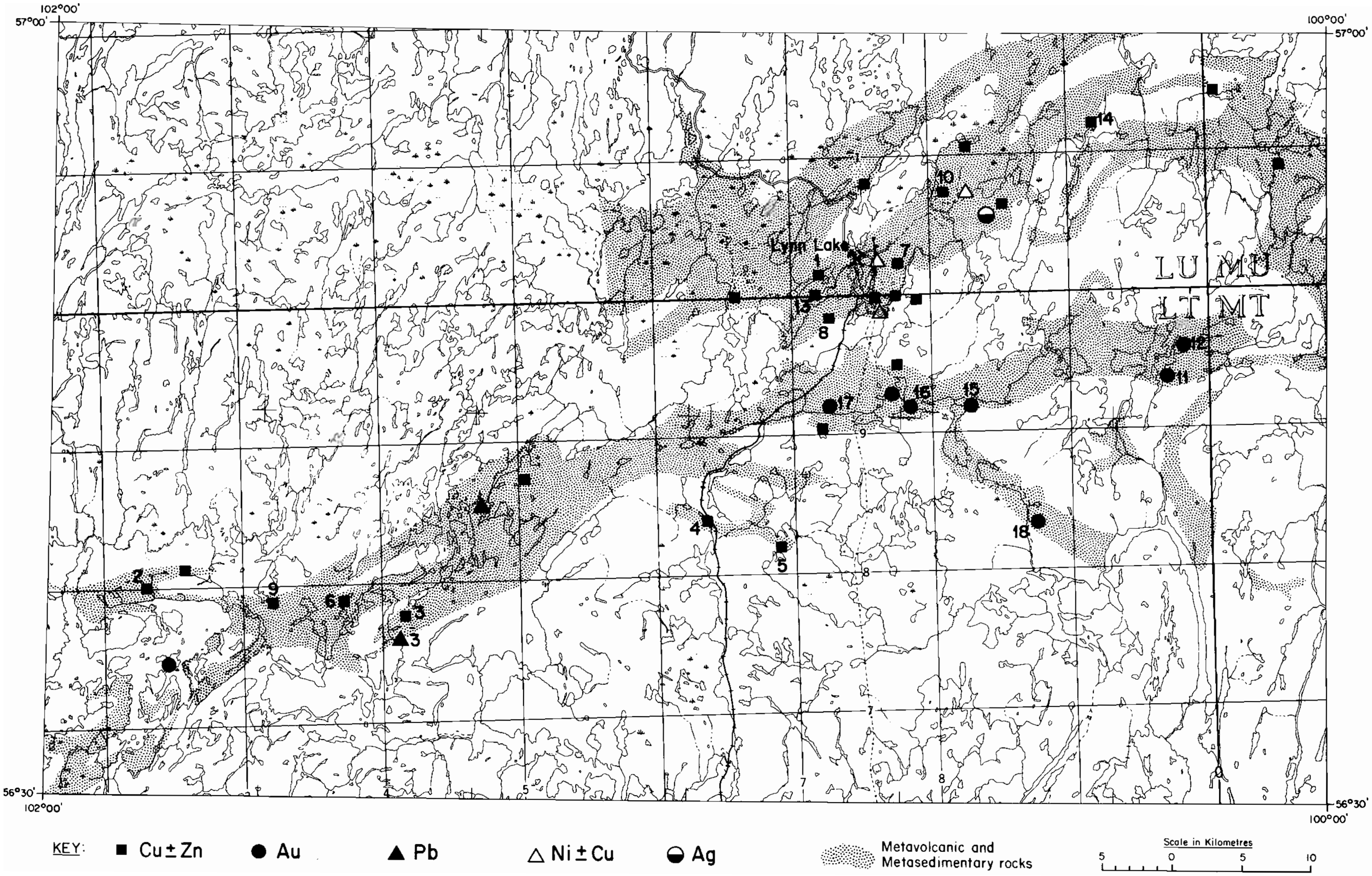

Figure GS-13-1: *Metavolcanic and metasedimentary rocks of the Wasekwan Group in the Lynn Lake area. 1. Sheila Lake-Margaret Lake occurrence. 2. Lar deposit. 3. Snake Lake occurrence. 4. Boiley Lake occurrence. 5. Counsell Lake occurrence. 6. Fox Mine. 7. Y deposit. 8. Nicoba deposit. 9. New Fox occurrence. 10. Agassiz deposit. 11. Giant deposit. 12. Cartwright Lake occurrence. 13. Frances Lake deposit. 14. Arbour Lake occurrence. 15. Central Manitoba occurrence. 16. Johnson Occurrence. 17. Ace occurrence. 18. Lasthope occurrence.*

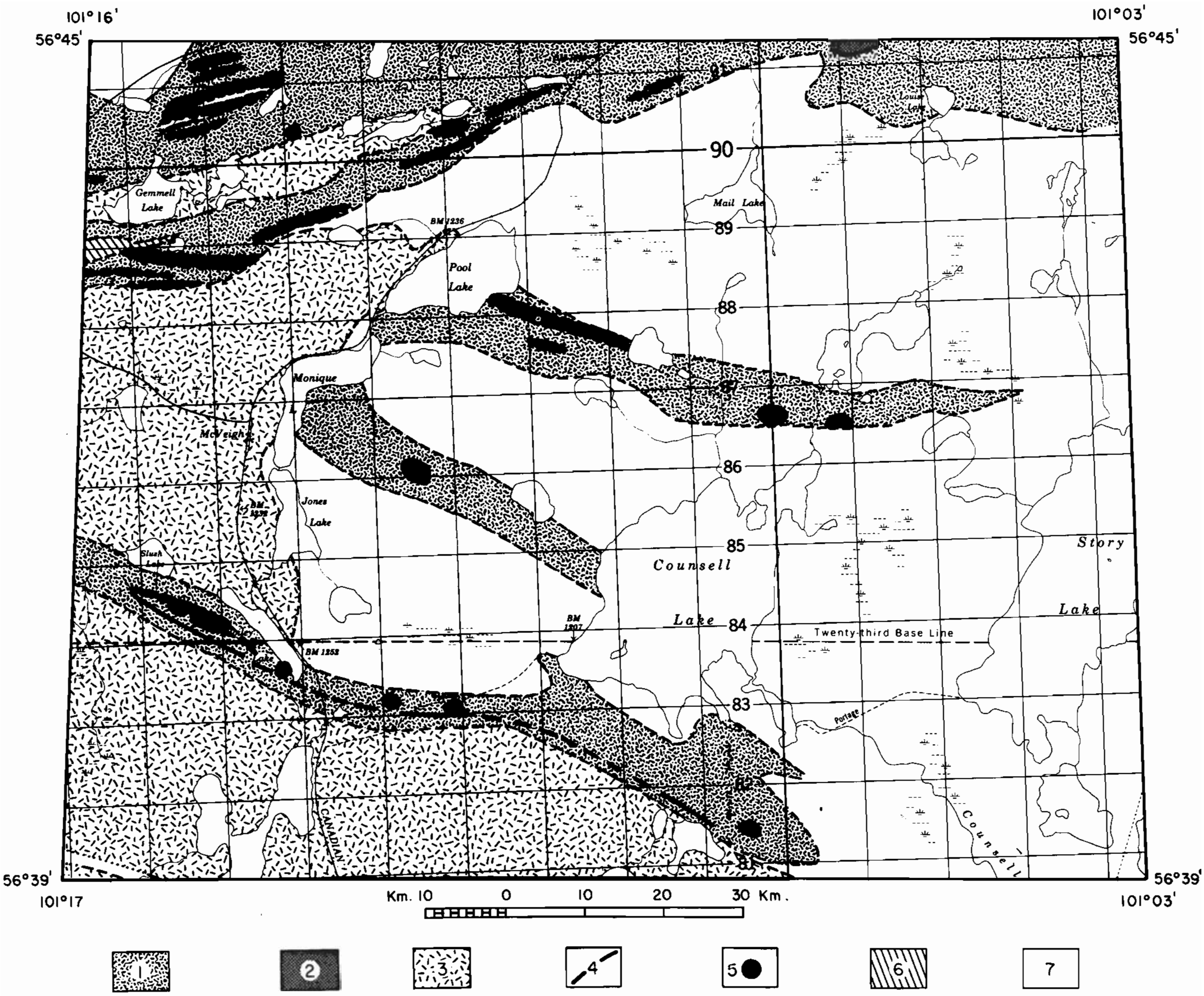

Figure GS-13-2: *General geology of the Boiley Lake-Counsell Lake region. 1. Mafic and intermediate volcanic rocks. 2. Rhyolitic and dacitic volcanic rocks. 3. Conglomerate and sandstone of the Sickle metamorphic suite. 4. Stratabound sulphide-bearing silicic rocks of probable exhalative origin. 5. Porphyroblastic schists + iron formation. 6. Gabbro, diabase. 7. Diorite, tonalite and granodiorite. Geology modified from Gilbert et al. (1980), Map No. GP80-1.*

OTHER ACTIVITIES

Drill cores from the Frances Lake, Y, Gods Lake, Fox and Nicoba deposits were examined in an ongoing investigation of stratigraphic tops, nature of mineralization and deposit types. Mineral occurrences on Snake Lake were mapped in detail as part of the mineral deposit data open file.

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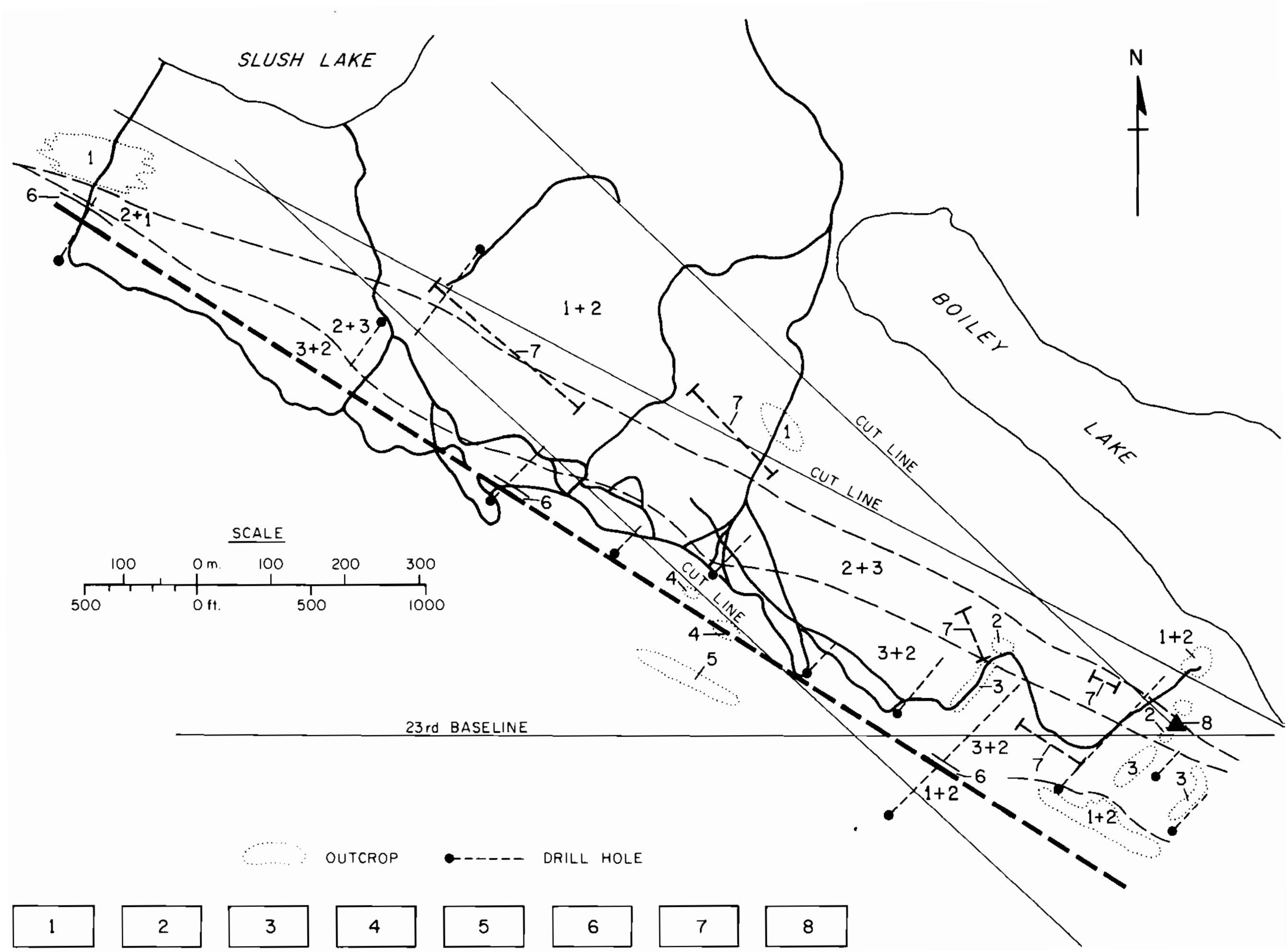

Figure GS-13-3: Geology of the Boiley Lake Area. 1. Layered amphibolite, includes mafic volcaniclastic rocks and minor felsic tuffaceous rocks. 2. Chlorite + magnetite schists. 3. Garnet-chlorite and chlorite-garnet porphyroblastic schists. 4. Hornblende-quartz-garnet schists. 5. Quartz-biotite-kyanite + muscovite schists with minor pyrrhotite. 6. Silicic sedimentary rocks (chert) containing biotite, muscovite, kyanite, cordierite, pyrite and pyrrhotite. 7. Electro-magnetic anomaly. 8. Chalcopyrite and pyrite in chlorite schist.

GS-14 STRATIGRAPHIC STUDIES OF FELSIC VOLCANIC ROCKS ASSOCIATED WITH MINERAL OCCURRENCES IN THE LYNN LAKE AREA, MANITOBA

by David.A. Baldwin

INTRODUCTION

Geological fieldwork was designed to investigate the stratigraphy and nature of mineralization in felsic volcanic rocks in the vicinity of Lynn Lake. Brief visits were made to a number of mineral occurrences to assess the availability of outcrop, the distribution of the mineralization, the extent of surface exploration, and the extent to which documentation of the occurrences can be made from surface examination.

Sulphide mineralization at Sheila Lake and the Cartwright Lake Rhyolite were documented at 1:600 and 1:1200, respectively. These two occurrences are reported here and serve to represent the style of mineral occurrence documentation to be pursued in the Lynn Lake area.

Stratigraphic studies were carried out in the Cartwright Lake Rhyolite and the Lynn Lake Rhyolitic Complex to identify the depositional environments of these felsic volcanic rocks. Massive sulphide deposits are present in the Lynn Lake Rhyolitic Complex (Fedikow and Gale, 1982). Their stratigraphic position and the environment of deposition of their host rocks in relation to that of the complex as a whole may have a direct bearing on future exploration in these felsic rocks. During the 1982 field season 225 samples were collected from the Lynn Lake Rhyolitic Complex for alteration studies (Fedikow and Gale, 1982). The stratigraphy of the volcanic rocks from which the samples were collected was studied in detail to facilitate interpretation of the geochemical data. The northern boundary of the Lynn Lake Rhyolitic Complex in the area north of Frances Lake has been redefined.

West of Flag Lake a hitherto unrecognized conglomerate with granitic pebbles has been identified stratigraphically below the Lynn Lake Rhyolitic Complex.

PRELIMINARY RESULTS

SHEILA LAKE

A unit of pyritic felsic sedimentary rocks exposed at Sheila Lake (Fig.GS-14-1) can be traced eastwards by airborne EM and on the ground and for a distance of 4.5 km from Margaret Lake east to West Lynn Lake. The geology of these rocks and the underlying and overlying lithologic units are well exposed on a peninsula on Sheila Lake (Fig.GS-14-1) and on the southeast shoreline of Sheila Lake (Fig.GS-14-1). The rocks are poorly exposed at the south end of Margaret Lake (Fig.GS-14-1). The geology of the occurrence on the peninsula at Sheila Lake is shown in Figure GS-14-2. The geology is similar at the other two localities; however, unit thicknesses and details of the geology vary from locality to locality.

The pyritic unit is approximately 40 metres thick at Sheila Lake and about 20 metres thick at Margaret Lake. The rocks consist of layered, fine grained, massive, pyritic siliceous sandstone with thin interbeds of siltstone. Pyrite and arsenopyrite are finely disseminated throughout the rock with local sulphide mobilizate concentrated in stringers. In drill core the sulphide, predominantly pyrrhotite, occurs as solid sulphide sections, stringers and veinlets. Minor pyrite and chalcopyrite occur with the pyrrhotite. The solid pyrrhotite sections probably account for the local magnetic anomalies encountered while mapping the area. On the peninsula at Sheila Lake the most southerly few metres of the sulphide unit are decidedly more siliceous than the remainder of the sedimentary rocks in the felsic unit. On the southeast shore of Sheila Lake the most southerly few metres of the sulphide unit is a pyritic chert layer that is overlain to the south by 2 to 3 metres of thinly banded chert. The pyritic chert contains about 15 per cent sulphide. At Margaret Lake a very siliceous pyritic sedimentary rock occurs at the southern margin of the pyritic unit.

On the south side of the pyritic unit there is heterolithic conglomerate (Unit 4; Fig.GS-14-2) that consists predominantly of felsic volcanic clasts with minor intermediate volcanic and sedimentary clasts in a felsic fine grained matrix. The contact between these two units, as exposed in a small outcrop on the peninsula at Sheila Lake, is sharp and planar. On the peninsula at Sheila Lake and at Margaret Lake mafic fine grained sedimentary rocks are interbedded with the heterolithic conglomerate. The clasts in the conglomerate are coarsest and most abundant on the southeast shore of Sheila Lake. Rare primary sedimentary structures in the conglomerate indicate that these rocks young toward the south. Local, rusty weathering sulphides form patches and anastomosing networks within this conglomerate.

The rocks north of the pyritic unit are also sedimentary. Adjacent to the pyritic unit there is a 40 to 50 metre thick unit of lithic greywacke with minor interbedded amphibolite and siltstone (Unit 2; Fig.GS-14-1). This rock is light greyish brown and has beds that are less than 1.5 metres thick. The amphibolites occur as fine grained, dark green, structureless layers up to several tens of centimetres thick. Siltstone occurs as discrete layers less than 3 cm thick within the lithic greywacke. Heterolithic conglomerate and greywacke (Unit 1, Fig.GS-14-2) occur along the north side of the peninsula at Sheila Lake, on the southeast shore of Sheila Lake and at Margaret Lake. The felsic, intermediate and rare mafic volcanic clasts of the heterolithic conglomerate are set in a dark green, amphibole-rich aphyric matrix. Beds are up to 2.0 metres thick. Clasts are highly deformed (clast elongation of about 10:1), however, size and abundance grading of clasts is observed locally. The greywacke consists of amphibole, feldspar and rare rock fragments. The mineral constituents are equigranular, and locally within some beds there is a gradation from the massive equigranular rock to a very thin parallel laminated rock distinguished by the alternation of light and dark green very fine grained layers.

In rock unit 4 small-scale S-folds plunge at about 35° to the west. In unit 1, faulting occurs either parallel to or nearly parallel to strike, and at a high angle to bedding. This faulting has occurred prior to major tilting in the area and as a result produced opposite facing directions in these rocks. This style of folding and faulting has not been observed in the other two rock units.

Metamorphosed hydrothermal alteration products commonly associated with volcanogenic massive sulphide deposits (Sangster, 1972a, 1980b) have not been observed in the vicinity of the pyritic unit at Sheila or Margaret Lakes. The stratiform nature of the SUlphide mineralization and the occurrence of chert on the south side of the mineralization does however suggest deposition from an exhalative vent and a southward facing rock unit. The deposition of the felsic sediment may have been contemporaneous with exhalative activity

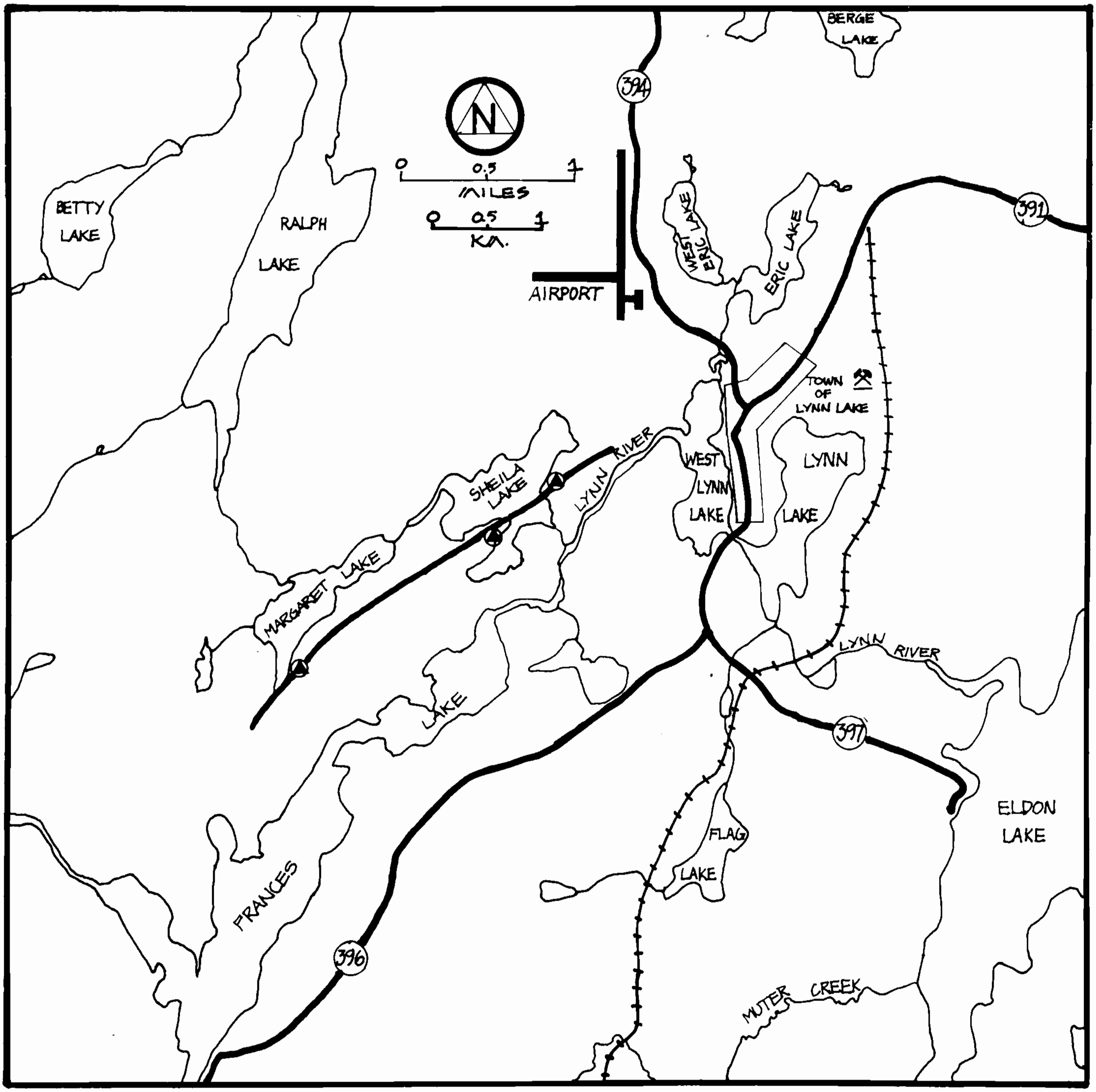

Figure GS-14-1: Map of Sheila-Margaret Lake area showing the location of exposed sulphide and the position of the E.M. anomaly associated with the sulphide mineralization.

and resulted in the dilution of the sulphide thereby producing a pyritic sediment. Alternatively the felsic sediment may be a distal exhalite stratum and metal concentration took place elsewhere on the paleo-ocean floor.

CARTWRIGHT LAKE RHYOLITE

The Cartwright Lake Rhyolite body is lens-shaped, 1300 m long and up to 500 m thick and is folded in the hinge zone of a northeast-trending anticline (Gilbert, **et al.,** 1980). Lithologies in the body have been described by Gilbert, **et al.** (1980). Chemically these rocks are comparable to calc-alkaline rhyolite.

During the past field season most of the rhyolite body was mapped at 1:1 200. The distribution of lithologies and location of the sulphide mineralization are shown in Figure GS-14-3 which illustrates the stratigraphy of the body and the position of the sulphide mineralization.

The sulphides occur throughout the rhyolite body but are confined to massive rhyolite units. Pyrite and arsenopyrite occur as

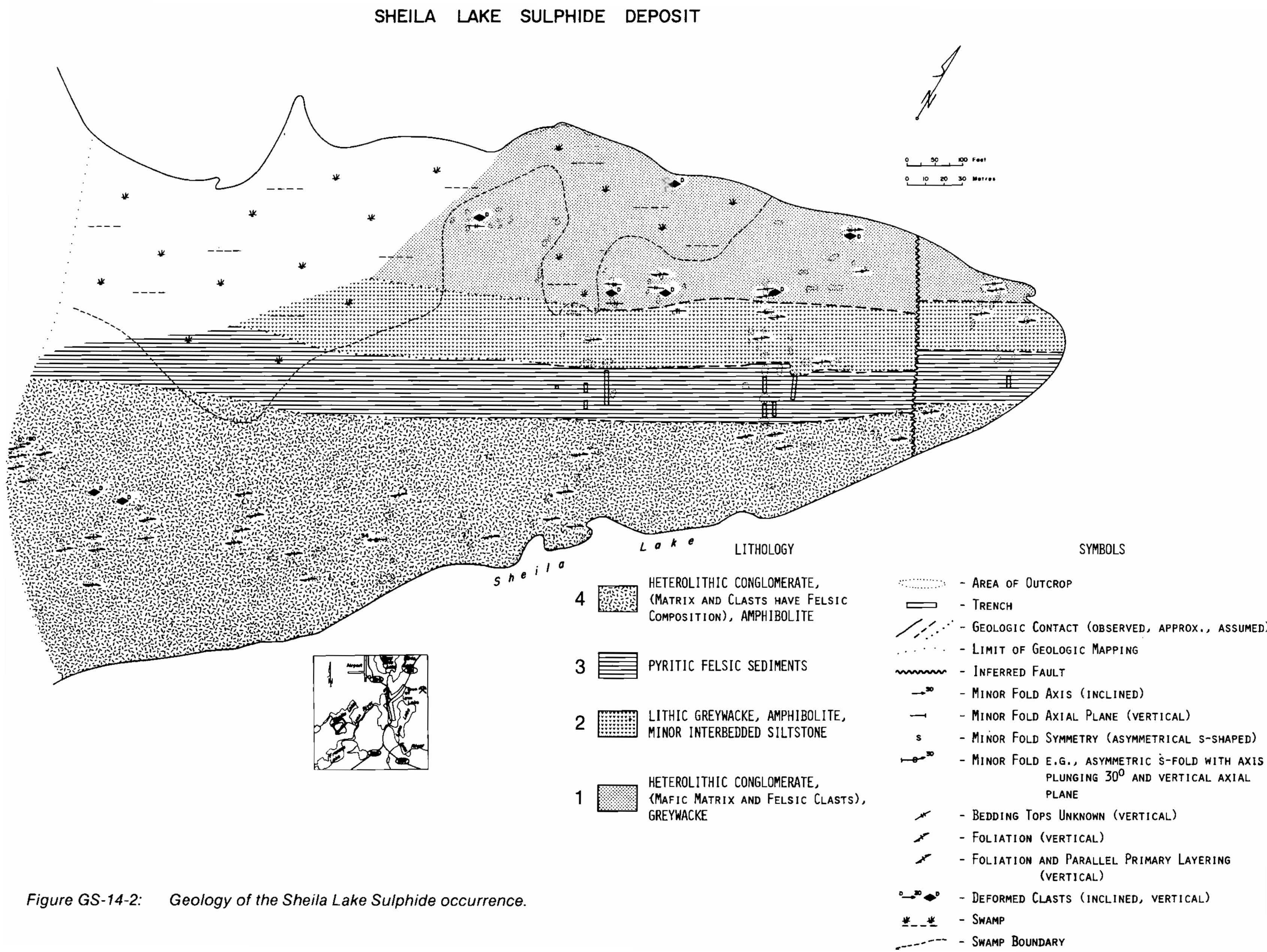

Figure GS-14-2: Geology of the Sheila Lake Sulphide occurrence.

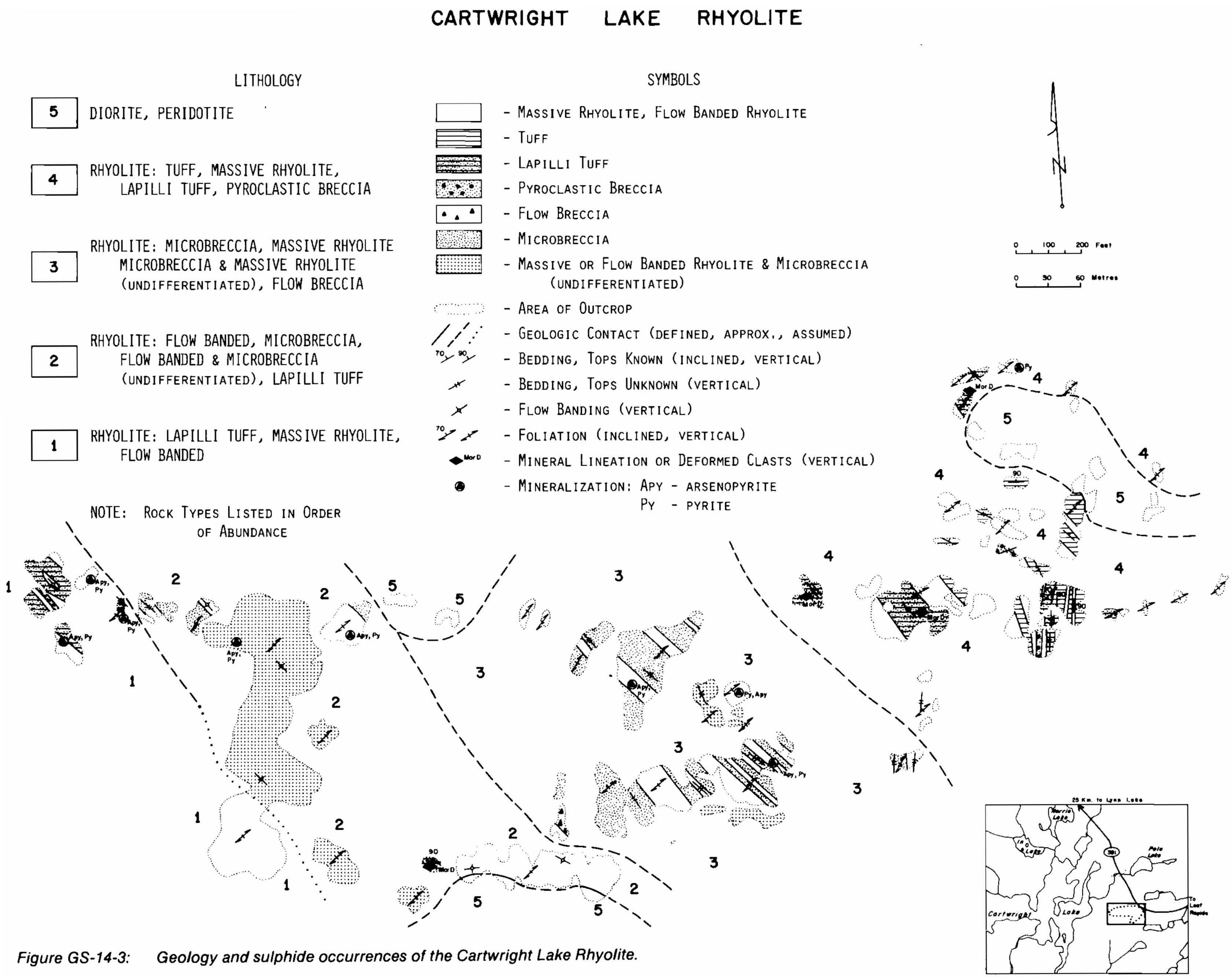

Figure GS-14-3: Geology and sulphide occurrences of the Cartwright Lake Rhyolite.

disseminated grains as smears or coating on shear surfaces and as fracture fillings within shear zones. The mineralized zones are up to a few metres wide and on outcrop surface are recognized by rusty weathering. The mineralized zones occur perpendicular to lithologic contacts and are generally parallel to regional foliation. These zones are contained within massive rhyolite units and do not cross-cut lithologic contacts. Sulphide coatings on shear planes are more abundant than disseminated sulphides and fracture fillings. Generally the shear planes are 1 to 2 cm apart but locally they are only a few millimetres apart. Fractures are generally discontinuous, less than 1 mm thick and rarely more than a few centimetres in length. Disseminated pyrite occurs as cubes and arsenopyrite as tabular crystals, whereas in fracture fillings the sulphide is fine grained and arsenopyrite is rare.

The mineralization is restricted to shear zones in massive rhyolite that parallel regional foliation. The present nature of the mineralization probably resulted from sulphide mobilization from an unknown source during metamorphism and tectonism with emplacement of the mobilized sulphide into shears and fractures produced in the competent rocks.

At the Giant Claims on Cartwright Lake a gold-bearing intrusive “porphyry” (Milligan, 1960) contains distinct quartz-filled fractures and irregularly distributed pods of quartz with indefinite shape. The relationship of this “porphyry” to other intrusive rocks or felsic intrusive rocks in the area has not been established, however, Milligan (1960) states that the porphyry closely resembles the siliceous red granite (unit 17, Gilbert, et al., 1980) that outcrops about 30 to 35 metres north of the Giant Claims. During the 1982 field season fourteen continuous chip samples were collected at waist height in trenches at the occurrence. The gold contents from these samples are given in TableGS-14-1 and their locations shown in Figure GS-14-4.

Pyrite and arsenopyrite, also occurs in fractures and fracture controlled quartz veins and pods in a granitic body (unit 17; Gilbert, et al., 1980) that outcrops on the peninsula in Cartwright Lake to the northwest of the Giant Claims.

LYNN LAKE RHYOLITIC COMPLEX

This felsic volcanic body, approximately 18 km long and up to 3 km thick, comprises pyroclastic rocks, lava flows and minor interlayered amphibolitic rock. Rare younging criteria indicate that the complex faces north.

During the course of the stratigraphic mapping a previously unrecognized unit of polymictic pebble conglomerate containing volcanic and plutonic clasts was encountered underlying the Lynn Lake Rhyolitic Complex immediately west of Flag Lake. This conglomerate indicates the presence of an unconformity in the lower part of the Northern Belt of the Lynn Lake Greenstone Belt. The provenance of the plutonic clasts in the conglomerate has not been determined. Five

TABLE GS-14-1
GOLD VALUES, GIANT CLAIMS, CARTWRIGHT LAKE

Table to be read in conjunction with Figure GS-14-4

Sample I.D.	Sample length (metres)	Au gm/tonne
1	3.05	0.84
2	3.23	1.67
3	2.87	0.56
4	3.23	0.84
5	5.44	1.12
6	5.26	0.84
7	1.36	5.35
8	4.41	1.96
9	3.56	0.28
10	3.33	0.28
11	4.92	0.28
12	5.08	0.28
13	6.80	0.28
14	9.52	0.24

quartz phyric flows from the rhyolitic complex, containing zircon, were sampled for U-Pb age determination (Syme, 1983).

Stratigraphic studies indicate that pyroclastic rocks make up about 75 per cent of the rocks in the complex. The complex can be separated into three stratigraphic units (Fig.GS-14-5). The southernmost unit is up to 850 metres thick and consists of plagioclase and quartz phyric, and aphyric tuff, minor pyroclastic breccia, lapilli tuff and few lava flows. Lava flows, generally less than 40 metres thick, occur predominantly in the upper one-third of the unit. Flow breccia is uncommon. Pyroclastic breccias occur in the lower one-half of the unit, whereas, tuff and lapilli tuff occur throughout the unit. The upper contact of the unit is placed at the same stratigraphic level as the Nicoba Zn-Cu deposit.

The central unit appears to consist entirely of quartz and plagioclase phyric pyroclastic rocks. Tuff and lapilli tuff are typically thin-bedded and in general tuff is the more abundant rock type. Pyroclastic flows are uncommon, however, where present they are 10 to 15 metres thick and locally the clasts are vesicular.

The northern unit of the complex, not previously considered to be part of the complex, is 700 to 750 metres thick and consists of tuff, lava flows and interbedded amphibolite. Tuffs are thin bedded and generally aphyric. Lava flows are massive, quartz and plagioclase phyric, biotitic, occur near the top of the unit and are less abundant than tuffs. Amphibolitic rocks make up 30 to 40 per cent of this unit. They are very fine grained, homogeneous, aphyric and have little or no textural and mineralogical variation. The genesis of the amphibolites is

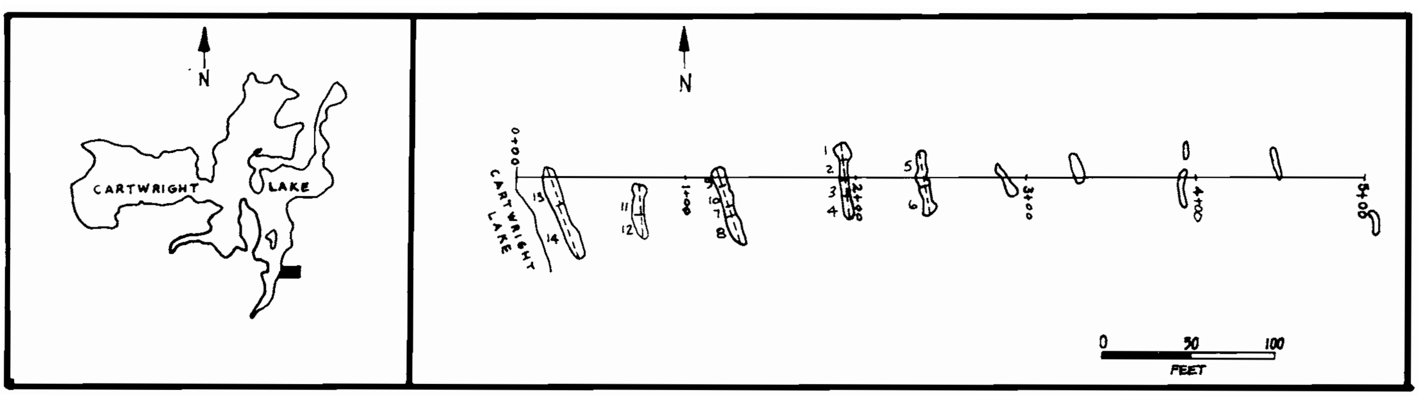

Figure GS-14-4: Location of chip samples, Giant Claims, Cartwright Lake. (Sketch from Milligan, 1960).

uncertain; however, on the basis of what appear to be chilled margins and the irregular distribution of small (1 to 1.5 mm) amygdales they are considered to be intrusive rocks The Frances Lake Cu-Zn deposit is contained within this unit.

East of the townsite of Lynn Lake the rhyolitic complex is poorly exposed and the stratigraphic units established for the complex are difficult to apply with confidence. The northern unit of the complex may be absent in this area.

The position of known massive sulphide deposits in the complex (Fig.GS-14-5) indicates that the deposits are probably located near or at the top of a stratigraphic unit.

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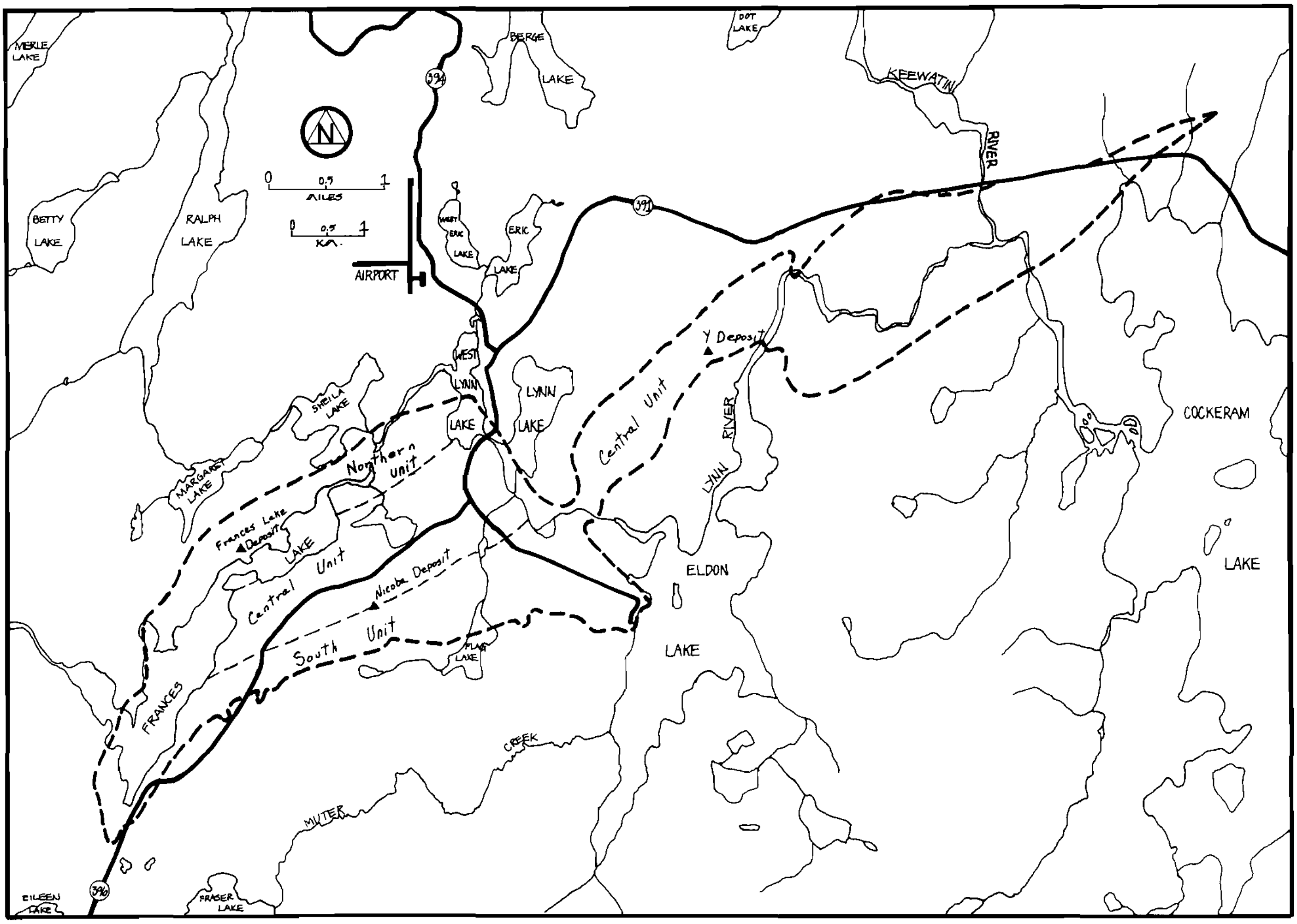

Figure GS-14-5: Preliminary breakdown of the stratigraphy of the Lynn Lake Rhyolitic Complex and the location of massive sulphide deposits contained in the complex.

GS-15 GEOLOGICAL AND GEOCHEMICAL STUDIES AT THE AGASSIZ Au-Ag DEPOSIT, LYNN LAKE, MANITOBA

by M.A.F. Fedikow

INTRODUCTION

Stratigraphic and geochemical studies initiated in 1982 (Fedikow and Gale, 1982) were continued in the vicinity of the Agassiz deposit. Additional diamond drill holes from the deposit were logged and sampled, and the area between the Agassiz deposit and Arbour Lake was reconnoitered for outcrop in an attempt to extend the Agassiz stratigraphic succession eastwards. A new phase of geochemical studies was commenced with the collection of a suite of biogeochemical samples over the Agassiz deposit. This work represents an attempt to provide the mineral industry with a geochemical exploration tool to be used in the search for Agassiz-type mineralization in areas of little or no outcrop.

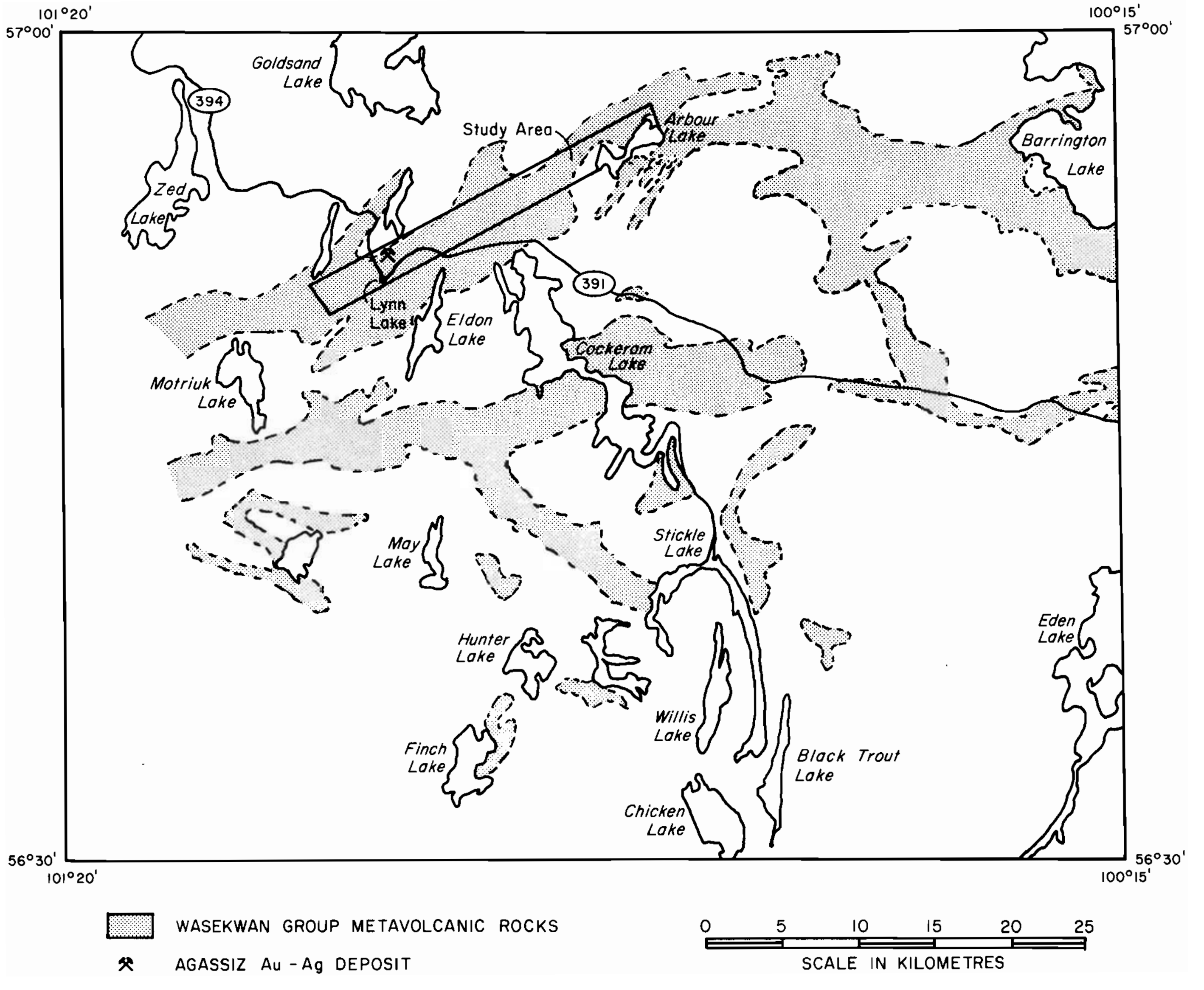

Figure GS-15-1: Location map for the Lynn Lake study area.

Geological Studies

Outcrop exposure northeast of the deposit is minimal and makes confident extrapolation of the Agassiz stratigraphy in this direction difficult. The persistent gradiometric anomaly that extends from the Agassiz deposit to the northwest shore of Arbour Lake suggests a stratigraphic continuity in this direction. Since oxide facies (magnetite-chert) iron formation is associated with the Agassiz deposit, areas in the vicinity of Minton and Arbour Lake with magnetic anomalies (Gilbert, **et al.,** 1980) were investigated. At Minton Lake a grey-green, fine-grained, rusty weathering, weakly magnetic siliceous rock (chert?) was observed. Malachite staining is also present along joints and fractures in the outcrop. This rock unit comprises part of the stratigraphic sequence that hosts the Agassiz-Arbour Lake magnetic trend. On the northwest shore of Arbour Lake three trenches expose an occurrence of near solid sulphide (NSS) to solid sulphide (SS) pyrrhotite-pyrite-chalcopyrite-arsenopyrite mineralization, This zone occurs at or near the contact between a sequence of predominantly clastic sedimentary rocks and a sequence of porphyritic, amygdaloidal, fragmental and tuffaceous basalt. A map of the geology and outcrop distribution in the immediate area of the trenches is presented in Figure GS-15-2. Figure GS-15-3 represents a more detailed geology map in the immediate vicinity of the trenches. Samples of the NSS-SS occurrence have been collected from the trenches for assay purposes. Three smaller trenches occur to the southwest of the sulphide occurrence; however, they are caved and filled with boulder alluvium. Overburden in the vicinity of these trenches is heavily Fe-stained. From south to north the rock sequence is characterized by: (i) a massive, laminated, pyritic, siliceous greywacke or siltstone; (ii) an interlayered unit of siliceous greywacke. mafic units consisting of an amphibole-chlorite-biotite mineralogy and occasional porphyritic basalt; (iii) laterally restricted and rhythmically banded siltstone (recrystallized chert?) and magnetite (B.I.F.); (iv) a tuffaceous siliceous rock (“dacite”, unit 6d. Gilbert, **et al.,** 1980) hosting the NSS to SS mineralization; and (v) a thick sequence of basaltic rocks. The stratigraphic top of this sequence is considered to be north-facing on the basis of the occurrence of graded bedding and scour channels in a unit of basaltic tuff located near map coordinates 5E, 4N (Fig. GS-15-2), The sequence has been intruded by quartz-feldspar porphyry and granitic dikes presumably related to the quartz diorite intrusion mapped to the south (Unit 16a, Gilbert, **et al.,** 1980). The occurrence of NSS to SS mineralization within a rock sequence that is host to the Agassiz-Arbour Lake gradiometric anomaly indicates that exhalative activity producing stratabound sulphides was not restricted to the vicinity of the Agassiz deposit. Furthermore. results of diamond drilling in the area of the NSS to SS occurrence by Rock Ore Exploration and Development Ltd. and geological mapping by Manitoba Mineral Resources Ltd. have indicated the presence of a rock unit that is texturally and mineralogically similar to the “picrite” at the Agassiz deposit. Currently, rock analyses have been undertaken to determine whether the Arbour Lake “picrite” is chemically similar to the Agassiz picrite.

The occurrence of (i) oxide facies iron formation, NSS toSS mineralization, and a picritic unit at Arbour Lake, and (ii) a magnetic siliceous chert at Minton Lake, as well as the association of these rocks with a coincident electromagnetic and magnetic anomaly that extends from west of the Agassiz deposit to the northwest shore of Arbour Lake suggest that:

1) this stratigraphic rock sequence persists over an extensive strike length of 12 km;
2) exhalative activity at this stratigraphic level has resulted in the deposition of chemical sedimentary rocks including NSS to SS that is in part gold-bearing;
3) the potential for repetitions of Agassiz-type stratabound and stratiform gold mineralization along this stratigraphic interval is high.

The Agassiz-Arbour Lake magnetic trend is truncated to the east of Arbour Lake by a granitic intrusion; however, the anomaly reappears north of Bob Lake and Pill Lake (Map GP80-1-2, Gilbert, **et al.,** 1980) and extends as far east as Key Lake where there is an associated pyrite-chalcopyrite occurrence. The potential for gold mineralization along this magnetic trend, therefore, is not limited to the Agassiz-Arbour Lake segment but extends both to the west of the Agassiz deposit and to the east of Arbour Lake.

BIOGEOCHEMICAL STUDIES

As a supplement to ongoing bedrock geochemical studies at the Agassiz deposit (Fedikow and Gale, 1982) and in an attempt to provide the mineral industry with a suitable geochemical exploration tool for Agassiz-type mineralization in terrane characterized by a lack of outcrop a program of biogeochemical sampling was undertaken. A total of 435 samples of black spruce **(Picea mariana)** and labrador tea **(Ledum groenlandicum)** were collected at 3 m sample intervals from 12 sampling lines oriented perpendicular to the strike of the east, central and west zones comprising the Agassiz deposit (Fig.GS-15-4). At each sampling site 5 labrador tea bushes or black spruce trees up to 10 m on either side of the sampling line were collected and bulked to give one sample. First-year growth from the black spruce trees was discarded and the remainder air dried. For the purposes of an orientation study to determine which parts of the black spruce or labrador tea are the most effective indicators of mineralization on the basis of their trace element content black spruce needles and twigs and labrador tea leaves and twigs will be analyzed separately. In addition to the biogeochemical samples 29 samples of humified peat were collected along a single line over the central zone of the deposit (Fig.GS-15-4). These samples along with approximately 90 biogeochemical samples from the same sampling line form the basis forthe orientation survey. Table GS-15-1 summarizes all of the relevant sampling information. Due to the expected low levels of trace element concentration in these sampling media the technique of neutron activation was selected for the analysis of Au, As, Sb and Zn. At the time of writing no analytical results are available. Upon completion of the analyses the results and interpretations will be made available to the general public by way of a mineral deposit open file. In addition, a study to determine the usefulness of permafrost peat bog sampling in defining geochemically anomalous areas has been commenced. This program was undertaken in association with the Geological Survey of Canada and preliminary results are discussed by Nielsen (1983).

TABLE GS-15-1
SUMMARY OF BIOGEOCHEMICAL AND SOIL SAMPLES COLLECTED AT THE AGASSIZ Au-Ag DEPOSIT, LYNN LAKE.

SAMPLING MEDIUM	NO.OF SAMPLE LINES	NO.OF SAMPLES	SA. SPACING	SA. LOCATION
Black Spruce *(Picea mariana)*	12	368	3m	East. Central and West Zones
Labrador Tea *(Ledum groenlandicum)*	2	67	3m	West and Central Zones
Humified Peat		29	3m	Central Zone

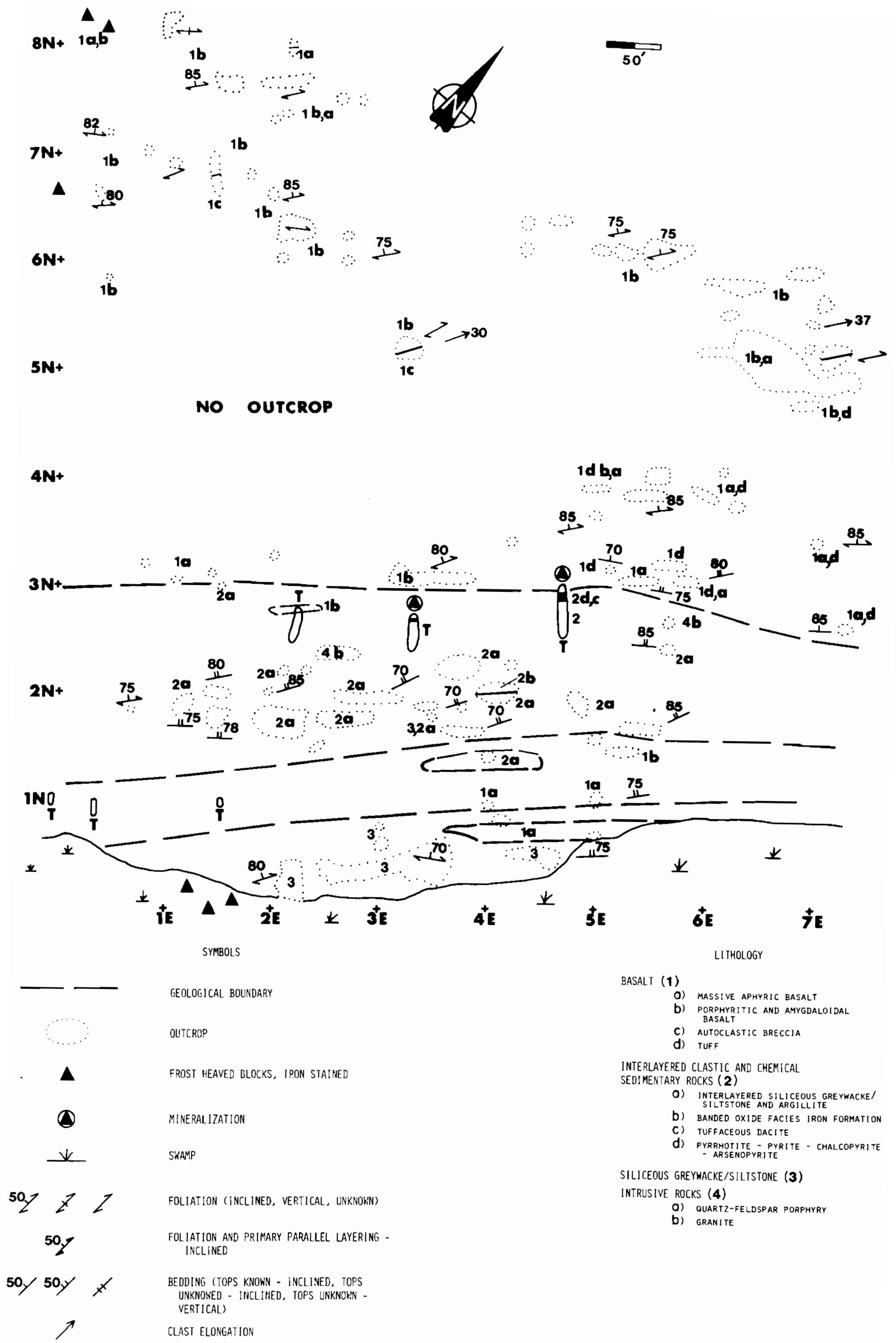

Figure GS-15-2: Geology of the NSS-SS Occurrence, Arbour Lake.

OTHER OCCURRENCES IN THE ARBOUR LAKE AREA

A pyrite occurrence mapped by Gilbert, et al. (1980) occurs at the boundary of a quartz diorite intrusion (Unit 16a) and variable basaltic rocks (Unit 4a, c; Map GP80-1-2). This locality is south of the NSS-SS mineralization discussed earlier. The occurrence consists of a chalcopyrite- pyrite- sphalerite-bearing quartz vein within an intensely iron stained quartz diorite. Trenches on the quartz vein and associated iron stained host rocks were mapped and samples collected for assay. Alluvium cover is extensive in the area.

A pyrite occurrence noted by Gilbert et al. (1980) on geological map GP80-1-2 occurs approximately 2 km north of the NSS-SS mineralization discussed earlier. The occurrence is marked by a laterally extensive (700 m) and vertically extensive (150 m) zone of iron staining within a unit of alternating greywacke, amphibolite-biotite-chlorite layers and porphyritic basalt. The geologic setting is similar to the aforementioned NSS-SS mineralization. The rusty-weathered nature of the rocks is due to disseminated pyrrhotite and pyrite. Assay samples have been collected from this zone and the results will be presented in a mineral deposit open file.

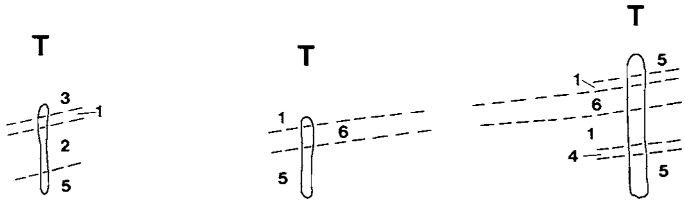

Figure GS-15-3:

Detailed Trench Geology Map of the NSS-SS Occurrence, Arbour Lake.

Units are as follows: 1 - tuffaceous dacite with minor pyrite and chalcopyrite; 2 - interlayered siltstone/greywacke/argillite with thin 1 cm wisps of magnetite; 3 - porphyritic andesite/basalt; 4 - greywacke; 5 -boulder alluvium; 6 - rear solid-sulphide (NSS) -solid sulphide (SS) pyrrhotite-pyrite-chalcopyrite-arsenopyrite.

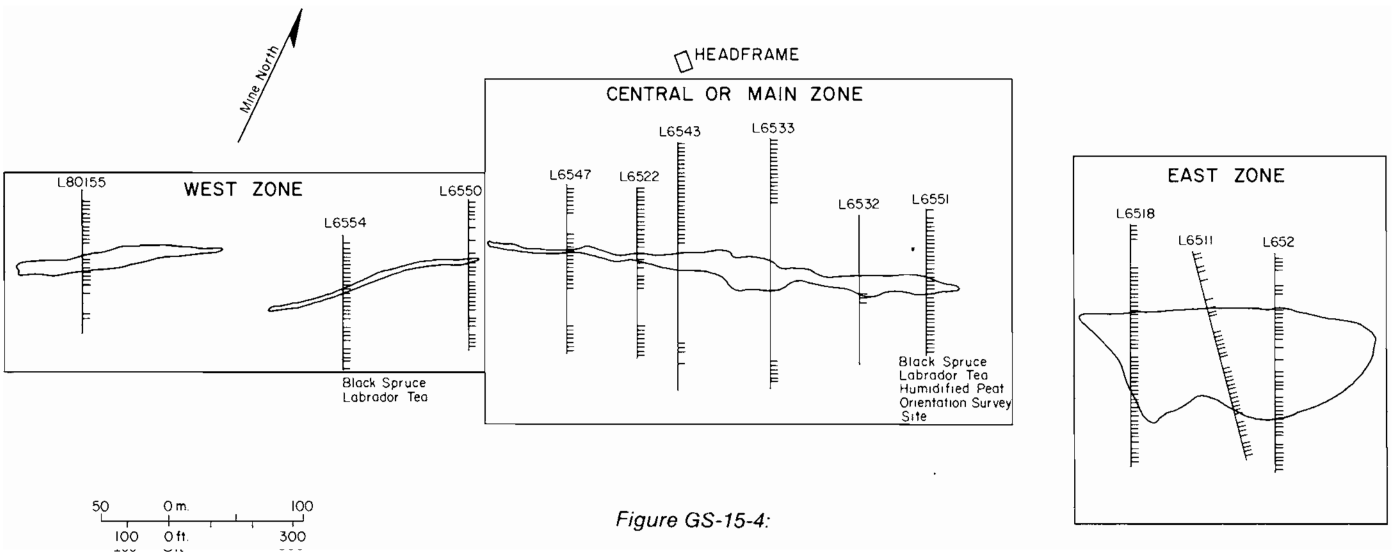

Figure GS-15-4:

Biogeochemical and humus sample location map, Agassiz Au-Ag deposit. Black Spruce (Picea-mariana), Labrador tea (Ledum-groenlandicum) collected from lines L6554 and L6551; humified peat also collected from L6551; black spruce samples only collected from remainder of sample lines. The horizontal bar represents a single sample location on the sampling line.

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GS-16 OVERBURDEN SAMPLING IN THE LYNN LAKE AREA

by Erik Nielsen

An additional 255 holes were dug in the Agassiz Mine-Minton Lake area this year (Fig.GS-16-1) to augment the 95 samples collected last year (Nielsen, 1982) to evaluate the feasibility of using overburden sampling as a method for low cost geochemical exploration. Of the 255 holes dug, 38 holes resulting in (65samples) were put down in an approximately 28000 m^2 area on, and immediately down ice from the ore zone of the Agassiz deposit (Fig.GS-16-2). Most of the remaining holes were dug to the east of the area sampled last year.

QUATERNARY STRATIGRAPHY

The stratigraphy of the surficial sediment is the same as that described for the area last year, namely lee-side till overlain by deep-water clay and littoral sand and gravel deposited in Lake Agassiz. In an estimated 50% of the holes dug this year there was a pronounced increase in the proportion of gravel with depth (Fig.GS-16-3). In many instances the coarse fraction and the matrix were comparatively well sorted. The sorting and the normal grading suggests that a great deal of the so-called till in the region was deposited as debris flows. The instantaneous transgression of Lake Agassiz with ice retreat means the debris flows were deposited subaqueously. It is not known how far the debris flows travelled before coming to rest. Presently it is assumed that the debris flows are of relatively limited areal extent and that they are chemically representative of the basal till in the immediate area.

SAMPLING

Sampling was restricted to hand dug holes because the extensive swampy terrain did not permit the use of a backhoe. The holes were generally between 90 and 120 cm deep and every effort was made to obtain fresh unoxidized material. An estimated 7 - 9 kg sample was collected from each hole. The samples are being processed in the manner proposed last year although heavy liquids, S.G.2.96, are used instead of the magnetic separator, which was found to be ineffective.

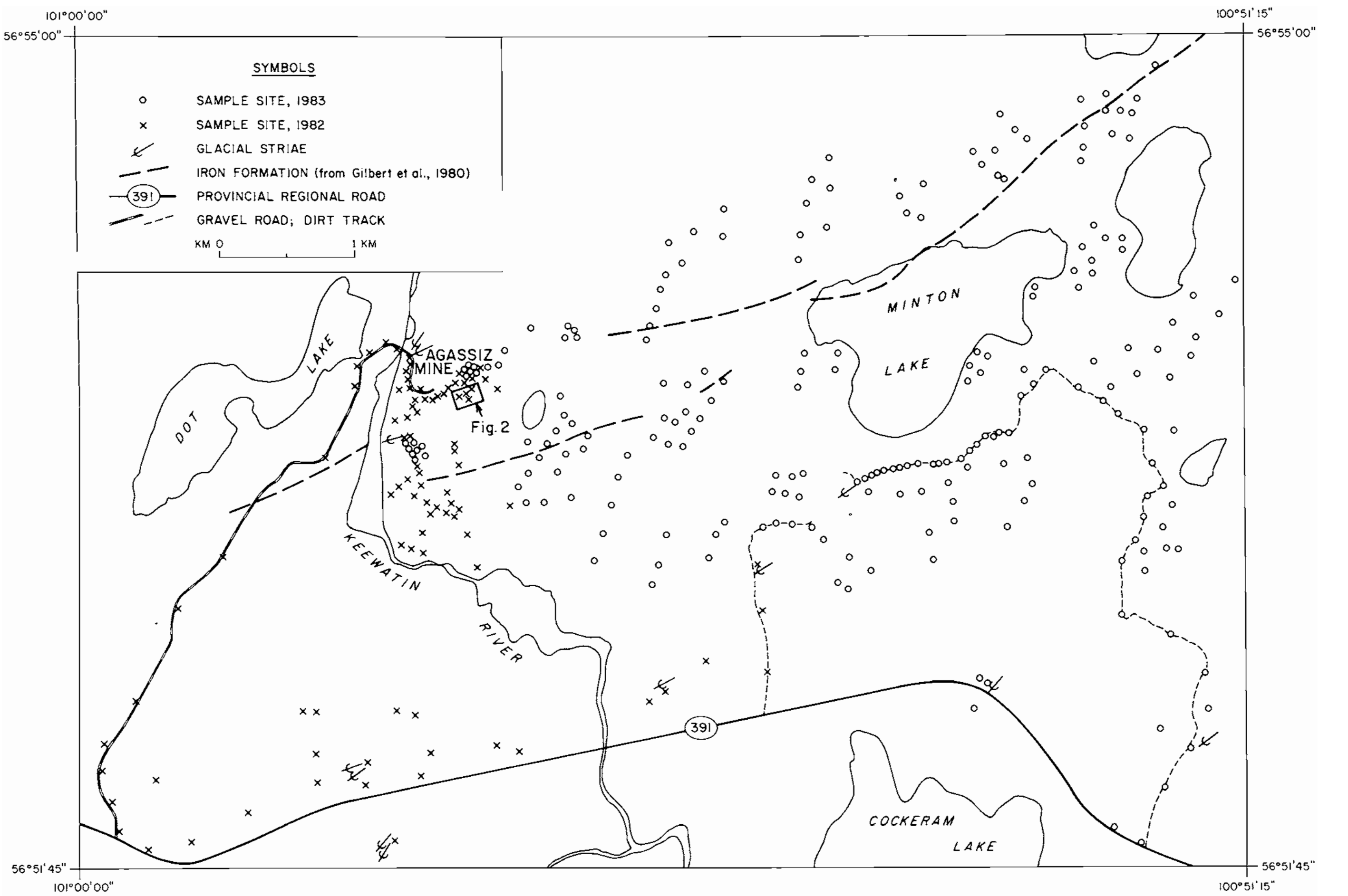

Figure GS-16-1: Location of samples collected and surficial geology of the Minton Lake area.

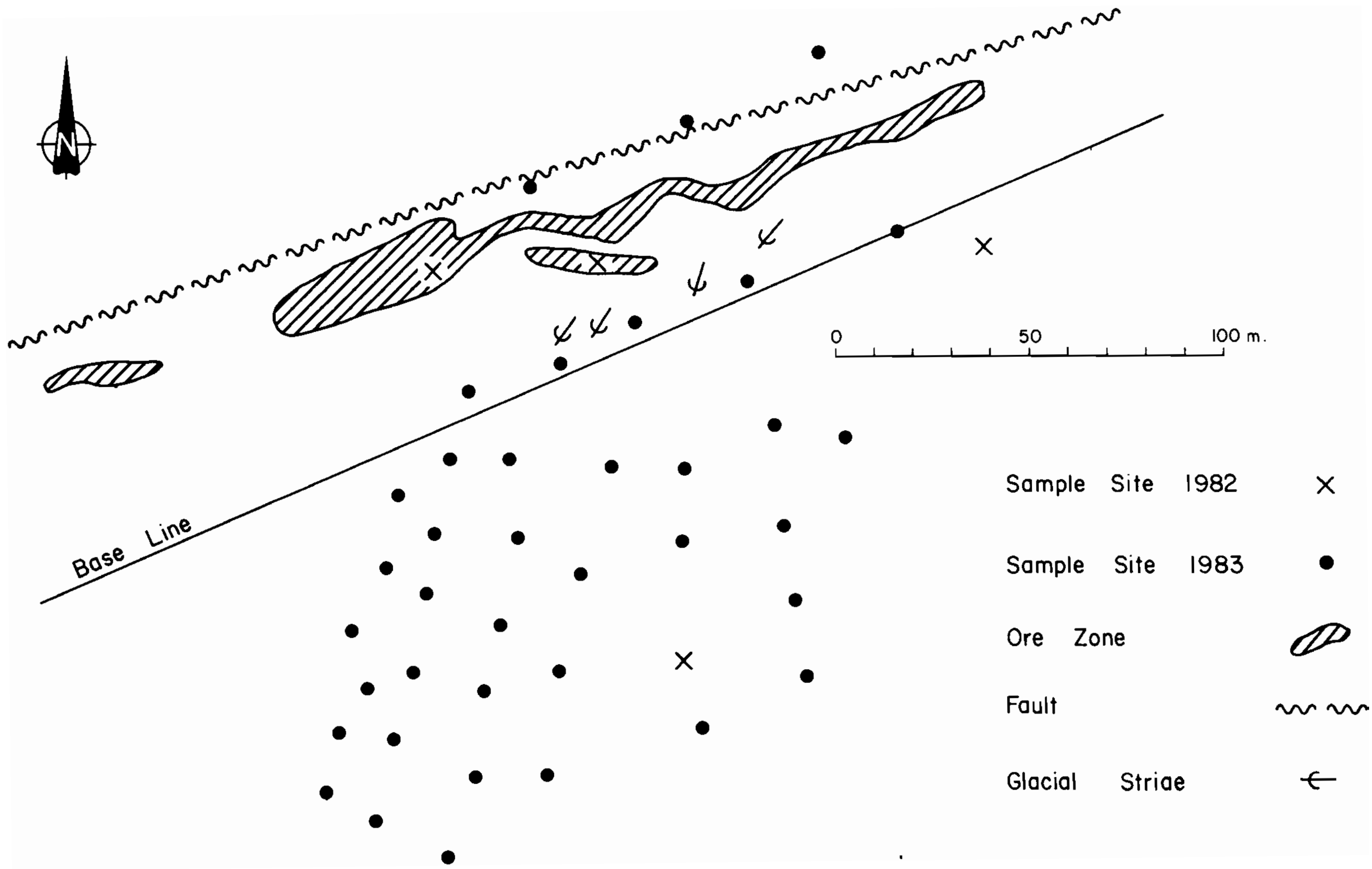

Figure GS-16-2: Location of samples collected in the Agassiz Mine area.

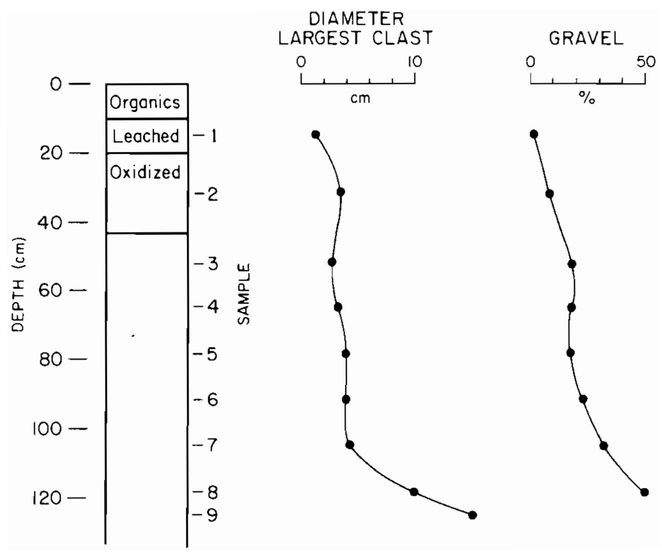

Figure GS-16-3: Textural variation through a debris flow at site 142.

The heavy mineral concentrate, and a representative fraction of material less than 2 microns, will be analysed for Cu, Pb, Zn, Co, Ni, Cr, Mn, Fe, Mo, U, Hg, Ag, Au, As, W, and Sb.

ADDITIONAL STUDY

To augment the biogeochemical studies conducted in this area by Mark Fedikow (Fedikow 1983) seven cores of frozen peat, resulting in 40 samples were collected in the sphagnum bog located to the south of the Agassiz ore zone (Fig.GS-16-4). The cores which varied between 0.5m and 2m in length were taken with a CRREL frozen peat corer.

The peat samples will be analysed for gold and associated trace elements to ascertain if frozen sphagnum is a useful exploration medium in this area.

ACKNOWLEDGEMENTS

I would like to thank Ron DiLabio of the Geological Survey of Canada for supplying the CRREL peat corer and for concentrating the less than 2 micron fraction of the till samples.

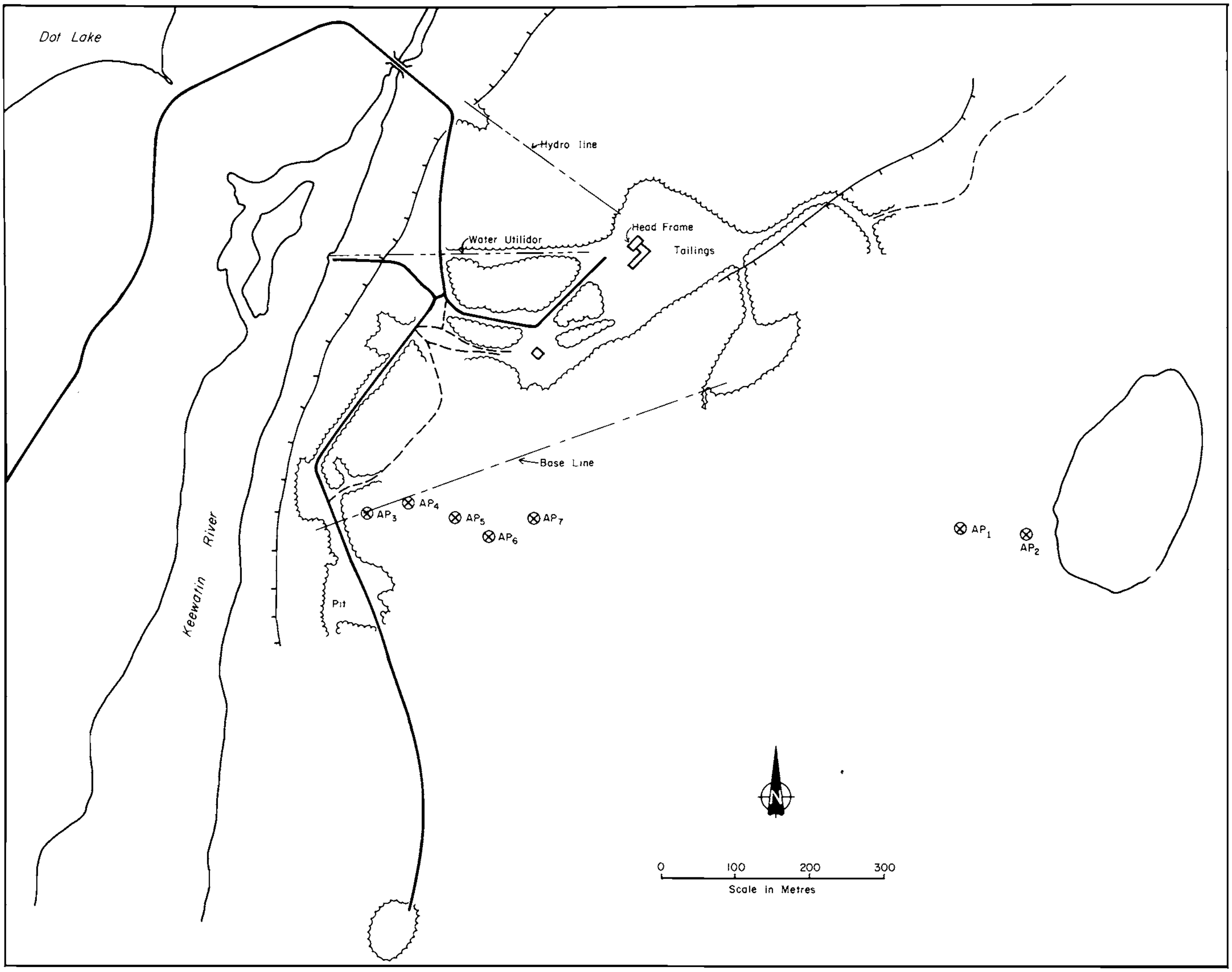

Figure GS-16-4: Location of peat cores.

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GS-17 GEOLOGY OF GOLD ENVIRONMENTS

IN THE BISSETT/WALLACE

LAKE PORTION OF THE RICE LAKE

GREENSTONE BELT

by Peter Theyer

INTRODUCTION

Mineral deposit studies included a study of the geology of the San Antonio Gold Mine at Bissett. Detailed geological mapping of the twenty-sixth mine level was complemented by sampling and brief examination of other mine levels in order to determine the nature of the host rocks to the gold bearing quartz veins in this deposit. In the Wallace Lake area the sequence of rocks containing gold and copper mineralization was determined to be of exhalative origin and to have a strike length of at least 20 km. Investigations in the area of the Jeep mine and, the Johnson gold occurrence have led to a tentative reinterpretation of the origin of the host rocks to these two gold occurrences that are now considered to be situated within the same stratigraphic unit. The host rocks to these gold occurrences are probably continuous along strike to the Vanson gold deposit in the west and to Beresford Lake in the southeast.

SAN ANTONIO GOLD MINE

Geological studies were undertaken at the San Antonio Gold Mine (Fig.GS-17-1) to determine:

1. The composition of the host rock to the gold-bearing quartz veins and its stratigraphic relationship to adjacent rock units; and
2. The nature of the alteration associated with the gold-bearing quartz veins.

This report deals with the first part of the study. It is based on detailed mapping of the twenty-sixth mine level and on brief examination of selected parts of the third. sixth, eighth and thirty-second levels. The second part of the study is reported by Fedikow (1983).

HISTORICAL BACKGROUND

The host rocks to most of the quartz veins in the San Antonio Mine have been described as “basalt, (intrusive)” (Geol. plan 3rd level dated 1933, anonymous author) as “meta-diabase” or as “diabase” (Stockwell 1938) or more recently as “diabase sill” (Stephenson 1971). It was generally assumed that the gold bearing quartz veins were contained within a diabase sill. The quartz veins were considered to occur along faults in which the orientations were controlled by the response of the sill to tectonic stress. One portion of the sill in the San Antonio Mine (the “diabase bulge” - mine terminology) was considered to be intrinsically related to the location of the gold bearing quartz veins.

GEOLOGICAL STUDIES

Several rock types are contained in the rock unit formerly classified as “diabase”. The majority of the rocks are homogeneous, massive, dense, fine grained dark to grey-black in colour and contain abundant small (0.5mm-1.0 mm) generally buff coloured (carbonate?) minerals. This rock is interpreted to be a mafic volcanic flow (basalt?). These flow rocks grade into layered mafic tuff, magnetite bearing mafic tuff and magnetite + sericite bearing mafic tuff. Magnetite bearing tuffs can be banded or mottled. Other rocks comprising the “diabase” are intermediate tuff (dacite?), and felsic tuff (rhyolite?). Only a very minor portion of this volcanic rock sequence exhibits an ophitic texture and these rocks are now considered to be volcanic flow rocks. The volcanic rock sequence formerly referred to as the “diabase” will henceforth be called the San Antonio Mine (SAM) unit.

The structural base of the SAM unit is a cream to buff coloured (bleached?) quartz-sericite schist that was observed on all mine levels visited. The structural top of the SAM unit is less obvious since it consists of felsic detrital rocks containing interlayers of felsic tuff, and minor amounts of slate. Metamorphosed quartz pebble conglomerate and quartzite, containing epidote and rare fuchsite overlie the SAM unit. Similar rocks were mapped in outcroppings as San Antonio Formation and were considered to be much younger in age (Weber 1971, Map 71-1/4).

Mapping on the twenty-sixth level revealed that mafic volcanic rocks (unit A) similar to those of the SAM unit are present outside the SAM unit (Fig.GS-17-2). These rocks are separated from the SAM unit by coarse- to fine-grained felsic fragmental tuff, intermediate tuff, carbonaceous slate and minor chert. The unit A rocks, suspected to be a repetition of the SAM unit were also observed in surface exposures on Rice Lake (Fig.GS-17-1) and could be the result of tight folding; there is no evidence of major faulting in the area.

The volcanic nature of the SAM unit implies a stratigraphic control in its position. The SAM unit is represented by a highly altered sequence of rocks that outcrop on the eastern shore of Rice Lake (Fig.GS-17-1). These rocks were traced in an east-northeast direction from Rice Lake for a distance of approximately 4 km (Fig.GS-17-1). Excellent exposures of the SAM unit occur along a hydro power line northeast of the mine where approximately 200 m thickness is equivalent to that of the SAM unit in the San Antonio mine. Rocks that are equivalent to the “footwall schists” of the San Antonio Mine are found in this location at the southern edge of the SAM unit. Detrital sedimentary rocks equivalent to those overlying the SAM unit in the San Antonio Mine also occur on the north side of the SAM unit east of Rice Lake (Fig.GS-17-1).

The SAM unit is sericitized, silicified, carbonatized and pyritized. Intense pyritization and carbonatization occur locally in the eastern extension of the SAM unit (Fig.GS-17-1). The southern edge of the carbonatization halo occurs in close proximity to the location of the Independence gold occurrence (Fig.GS-17-1). The extension of the SAM unit west of the San Antonio Mine has not been investigated during this study.

GOLD ENVIRONMENTS OF THE WALLACE LAKE AREA

Geological studies of the Wallace Lake area focussed on defining the host rocks and genesis of known gold showings. The search for stratabound gold deposits was emphasized in view of the abundance of chert, iron formation and carbonate mapped in this area (McRitchie 1971, Map 71-1/6). A sequence of stratabound rocks including iron formation, ferruginous sedimentary rocks, chert, carbonate, greywacke, arkose, slate and spinifex textured (extrusive?) ultramafic rock was delineated as the host to the Conley, the Gatlan and other gold occurrences.

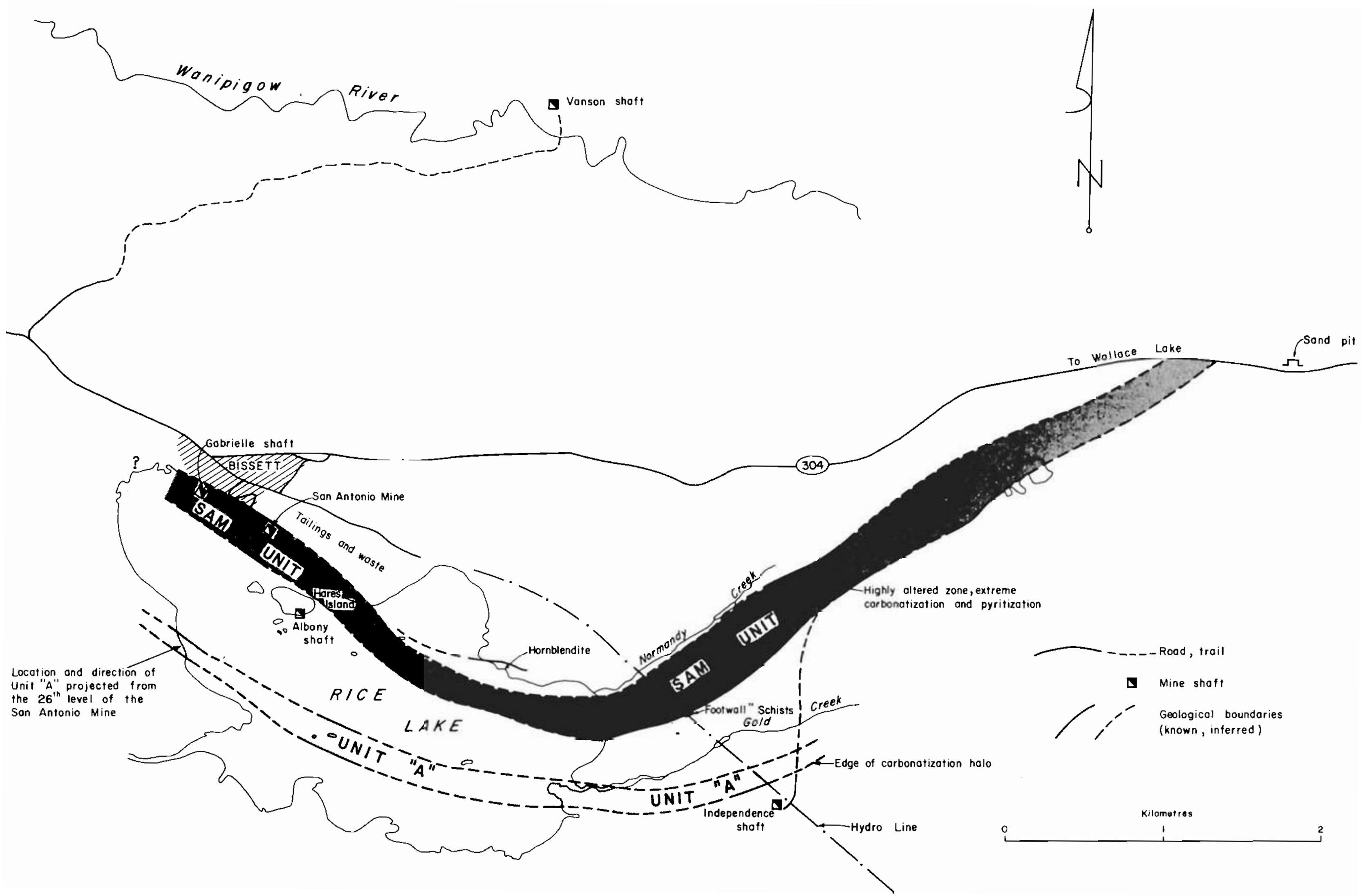

Figure GS-17-1: *Geological map of the Rice Lake area showing the location of the SAM Unit and Unit* A.

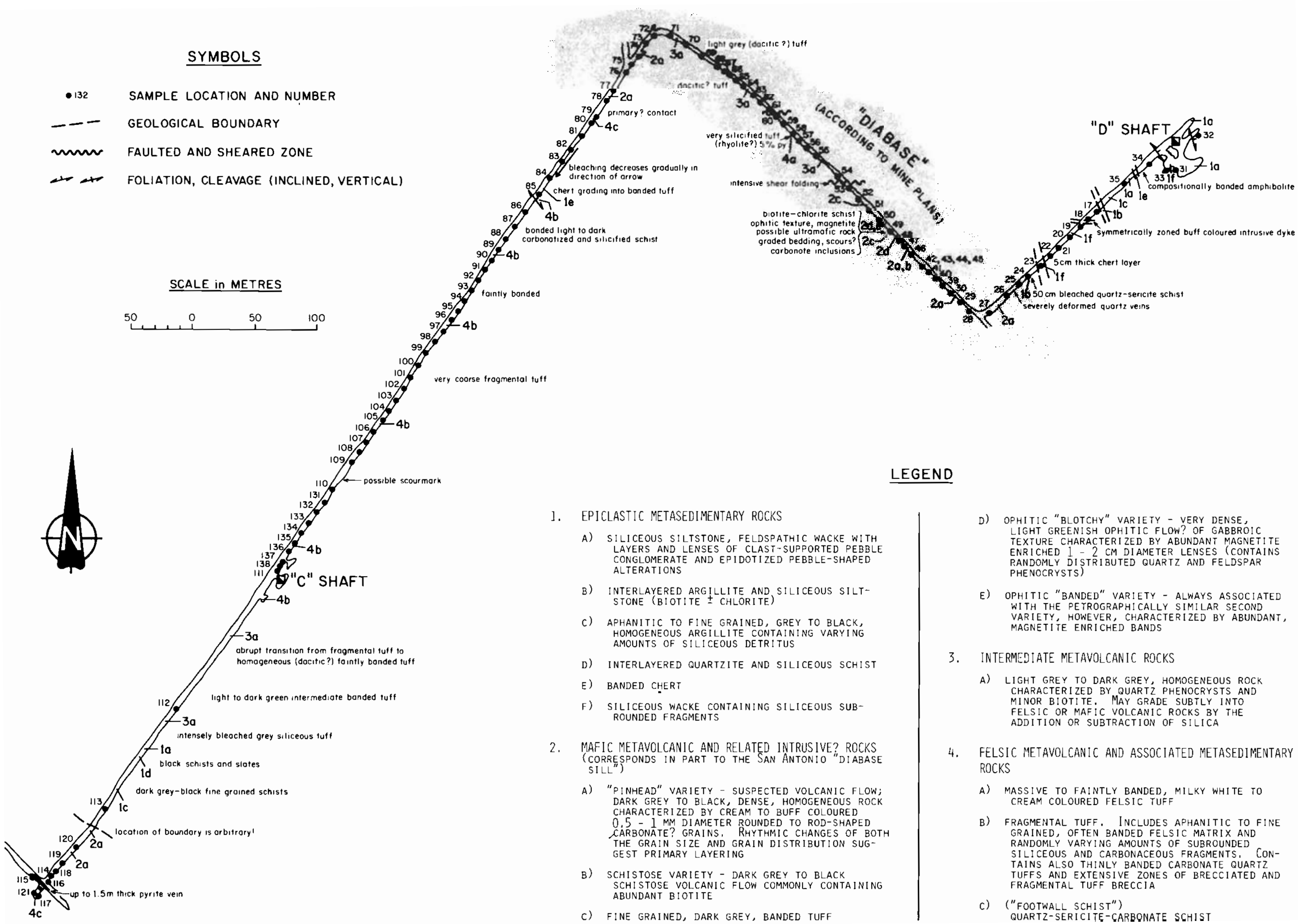

Figure GS-17-2: Geological map of the 26th mine level, San Antonio Mine.

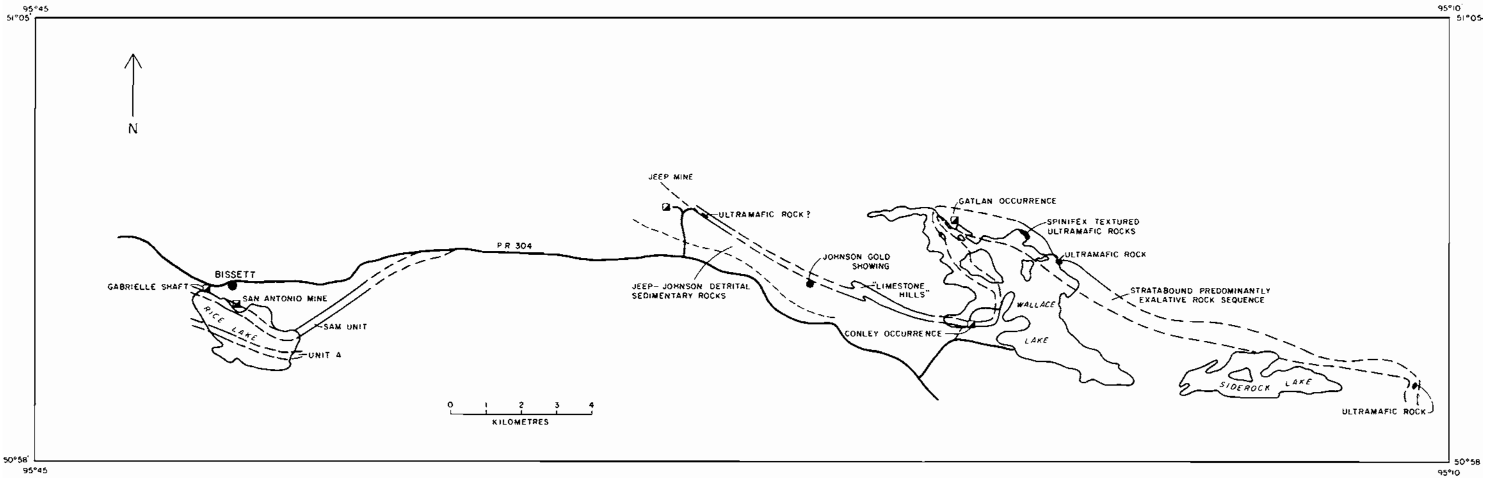

Figure GS-17-3: Geological map of the Rice Lake-Siderock Lake area.

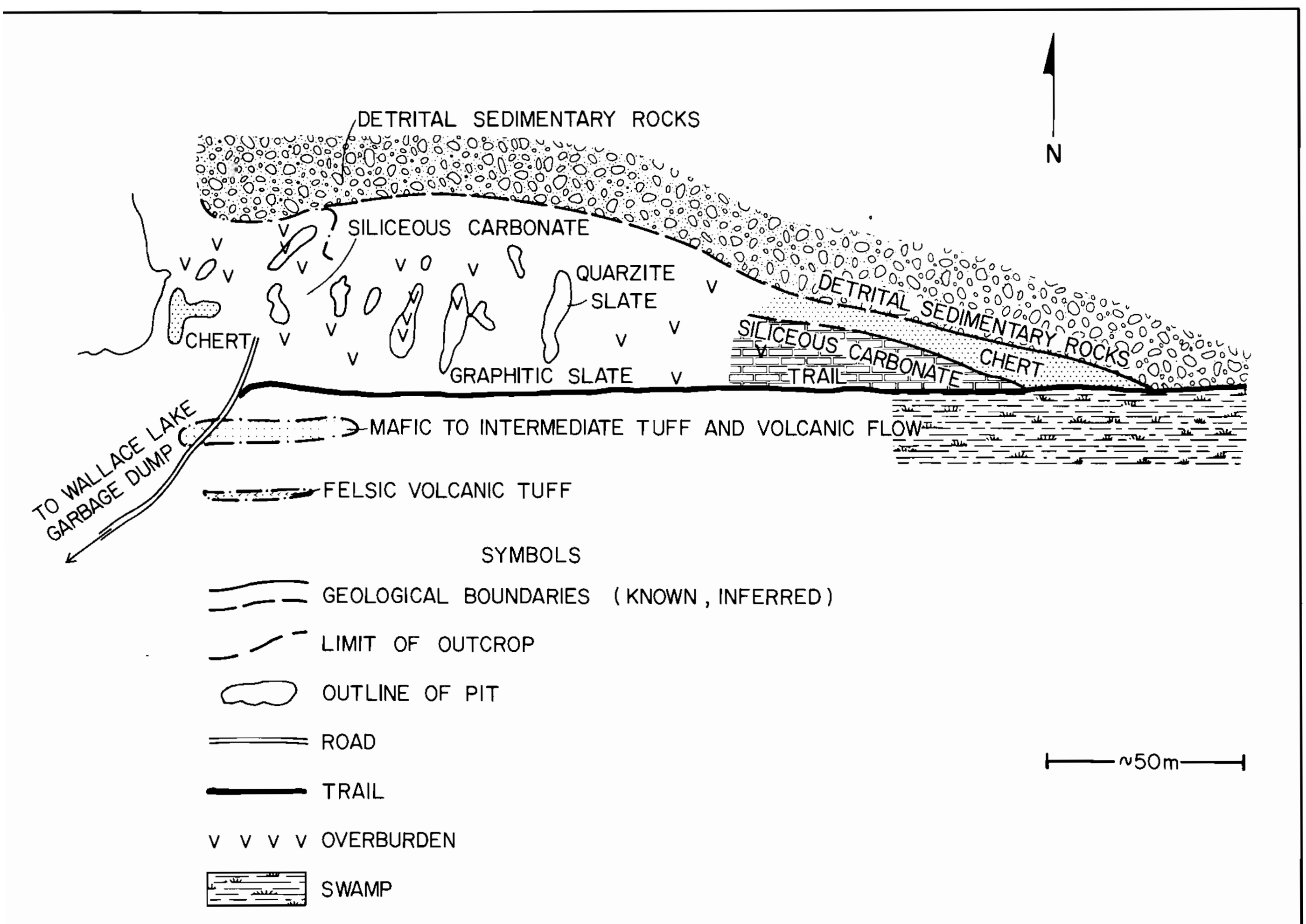

Figure GS-17-4: Geological sketch map of the Conley gold showing.

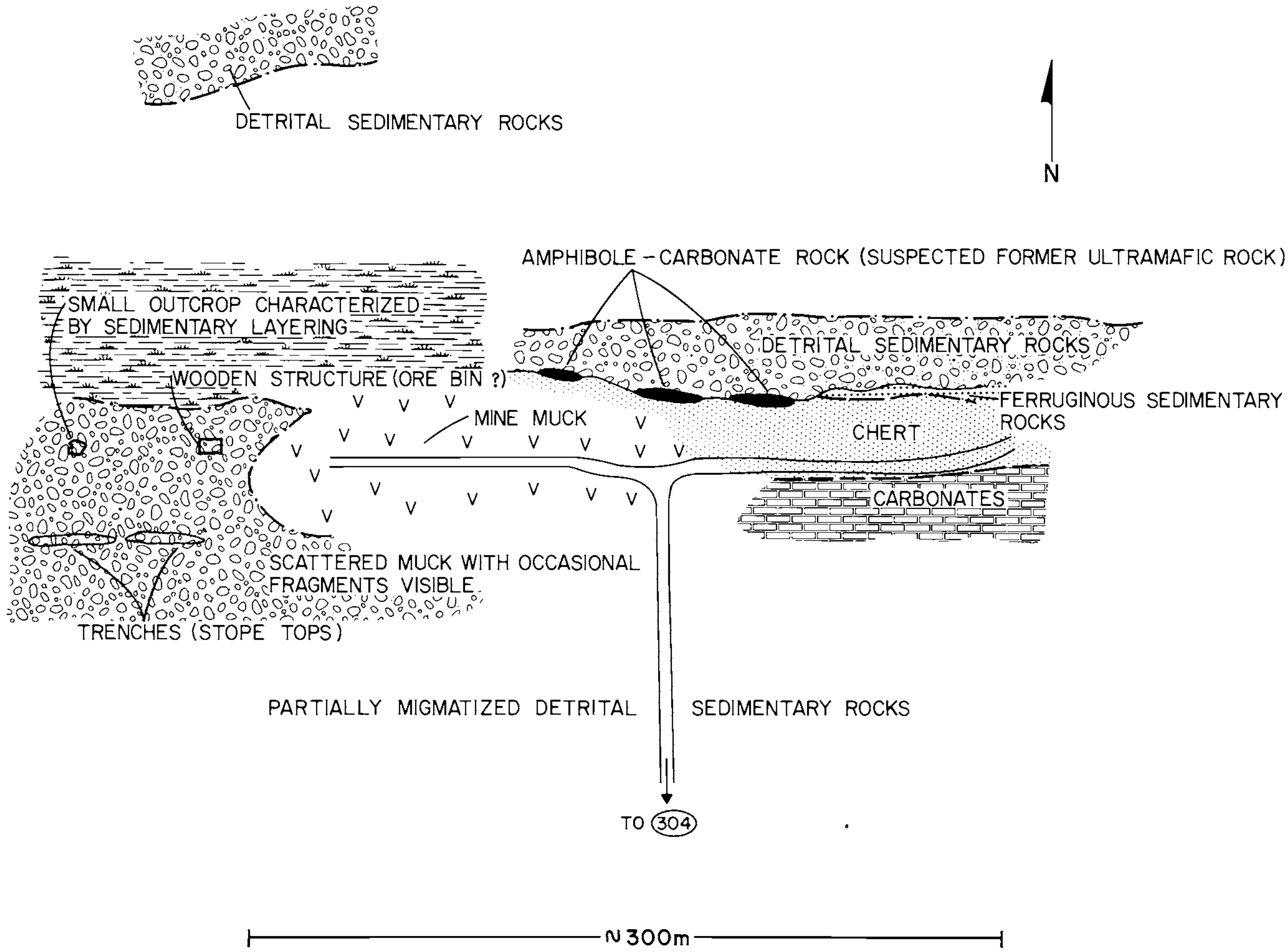

Figure GS-17-5: Geological sketch map of the Jeep Mine area.

STRATABOUND GOLD MINERALIZATION

The Conley occurrence is exposed in a group of pits and trenches cross cutting a sequence of rocks characterized by ferruginous sedimentary rocks, chert, greywacke, black slate, chert and carbonate (Fig.GS-17-4). Minor amounts of chalcopyrite, azurite, and malachite are present. Sphalerite and galena have been reported (WConley pers. comm. 1983). however, the author was unable to confirm the existence of these minerals. Assays of material from this showing indicate minor amounts of gold mineralization (Fedikow 1981).

Rocks immediately south of the Conley occurrence consist of interlayered mafic, intermediate and minor felsic volcanic rocks that are characterized by a local recrystallization to a gabbroic textured rock. Rocks adjoining the north of the Conley occurrence appear to be felsic detrital sedimentary rocks containing conglomerate, grit and chert layers. The rock sequence hosting the Conley occurrence, characterized by predominantly exhalative rocks underlain by mafic to felsic volcanic rocks, and overlain by sedimentary rocks, can be traced eastwards from the Conley pit to Wallace Lake and to Siderock Lake (Fig.GS-17-3). The western extension of these rocks is exposed in several locations e.g. in an area known locally as "Limestone Hills" (Fig.GS-17-3). This rock sequence was also found approximately 300 m east of the Jeep mine (Fig.GS-17-5).

Ultramafic rocks occur in at least three localities within this sequence. Spinifex textures, found in a previously unknown ultramafic on Wallace Lake (Fig.GS-17-3), are strong evidence that this ultramafic occurrence may be extrusive. Other ultramafic rock occurrences located at this stratigraphic level appear to be stratabound and thus are probably of extrusive origin. In the Island Lake area ultramafic rocks of probably extrusive origin are also associated with a gold-bearing sequence of sedimentary rocks, including rocks of exhalative origin that are also underlain by a volcanic rock sequence and overlain by coarse clastic sedimentary rocks (Theyer 1980, 1981, 1982 and in prep.).

GEOLOGY OF THE JEEP MINE AND JOHNSON OCCURRENCE

The host rocks to the Jeep gold mine have been recorded as gabbro (Weber 1971, Map 71-1/4) This gold mine was outstanding due to the high average tenor (26.6 grams/tonne) of the gold ore mined. The host rocks have been reinterpreted as detrital sedimentary rocks that were subjected to varying degrees of migmatization and concomitant recrystallization. Highly migmatized portions of this detrital sequence are locally recrystallized to a rock resembles a homogeneous granite or granodiorite, however, adjacent less migmatized portions still show evidence of a sedimentary origin in the form of clasts and primary layering. The migmatized portions are interlayered with large amounts of less altered detrital sedimentary rocks containing graded bedding, cross bedding, and slump textures.

The stopes of the Jeep mine are located in a highly recrystallized portion of the sedimentary rocks, however, some of the blasted muck and outcrop located approximately 15 m north of the Jeep stopes show faint outlines of fragments and evidence of sedimentary layering (Fig.GS-17-5). The Johnson gold pit (Fig.GS-17-3) is also located at the edge of a highly migmatized portion of the same sequence of rocks. It is proposed that the mineralization of the Jeep mine and of the Johnson pit were formed by migration of gold from the detrital sedimentary rocks, followed by deposition with quartz in nearby fractures. The thermal energy needed for this activity may have been provided by the shallow intrusions that were responsible for the pervasive migmatization of the host rocks. This type and mode of mineralization is expected to occur in other migmatized portions of these sedimentary rocks. Although the extent of the gold-bearing rock sequence has not been completely documented, it is worth noting that similar rocks were mapped within the Edmunds Lake Formation (McRitchie pers. comm. 1983) which can be traced over a large part of the Rice Lake greenstone belt including the southeastern portion in the vicinity of Beresford Lake (Weber 1971, Map 71-1/4).

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GS-18 GEOCHEMICAL STUDIES AT THE SAN ANTONIO GOLD MINE, BISSETT, MANITOBA

by M.A.F. Fedikow

INTRODUCTION

Three weeks were spent working underground at the San Antonio gold mine in Bissett in order to: 1) determine the nature of the diabase host rock for the gold-bearing quartz veins including the chemical composition and internal stratigraphy of the diabase and the stratigraphic relationship with the adjacent rock units; and 2) undertake chemical and mineralogical studies of the geochemical alteration associated with the gold-bearing quartz veins. This preliminary report is concerned solely with the geochemical alteration studies. Preliminary results concerned with study (1) are discussed by Theyer (1983).

GEOCHEMICAL ALTERATION

The introduction of large quantities of silica into fracture systems within the host rocks of the San Antonio gold deposit (Fig. GS-18-1) has resulted in a chemical readjustment or reconstitution of the host rocks adjacent to the veins. This chemical/mineralogical reconstitution is visible as bleached zones or colour changes and/or textural changes. The area of influence of the geochemical alteration can often be extended beyond the "visible" zone by careful thin section, X-ray diffraction, electron microprobe and major and trace element analyses. The determination of the extent of the visible and "invisible" alteration and the speciation of the mineral constituents of these zones adjacent to the gold-bearing quartz veins is the main thrust of these alteration studies.

SAMPLING

The wallrocks adjacent to both 16-type (northeast trending, 50°-60° dipping, quartz sheets) and stockwork veins were sampled for this study. Wallrock samples were generally restricted to within 3 to 5 m of the vein/wall rock contact; however, a drilling program in the mine by Brinco Ltd, will allow the collection of samples at some distance from the mineralized veins. The quartz-sericite schist developed on the footwall side of the diabase was also sampled for analysis and samples of carbonate and vein quartz were collected for mineralogical speciation and fluid inclusion studies, respectively. Table GS-18-1 gives a complete sampling breakdown for the project.

OBSERVATIONS

The following preliminary observations are made with respect to geochemical alteration:

1, Visible wall rock alteration appears to be more intensive and extensive in association with quartz veins located outside of the "diabase sill" (e,g., 304 vein in hanging wall tuffaceous sedimentary rocks where primary permeability and porosity are higher).

2, Visible wallrock alteration associated with stockwork veins appears to be more intensive and extensive than 16-type vein systems.

3, The style or extent of visible alteration in wall rocks of both the 16-type and stockwork veins does not vary with depth.

4, Within the geological boundaries of the "diabase sill" the "diabase" appears in 3 different phases in association with auriferous quartz veins. Colour, mineralogy and rock texture, as well as size, distribution and number of quartz phenocrysts in the "diabase" varies considerably. This variation suggests (i) a composite sill/rock sequence; or (ii) variable styles of alteration that may be related to the mineralizing event and/or metamorphism.

SUMMARY

No analytical results are available at the time of writing. Final interpretations will be based upon thin section studies, chemical analyses and the use of the results of Ph.D. studies conducted by Davies (1963) and Stephenson (1972).

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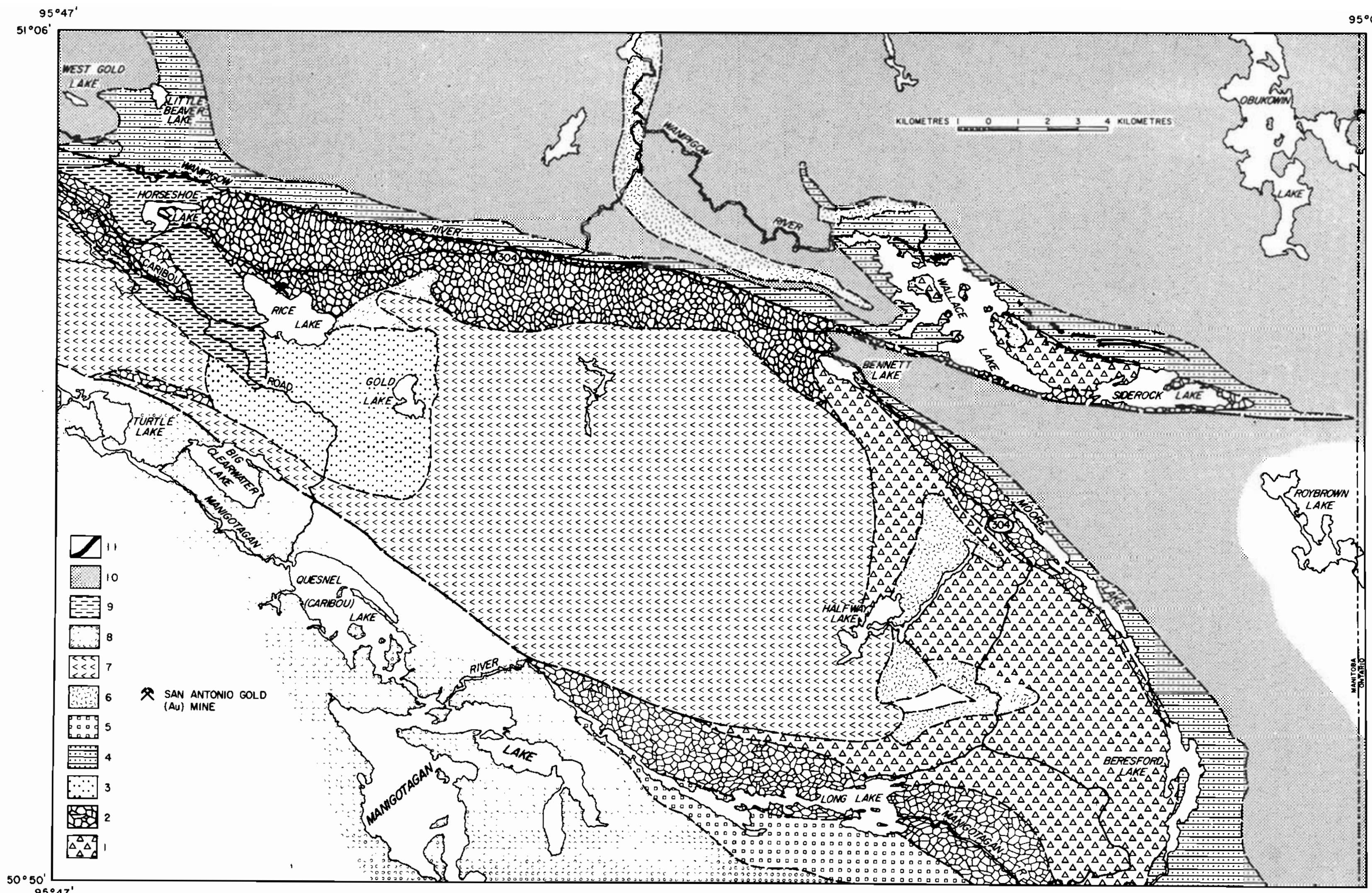

Figure GS-18-1: Location map of the San Antonio Mine and general geology in the Bissett area. Legend as follows: 1. Pillowed and massive basalt, basalt breccia; 2. Tuff breccia, crystal tuff. lapilli tuff and gabbro; 3. Massive and fragmental siliceous volcanic rocks; 4. Argillite with interlayered greywacke, chert and iron formation; 5. Greywacke with minor argillite; 6. Gabbro; 7. Hornblende-quartz diorite and biotite-quartz diorite; 8. Metasedimentary gneisses and schists with tonalite and monzonite intrusive rocks; 9. Arkose with minor slate; 10. Biotite trondhjemite, hornblende-quartz diorite and derived gneiss; 11. Magnetite-chert iron formation. Geology modified from Map 71-1/4 - Project Pioneer.

TABLE GS-18-1
SAMPLING BREAKDOWN FOR THE SAN ANTONIO PROJECT

LEVEL	VEIN: TYPE & LOCATION	NATURE OF SAMPLE: WALL ROCK Alteration/ Mineralogy (#) of Sa.	QUARTZ VEIN Fluid Inclusion/ Mineralogy (#) of Sa.	CARBONATE Speciation (#) of Sa.	COMMENTS/DESCRIPTION
	317 — 16 Type	20	5	—	Black-green fine grained/porphyritic diabase; within sill
3	3-105 — 16 Type	6	—	1	Diabase: within sill
	304 — 16 Type	12	5	—	Hangingwall tuffaceous sedimentary rocks outside of diabase sill; intensive bleaching
4	415 Dr./404 x-c Stockwork	25	5	1	Grey, porphyritic silicified(?) diabase; within sill
	838 S #3 Dr. Stockwork	8	—	1	Fine grained and porphyritic diabase; within sill
8	844 x-c (wallrock)	4	—	1	Fine grained grey-green-black diabase; within sill
	816 Dr. (footwall schist)	12	—	—	Quartz-carbonate-sericite schist with occasional euhedral-subhedral pyrite and rounded quartz eyes; layering with siliceous fragments; may be cut by white quartz-carbonate veins
	838 S. Dr/ 809 x-c	—	—	—	Grey, porphyritic (quartz eyes), diabase; within sill
16	16 x-c (footwall schist)	7	—	—	See 816 Dr.
	26 x-c (footwall schist)	8	—	—	See 816 Dr.
	26 x-c	4	—	1	Diabase-hosted quartz-carbonate vein
	26 x-c	4	—	—	Quartz-carbonate veins in hangingwall sedimentary rocks
	3293 — 16 Type	10	—	1	Black-grey fine/medium grained diabase with sedimentary sections (quartz porphyry); within sill
32	3202 x-c Stockwork	10	—	—	Black-grey fine/medium grained diabase; within sill
	3298 — Stockwork (muck)	3	—	—	Green-black-grey (altered) diabase; within sill
	3393 — 16 type	12	—	—	Black, fine grained diabase; within sill
33	3397 Stockwork	4	5	—	Samples from within stockwork breccia zones; within diabase sill

GS-19 PLATINUM GROUP METAL EVALUATION

PROJECT BIRD RIVER SILL

(SOUTHEASTERN MANITOBA)

by Peter Theyer

The Bird River Sill (BRS) is considered to be a potential source of Platinum Group Metals (PGM) (Theyer, 1982). Systematic sampling of the BRS for PGM initiated in 1982 was continued in 1983. A virtually continuous channel sample was cut across the BRS in the vicinity of the "Chrome" claims (Fig.GS-19-1). Cutting was accomplished using portable rock saws, model STIHL 350, mounted on dollies (Fig. GS-19-2). Cutting blades used were TARGET type IL diamond blades. Cooling water was pumped from a local pit and distributed by garden hose.

The thickness of the BRS in the vicinity of the channel cut is approximately 600 m. Eighty metres remain uncut due to the steep slopes on the outcrop of the basal portion of the BRS as well as the very hard rocks towards the top of the BRS. The retrieved samples represent a 400 metre cut. The difference between this measurement and the theoretically possible cut is a result of outcrop discontinuities.

Preliminary studies of the sample portion cut in 1982 showed the existence of several discrete sulphide layers not visible in outcrop. These sulphides, especially those contained in the gabbroic portion of the BRS, are potential collectors and carriers of PGM. The discovery in 1982 of harristic olivine in a part of the ultramafic portion of the sample is of petrological interest. These textures originate by sudden cooling and/or decompression of a magnesia-rich parental magma causing olivine to grow in a skeletal fashion (Donaldson, 1974; 1976). Harristic textures are genetically similar to spinifex textures that have been observed in ultramafic rocks of suspected extrusive nature. It is expected that close scrutiny of the channel sample will result in the discovery of more petrographic details not discernible on weathered rock surface and thus will contribute to the understanding of the genetic history and composition of this intrusion.

Assaying for PGM in portions of the sample containing sulphide and petrological studies will continue in the winter of 1983/84. Detailed stratigraphic studies of the ultramafic portion of the Bird River Sill (Scoates, 1983) have shown that several additional layers are exposed along strike to the west of the cut section. These unsampled lower portions of the Sill will be cut in 1984.

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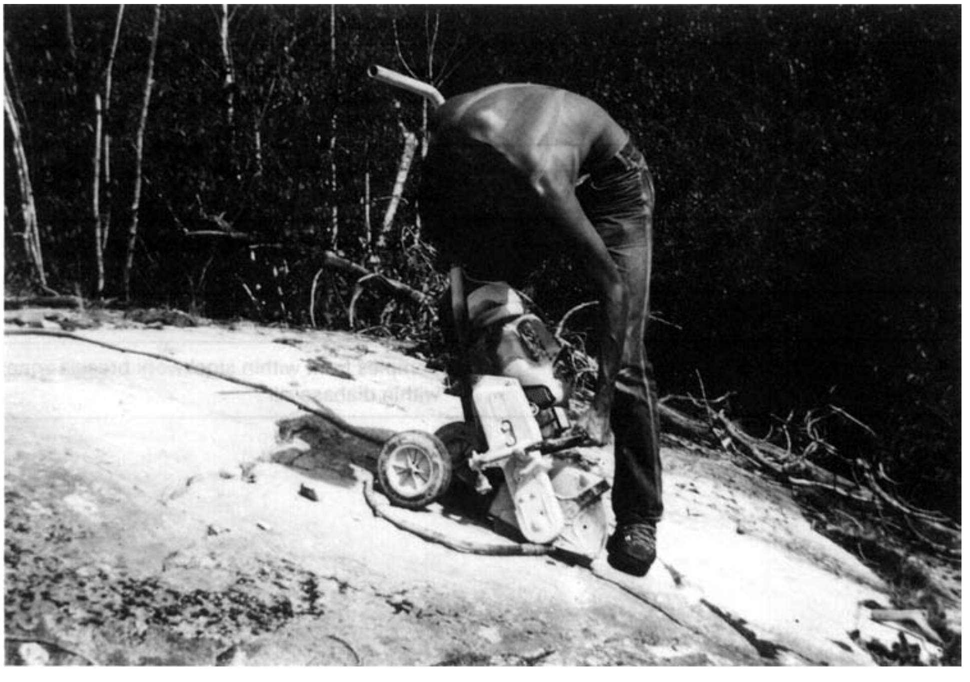

Figure GS-19-2:

Stihl 350 rocksaw on dolly.

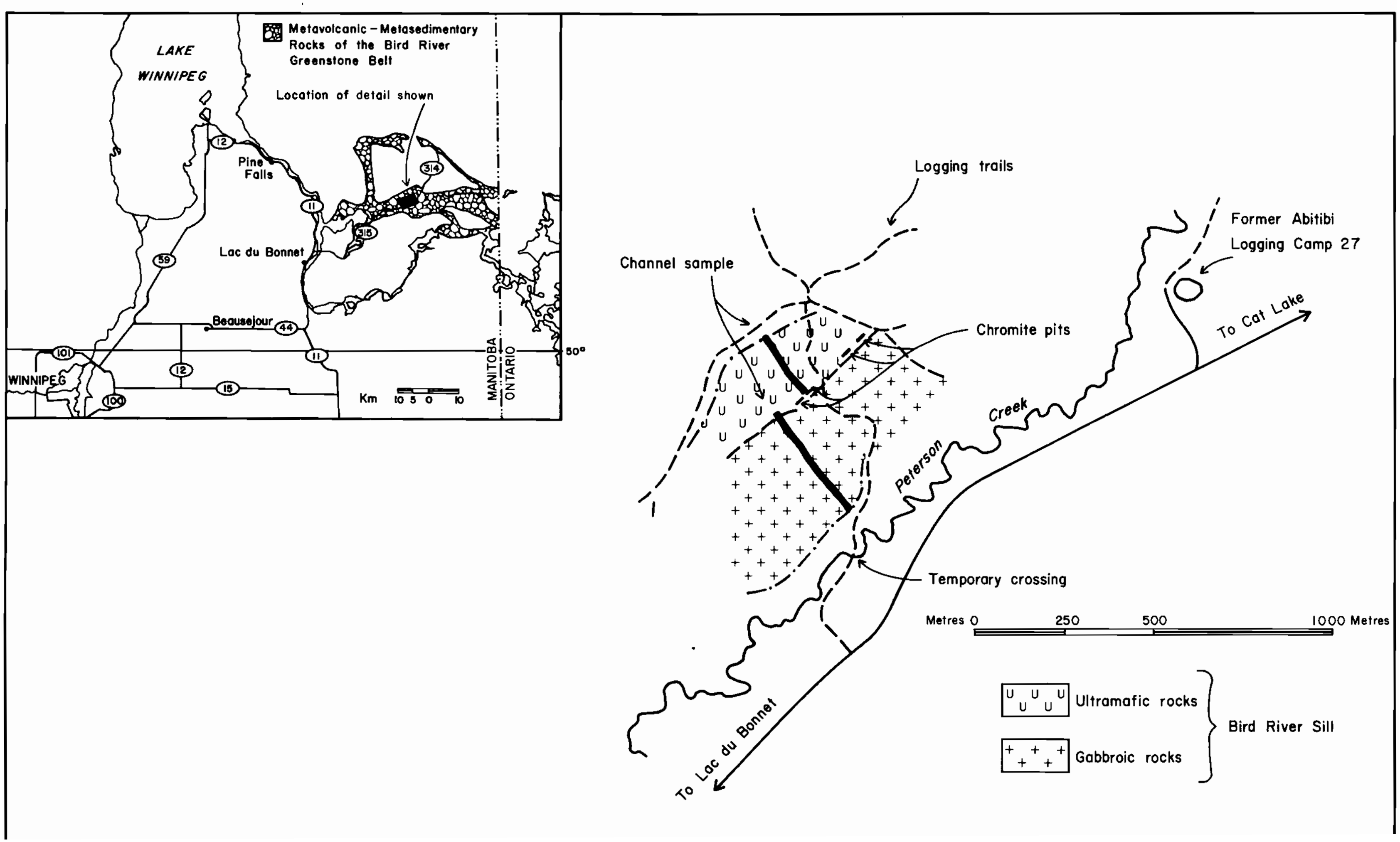

Figure GS-19-1: *Location and outline of channel sample.*

GS-20 THE BIRD RIVER PROJECT:

BACKGROUND AND STATUS

by D.M. Watson

At this time all chrome that is used in Canada, and the rest of North America, comes from overseas (Table GS-20-1). Many of these countries are considered to be politically unstable and in case of internal troubles the supply of chromite to North America users could be cut off. It is desirable then, to have an inventory of potential sources of chromite within our own borders.

Aside from a few smaller deposits of chromite in Appalachian-type deposits in Newfoundland, Quebec and British Columbia, the only substantial deposits of chromite in Canada are found in the Bird River 'Sill' in Manitoba. In addition to chromite, the 'Sill' is also known to contain valuable amounts of platinum, nickel, and copper. It has been explored for various of these metals since the early 1900's, and was the scene of staking and line-cutting operations as recently as this spring.

Little quantitative work has been done on the sill over the last 30 years and accordingly the present project was initiated to obtain firmer tonnage and grade estimates for the various chromite deposits.

PREVIOUS ACTIVITY

Since the initial exploration of the 'Sill' in the early 1900's, the area has been examined for asbestos, chrome, nickel, copper and other elements. At this time there are claims in good standing covering most of the area.

The largest amount of exploration has been on the southern portion of the 'Sill', with the majority of activity in the area of the former Dumbarton Mine. Over the years this area has been covered by numerous grid systems and been tested with various geophysical instruments and by drilling. Many of the other areas of the 'Sill' have also been drilled or tested by geophysics. Much of this information has already been compiled by the Department of Energy and Mines as an Open File Report (OF 82-1). Drill logs are available for some of the drilling that has been done, although with the exception of some of the core from the Dumbarton-Maskwa area, the core has all been lost over the years.

In addition to the Open File Report on Geophysical work (Hosain, 1978), several other government reports cover this area. The most recent of these publications is the Open File Report by Bannatyne and Trueman (1982). While this report is the best compilation to date and covers the entire 'Sill', it makes use of old company reports and deals with the different properties in separate blocks. The lack of correlation between properties in this and other reports is due to the disrupted nature of the geology as well as the difficulty of interpreting company reports.

University geology departments across the country have contributed their share to the knowledge of the 'Sill' geology. Reports (theses, papers and contributions to government reports) range from mineralogy of the chromite (Gait, 1964; Talkington, 1982) to geology of the entire 'Sill' (Trueman, 1972). While these add to the general knowledge of the 'Sill', the interpretation is always subject to new theories and ideas. In addition, these papers tend to be narrow in their scope, and are therefore limited in their usefulness from a reserves-evaluation point of view.

TABLE GS-20-1
CHROMITE IMPORTS – CANADA & U.S.A.

		Chrome Bearing Materials (000 tonnes)	% of Total
Into Canada			
From:	Mozambique	9.2	17.3
	Phillipines	6.2	11.7
	S. Africa	32.9	61.7
	Brazil	4.5	8.4
	W. Germany	0.1	0.2
	Other	0.4	0.7
Total		53.3	100.0
Into United States			
From:	Albania	12.0	2.8
	Brazil	3.0	0.6
	Finland	16.0	3.4
	W. Germany	3.0	0.6
	Phillipines	41.0	8.8
	S. Africa	187.0	61.6
	Sweden	6.0	1.3
	Turkey	19.0	4.1
	USSR	42.0	9.0
	Yugoslavia	26.0	6.6
	Other	10.0	2.3
Totals		465.0	100.0

Figures calculated from Canadian and U.S. government sources.

SCOPE OF THIS PROJECT AND DIVISION OF RESPONSIBILITIES

The need for an assessment of the chromite reserves of the Bird River 'Sill' has already been outlined. In order to do this, available information from company, government and university sources is being compiled and re-evaluated. It is also necessary to examine the rocks in the field in order to be able to correlate the work done on the various blocks. Metallurgical examination of the ores from different properties may be necessary in order to assess the potential for actually using the chromite reserves outlined.

The various segments of the project may be outlined as follows:

1. Compilation of existing reports from various sources (government, university, companies, etc.)
2. Geological mapping and related lab work (analyses, petrology, etc. by government staff).
3. Geophysical surveys and/or drilling to fill in gaps in outcrop areas.
4. Metallurgical examination of samples collected during geological mapping (beneficiation studies).
5. Compilation and assessment of material assembled during 1-4 above.

Current activities entail:

1. Examination of the platinum minerals and their occurrence (Theyer, Report GS-19, this volume).
2. Detailed examination of the Bird River 'Sill' geology, including the ultramafic and gabbroic portions. This study will include detailed examination of individual layers (Scoates, Report GS-12, this volume).
3. Examination of the geology of the rocks immediately above and below the 'Sill' to determine the exact relationships of the 'Sill' rocks to those that are intruded and those that postdate the 'Sill'

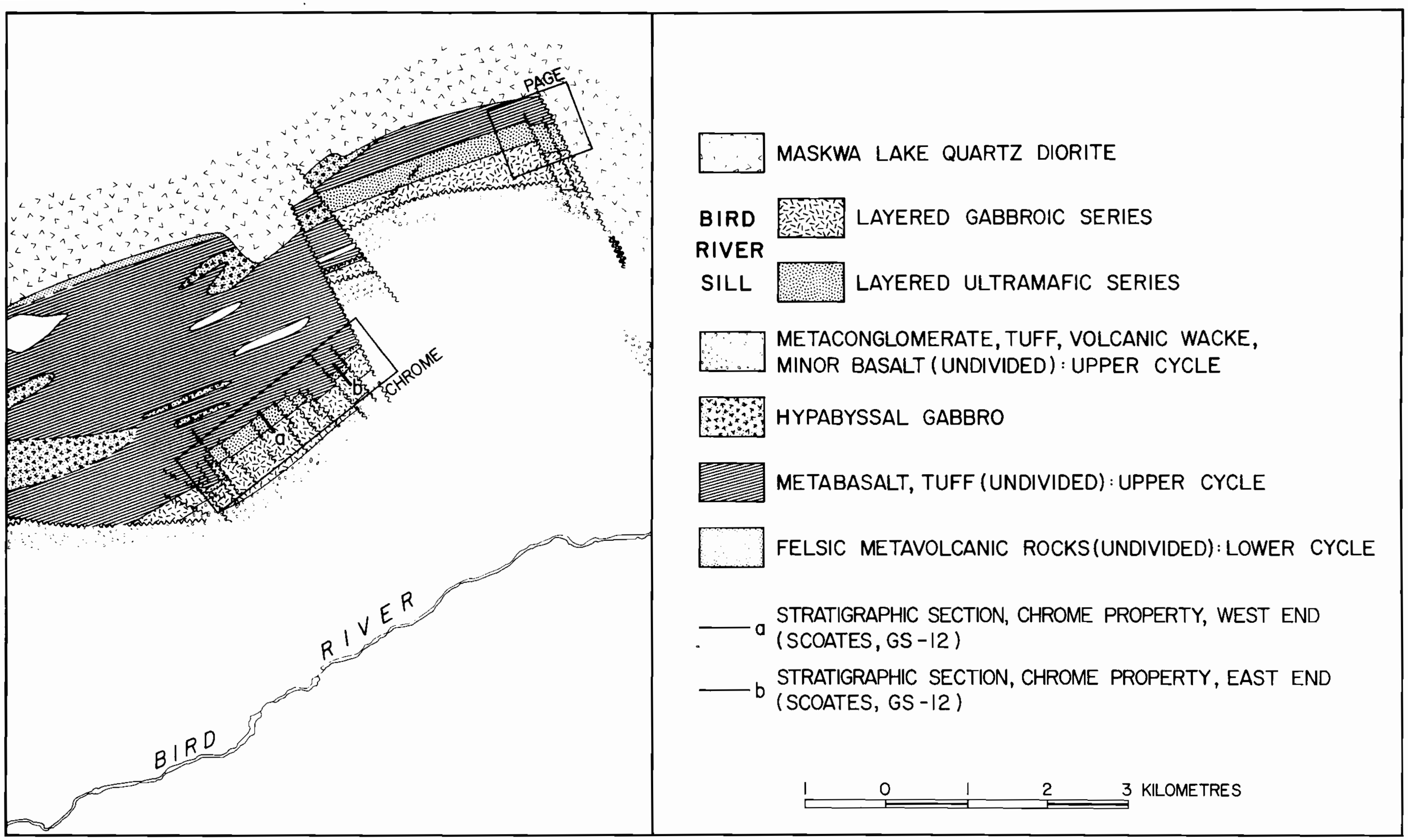

Figure GS-20-1: General geology of the “Chrome” and “Page” areas and location of the 1983 field work.

emplacement.

4. Examination of the chromite mineralization to determine the mode of occurrence and its relationship to the geology of the rest of the 'Sill'.
5. Evaluation of the geology of the copper and nickel deposits of the 'Sill' to determine their exact relationship to the rest of the 'Sill' and especially the chrome mineralization:

As a result of several meetings between representatives of the Federal Department of Energy, Mines and Resources (EMR) and the Provincial Department of Energy and Mines, the areas of reponsibility were outlined.

The Manitoba contribution is to provide the geological groundwork and detailed mapping of the 'Sill' rocks. This will include sampling and detailed study of the ultramafic and gabbroic portions of the 'Sill' as well as the chromite-bearing horizons. In addition, the province will prepare a compilation of existing work by companies, government and universities.

The Federal contribution is mainly in the area of laboratory and financial support for analyses related to the project. This will consist of microprobe and other analyses, petrographic descriptions of samples, and possibly metallurgical testing of selected samples.

CONTRIBUTIONS FROM OTHER GOVERNMENT AND UNIVERSITY PROGRAMS

The University of Windsor (Ontario) has collected samples for age dating and paleomagnetic studies. This study will add to the knowledge of the 'Sill' and help to unravel the relationships between the 'Sill' and the rocks above and below the 'Sill'.

Approximately 600 boxes of core of various sizes are located on properties on the 'Sill'. These samples would provide a valuable contribution to the study of the 'Sill', and negotiations are currently underway to recover and catalogue this core, as part of the Province's core retrieval program.

PROJECT ACTIVITY AND SCHEDULING

1982-83

Initial sampling of the chromite layers was carried out by Watson and Talkington. These samples were split and a portion examined and analysed by Talkington et al., (1982). The results have been reported to the Geological Survey of Canada as part of report OSR 82-00053. Watson also carried out a series of gradiometer test profiles across the 'Sill' in order to determine the suitability of this instrument in delineating the chromite horizons. This work was reported in the 1982 Manitoba Report of Field Activities (Watson, 1982).

At the same time, Theyer commenced collection of a continous channel sample across the 'Sill'. During the 1982 field season a total in excess of 200m of sample was collected. This sample has been partially polished and is being examined for traces of sulphide mineralization as part of his study of the distribution of the platinum group elements.

1983-84

Three field parties from the Manitoba Geological Services Branch worked on projects on the 'Sill' during the 1983 field season.

Dr. Jon Scoates examined the entire range of 'Sill' rocks in a series of cross-sections concentrating initially on the area around the Chrome property (Scoates, GS-12, this volume). In addition to developing a profile of the 'Sill' rocks and an understanding of the mechanics of the 'Sill' emplacement. Scoates looked for distinctive features of individual layers. In areas of poor outcrop, it will be these features that will enable us to assign the rocks to a particular stratigraphic position and then unravel the geology. Scoates also examined the rocks intruded by and overlying the 'Sill'. There is evidence that at some time the 'Sill' has been unroofed at least down to the chromite layers.

Dr. Peter Theyer completed (in 1982) approximately 250m of a sawn cross-section of the 'Sill'. This section includes all of the layered ultramafic rocks up to the gabbroic contact. During the 1983 season, the cut through the gabbroic rocks was completed (Theyer, GS-19, this volume). Samples will be polished and examined for sulphide-rock layers as a guide to the platinum group element distribution.

The author started the 1983 season by preparing a plane table base map of the Chrome property, Because of its excellent exposure, this property is the focus of the Department's activities at this time. The major problem, however, is the lack of good ground control. The plane table survey provides an accurate base for the work of Scoates and Theyer, as well as enabling the relationships between the various chromite seams to be studied. In areas of poor outcrop, geophysics will provide the only method of tracing the various chromite-bearing layers. As a continuation of the sampling program started in 1982, samples were collected from additional areas for examination both by the Manitoba and Federal governments.

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GS-21 MINERAL DEPOSIT STUDIES OF PHANEROZOIC ROCKS IN SOUTHERN MANITOBA

by Erik Nielsen and George Gale

INTRODUCTION

This ongoing project, initiated in 1981 (Gale **et al.,** 1981). in search for the origin(s) of two mineralized pebbles previously discovered in the overburden of southern Manitoba, was continued in 1983.

Emphasis this season was placed on: (1) till sampling and analysis of the Quaternary stratigraphy in the Komarno area of the southern Interlake and in the Porcupine Mountain-Swan Lake area (Figs. GS-21-1 and GS-21-2), and (2) sampling of Paleozoic rocks in drill core.

KOMARNO AREA

A total of 44 backhoe pits were put down in the Komarno area resulting in 87 samples. The sampling was done along an east-west transect across the Ordovician and lower Silurian bedrock. This area was chosen because trace element geochemistry of drill core samples indicate the Selkirk Member is slightly enriched in lead relative to the rest of the Ordovician and the Silurian. All previous overburden sampling has been limited to areas underlain by bedrock young than the Selkirk Member. The two diamictons previously called the 'putty till' and the hard till are found ubiquitously throughout the area and the stratigraphy is similar to that described for the Shoal Lakes and Moosehorn areas (Nielsen and Gale, 1982) (Fig. GS-21-3). Pebble counts. relative compaction, fissility, evidence of shearing and the presence of boulder lags in the two diamictons from Shoal Lakes and Mossehorn clearly indicates that they are tills which can be ascribed to two separate ice advances. The till which was deposited by the first of the two glaciations is termed 'Inwood till' and the till from the second ice advance is termed 'Komarno till' (Fig. GS-21-4).

The northwestern provenance of the Komarno till is clearly evident by the orientation of flutes, glacial striae, and the presence of erratics, in the Komarno area, of probable meltrock derived from the Lake St. Martin crater. Till fabric analysis undertaken at three sites in the Inwood till to determine its provenance indicate a pronounced southwesterly ice flow attributed to the Inwood till but with the southeasterly fabric of the Komarno till imprinted on it (Fig.GS-21-5).

PORCUPINE MOUNTAIN-SWAN LAKE AREA

Investigations in the Mudlen Creek area of the Swan River Valley to determine the origin of the Kostiuk pebble (Nielsen and Gale. 1982) resulted in 79 backhoe pits and 6 hand-dug holes being dug and 159 samples being collected (Fig.GS-21-2). Backhoe pits 4 to 16 were over Devonian carbonate bedrock, whereas the rest of the samples were collected from areas underlain by Cretaceous sandstone and shale.

Physiographically the area can be divided into three regions. Below 1100 ft. (336 m) is the Manitoba Westlake Plain, a gently eastward sloping region underlain by Devonian carbonate and Cretaceous sandstone. This region is bordered on the west and northwest by the Manitoba Escarpment which rises to an elevation of about 2000 ft. (610 m). The Manitoba Escarpment is underlain by Cretaceous shale to an elevation of about 1350 ft. (412 m), above which it is probably com-

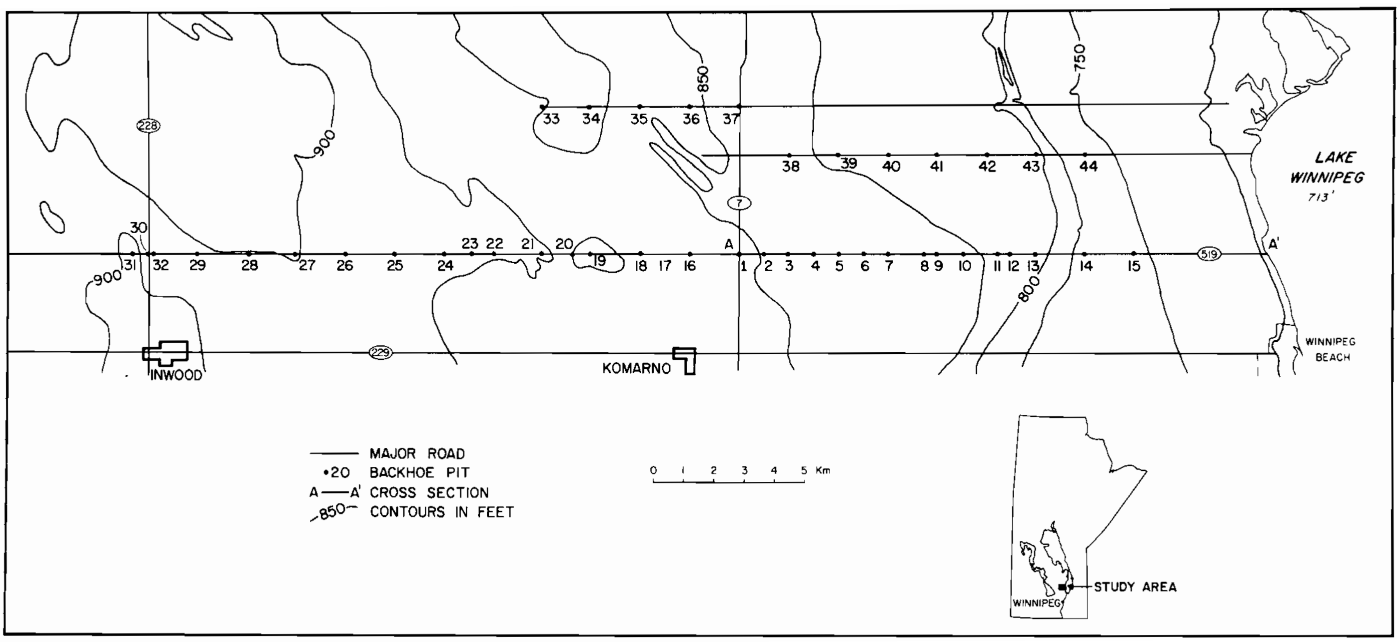


Figure GS-21-1: Location of samples collected in the Komarno area.

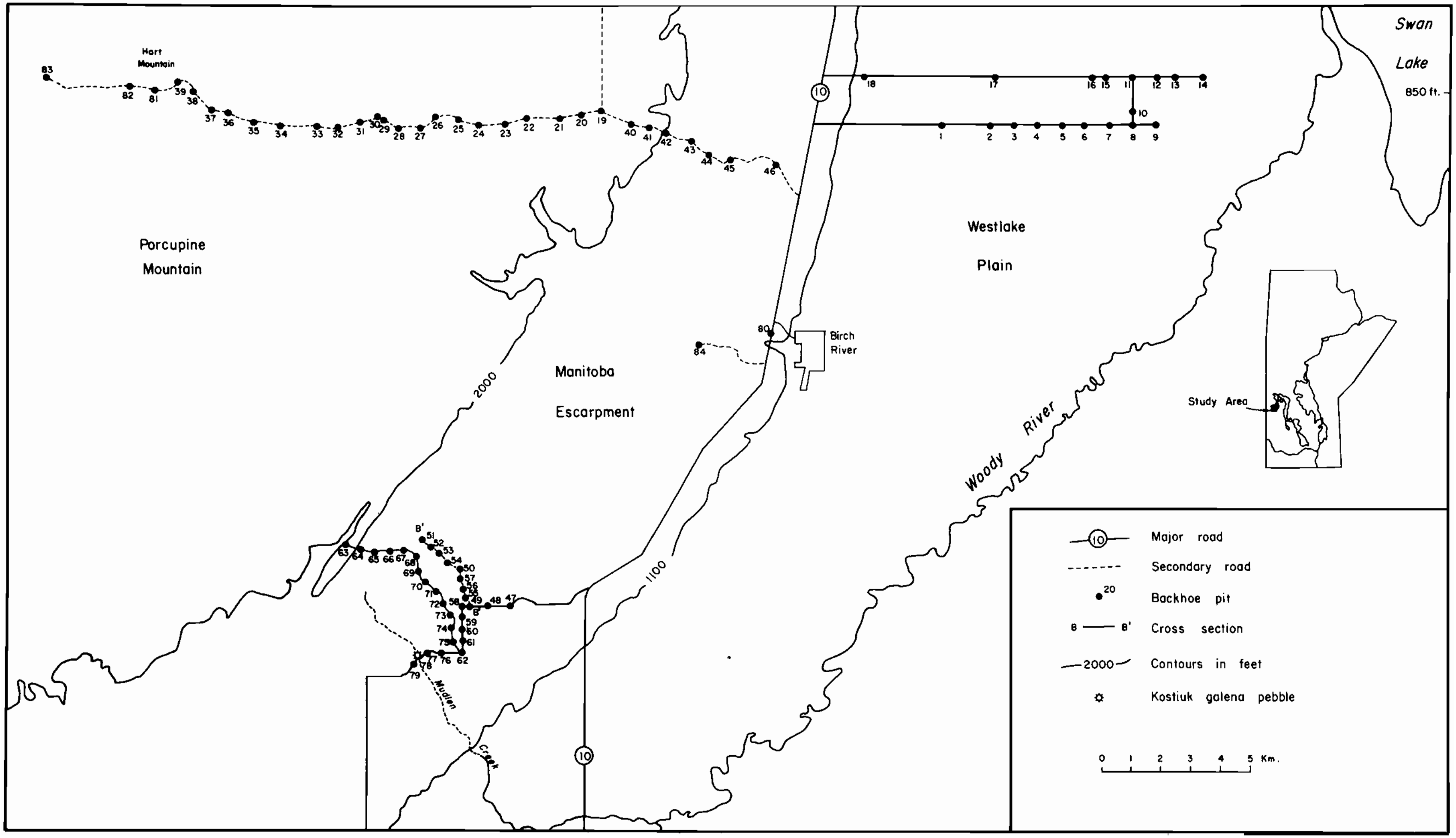


Figure GS-21-2: Location of samples collected in the Porcupine Mountain-Snow Lake area.

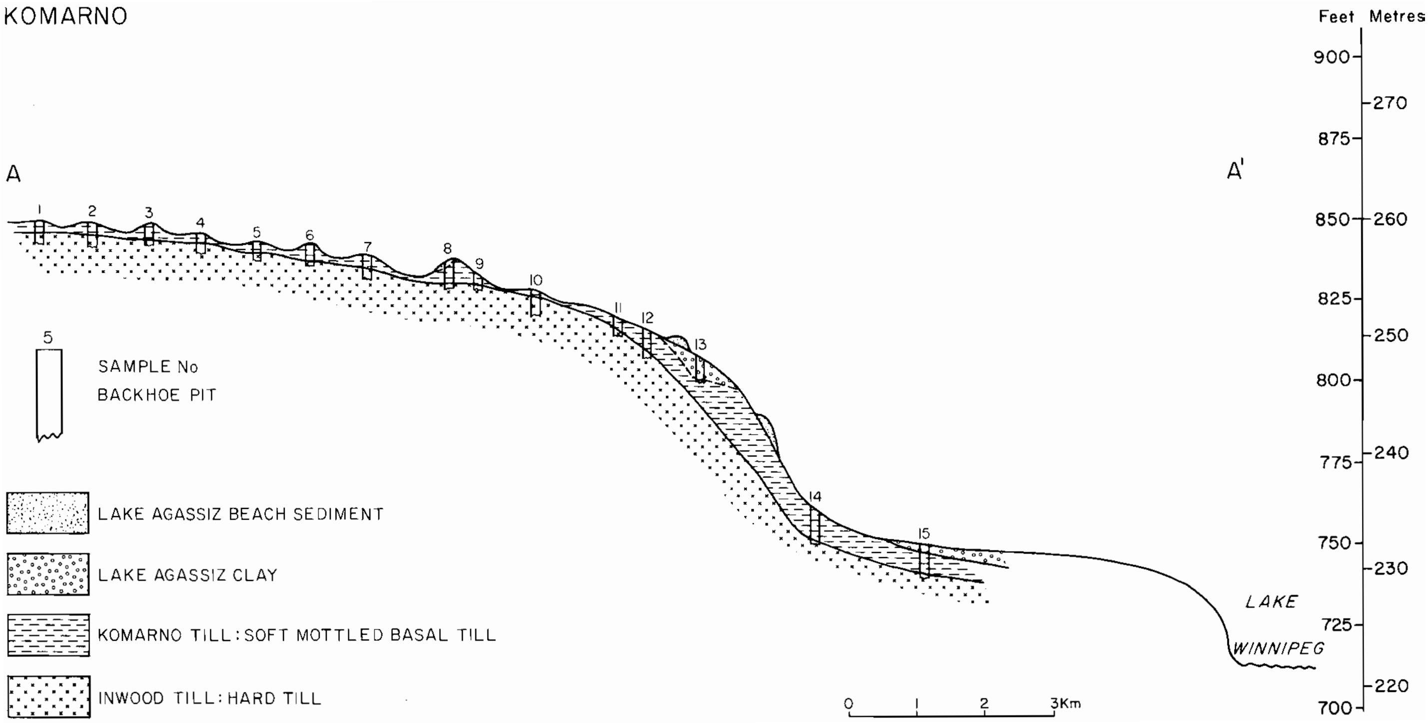
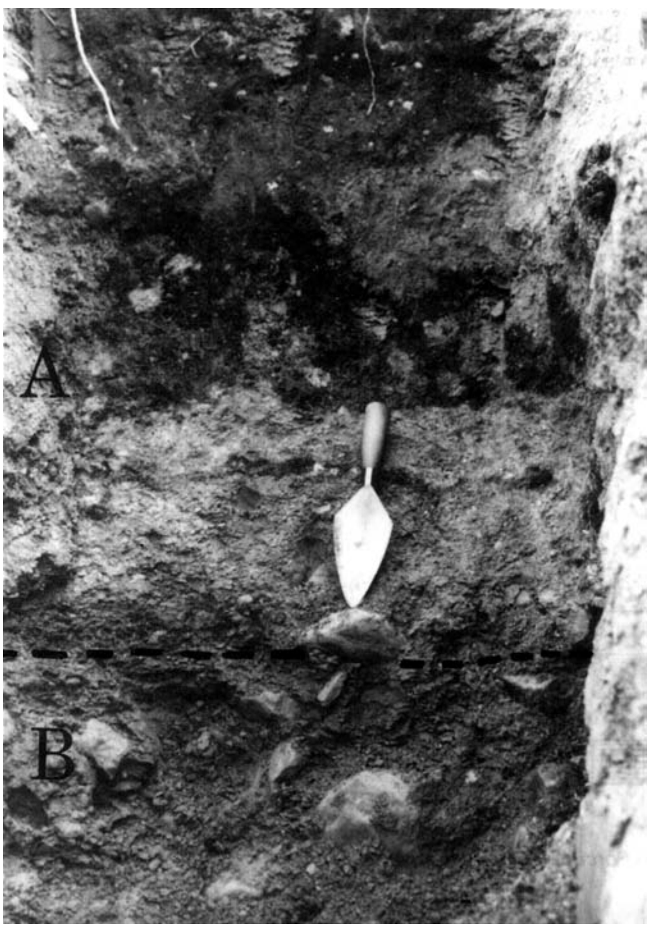


Figure GS-21-3: *Stratigraphic cross-section of the surficial deposits in the Komarno area.*



posed of Pleistocene and possibly Tertiary sediments. Above 2000 ft. (610 m) the escarpment levels out to become Porcupine Mountain, a broad area of hummocky stagnation moraine which reaches elevations over 2400 ft. (732 m).

Till outcrops extensively on Porcupine Mountain and on the upper and steeper parts of the escarpment. Till on the lower part of the escarpment and on the adjacent Westlake Plain is largely obscured by ice-marginal lake sediment, deltas, Lake Agassiz beach deposits and alluvial fan deposits of Holocene age. Much of the till exposed along the Manitoba Escarpment shows evidence of slumping.

The Quaternary stratigraphy of part of this area is shown in Fig.GS-21-6. The oldest sediment exposed is relatively soft brown clay till outcropping at the surface throughout Porcupine Mountain. The abundance of erratics of Hudson Bay provenance in this till indicates it was deposited by ice flow from the north-northeast. A correlative of this till has not been positively identified in the lowlands to the east. Ice-marginal lake conditions prevailed along the eastern and southern part of Porcupine Mountain subsequent to the retreat of this early ice advance, but was interrupted by a glacial readvance down the Interlake. This ice flow was generally southerly but in this area the flow was diverted by the northeastern extension of Duck Mountain and ice flow was southwesterly in the Swan River Valley. The highly calcareous cream or pink coloured till deposited by this ice advance is correlated with the Arran till described by Klassen (1979). The maximum southwestern extent of this advance is near Arran, Saskatchewan, 60 km southwest of Swan River. The highest point discovered to date where Arran till was deposited on Porcupine Mountain is site SL42 at an elevation of 2000 ft. (610 m). The occurrence of Arran till at this relatively low

Figure GS-21-4:

Soft, mottled Komarno till overlying compact Inwood till at site KO 32.

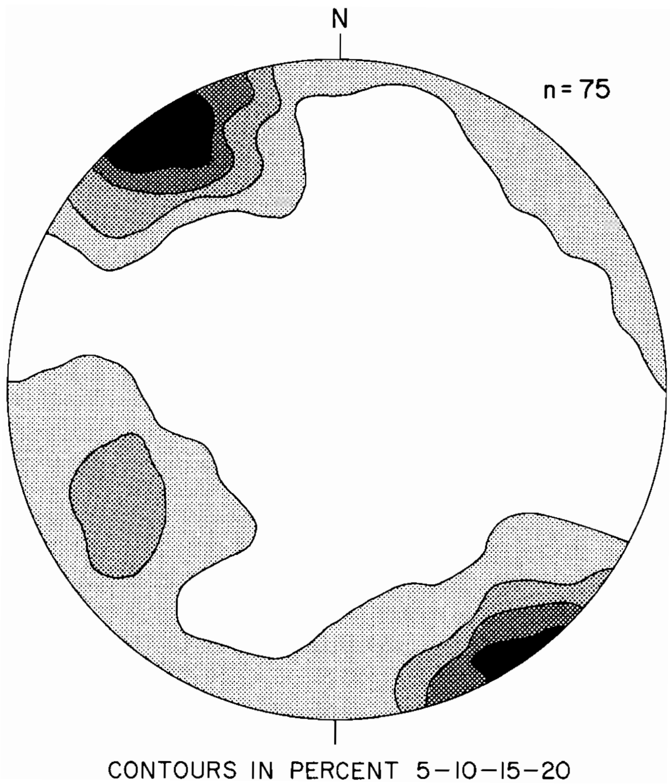


Figure GS-21-5: *Lower hemisphere equal-area projection of pebble orientations in Inwood till. (25 pebbles were measured at each of sites 5, 20 and 26).*

elevation and its absence from Porcupine Mountain (and Duck Mountain) as well as the diverging flow pattern around Duck Mountain recorded in the swell-and-swale topography south of Pelican Lake indicates the ice profile was approximately 1/3 the minimum theoretical profile. This would suggest that the ice advance which deposited the Arran till was a glacial surge. Glacial lake conditions were re-established along the margin of Porcupine Mountain as the ice sheet retreated for the final time.

MUDLEN CREEK DEPOSITS

The Kostiuk galena pebble was found in Mudlen Creek near site SL78 (Fig.GS-21-5) well below the maximum elevation of Arran till. In the area where the road crosses Mud/en Creek only deltaic sand and gravel is exposed, although 100 m upstream the delta appears to overlie lake clay. Point bar deposits in the creek bed, which is about 1 m wide, consist of sand and gravel, otherwise clayey alluvium is most commonly found. The gravel in the creek consists of a variety of lithologies notably carbonate, shale and an abundance of Precambrian lithologies all derived from the till on Porcupine Mountain. Well rounded taffy coloured metaquartzites associated with well rounded petrified wood fragments and other 'exotic' lithologies suggest that Tertiary gravel deposits derived in part from the Rockies may occur under the Pleistocene deposits on Porcupine Mountain. The obvious western provenance of these lithologies may account for the occurrence on Porcupine Mountain of the Kostiuk galena pebble which yeilds similar lead isotope ratios to the Pine Point deposit. There are, however, no known occurrences of float from Pine Point in Saskatchewan and it is also highly unlikely that a galena pebble would withstand fluvial transport from Pine Point to Porcupine Mountain. It is therefore still considered possible that the Kostiuk pebble may have been derived from a local Manitoba source.

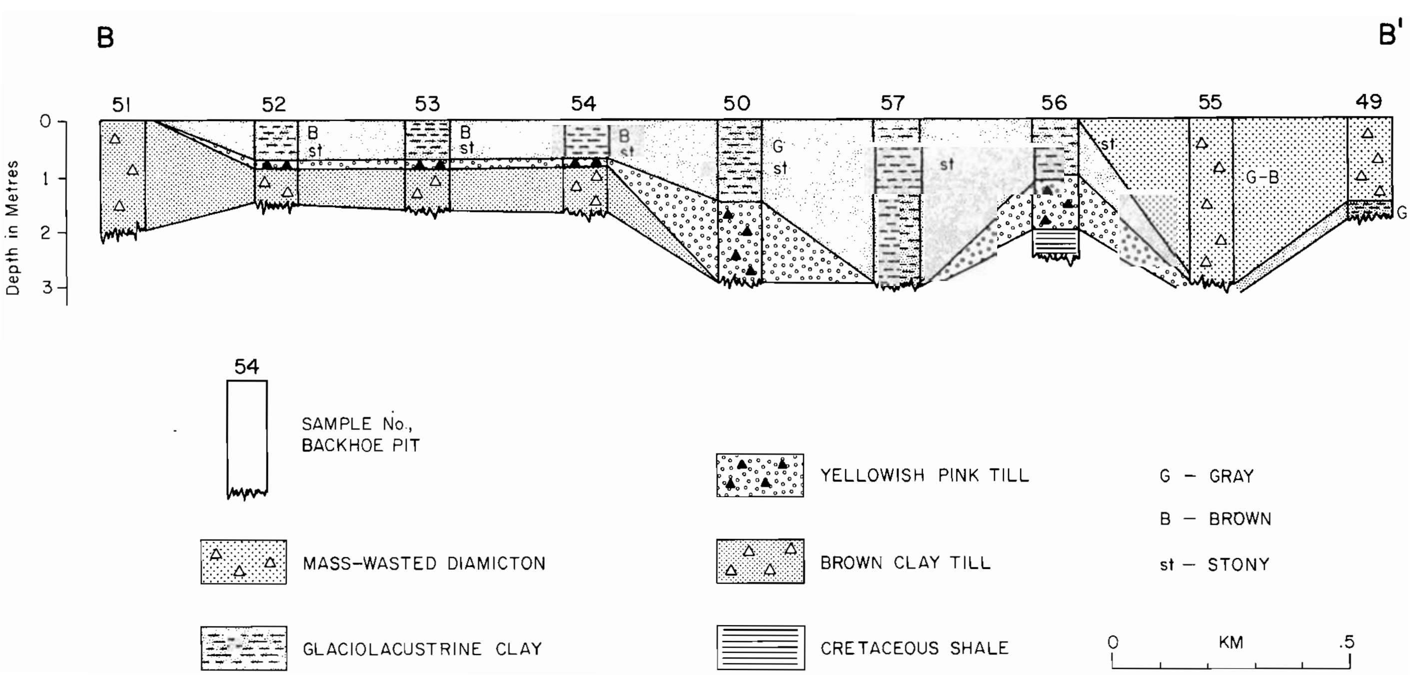


Figure GS-21-6: *Stratigraphic cross-section of the surficial deposits in the Porcupine Mountain-Swan Lake area. Location of cross-section is indicated in Figure GS-21-1.*

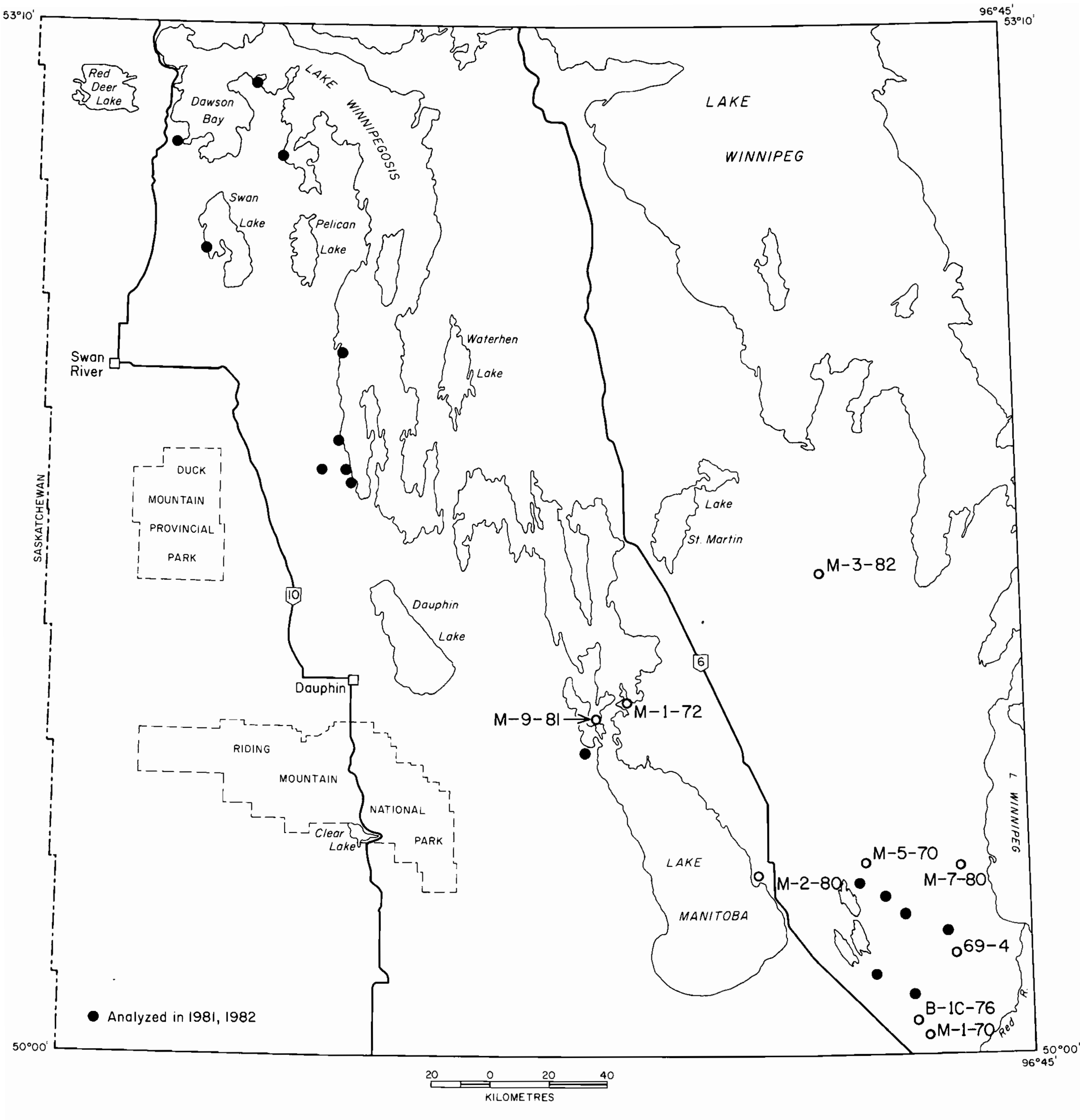


Figure GS-21-7: Location of Paleozoic drill cores sampled in 1983.

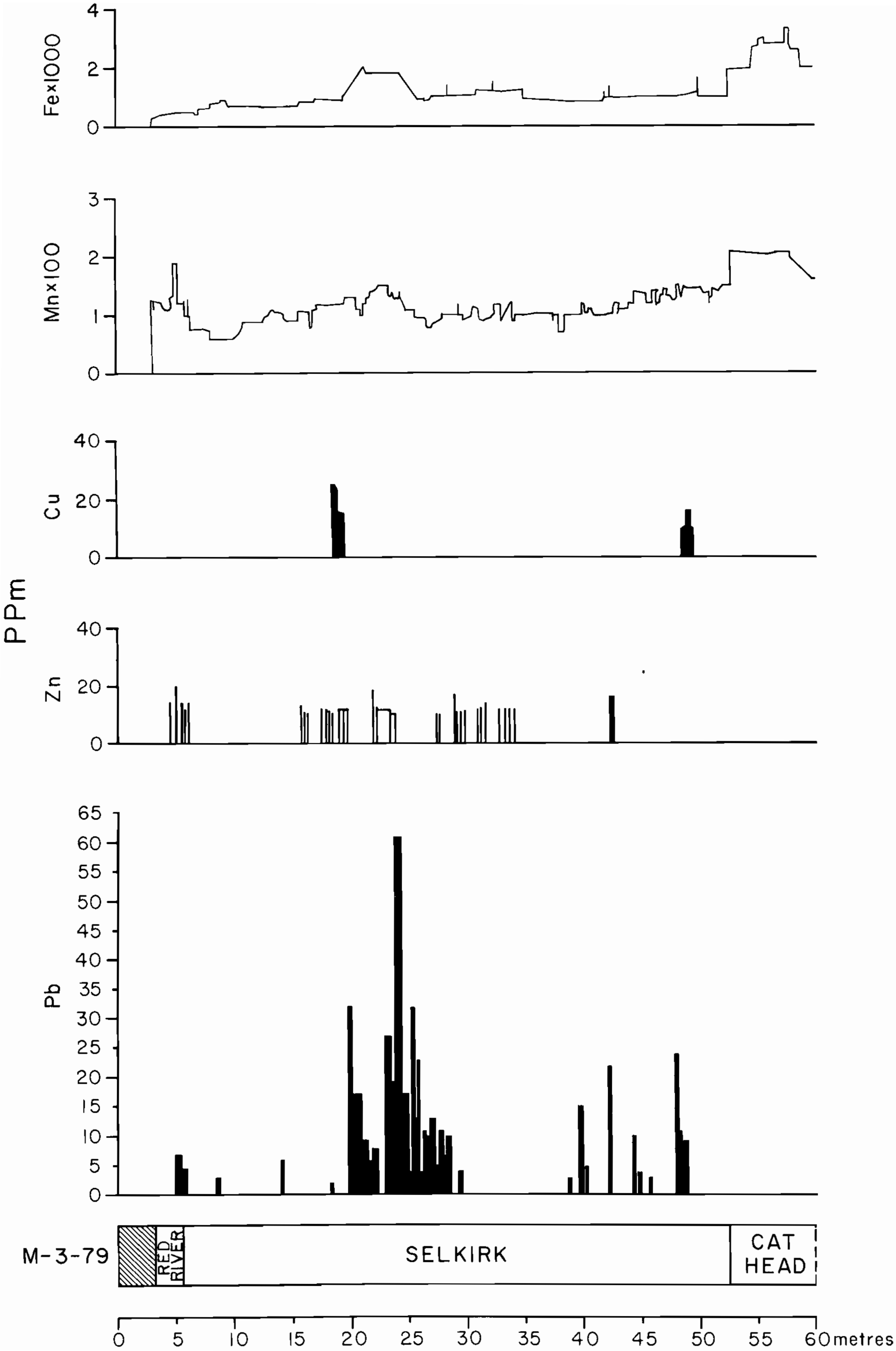


Figure GS-21-8: Geochemical profile from selected drill cores.

SAMPLE ANALYSIS

Heavy mineral concentrates and the less than 2 micron fraction from the till samples will be analysed for Cu, Pb, Zn, Ni, Co, Cd, Mn, Fe, Sa, and Hg.

BEDROCK GEOCHEMISTRY

Drill cores (Fig.GS-21-7) of paleozoic rocks were sliced and crushed to provide continuous sampling over one metre intervals. The 1100 samples of drill core will be analysed for Cu, Pb, Zn, Ni, Co, Cd, Mn, Fe, Sa, and Hg.

Several drill cores sampled during the 1982 season contain trace amounts of lead and zinc in the Ordovician rocks. A typical profile is shown in Figure GS-21-8. The 1983 program will test whether Ordovician rocks in other parts of the Province are also anomalous in base metals.

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GS-22 STRATIGRAPHIC MAPPING AND STRATIGRAPHIC AND INDUSTRIAL MINERALS CORE HOLE PROGRAM

by H.R. McCabe

The 1983 stratigraphic mapping and stratigraphic and industrial minerals core hole program covered five separate project areas. A total of 24 holes were completed for a combined total depth of 1 103 m. Cumulative drilling since the inception of the program in 1969 now amounts to 202 holes and 8 815 m. Drill hole data for 1983 are summarized in Table GS-22-1. Limited ground mapping was carried out in conjunction with the Lake St. Martin crater project, and ground magnetometer profiles were run for siting the Precambrian test holes for Operation Cormorant.

1) CITY OF WINNIPEG: A single core hole 84.5 m deep was drilled in the St. James area to aid in evaluation of the hydrogeologic conditions in the vicinity of an abandoned landfill site. Data also were obtained for dolomite and limestone resources studies by B.B. Bannatyne (GS-24, this report). The stratigraphy of the carbonate rocks was an expected, but the upper dolomite beds of the Gunton Member were found to be "dry", with static water level at a depth of approximately 9 m. This is the thickest "dry" interval yet intersected in Branch drilling in the Winnipeg area, and could possibly have considerable significance for migration of waste-derived methane gas generated in the waste disposal site.

2) GREEN OAK AREA: Three core holes were located along an east-west profile, just west of an anomalous Precambrian outcrop in NE3-14-8EPM, a short distance northeast of the town of Beausejour (Fig.GS-1). This granite outcrop marks the emergence of the Precambrian Shield in this area, but regional structural data suggested that the granite is about 35 m higher than "normal". The purpose of this project was to determine the nature of this Precambrian high, and the possible effect it may have had on Paleozoic deposition.

A reflection seismic profile was run in this area in 1982 by the G.S.C., in an attempt to determine the configuration of the Precambrian basement and the overlying Paleozoic strata. Two holes were located along the seismic profile to ground truth the seismic data. One additional hole was drilled immediately west of the seismic profile to tie in to the regional structural/stratigraphic framework. Results of the drilling are shown in Figure GS-22-1.

In the vicinity of hole M-2-83, seismic data had shown several reasonably well defined reflections, which were thought to be related to the limestone/shale/Precambrian sequence expected at this location. The core hole, however, proved to be located beyond the erosional edge of the limestone (Red River) strata, and intersected a thick

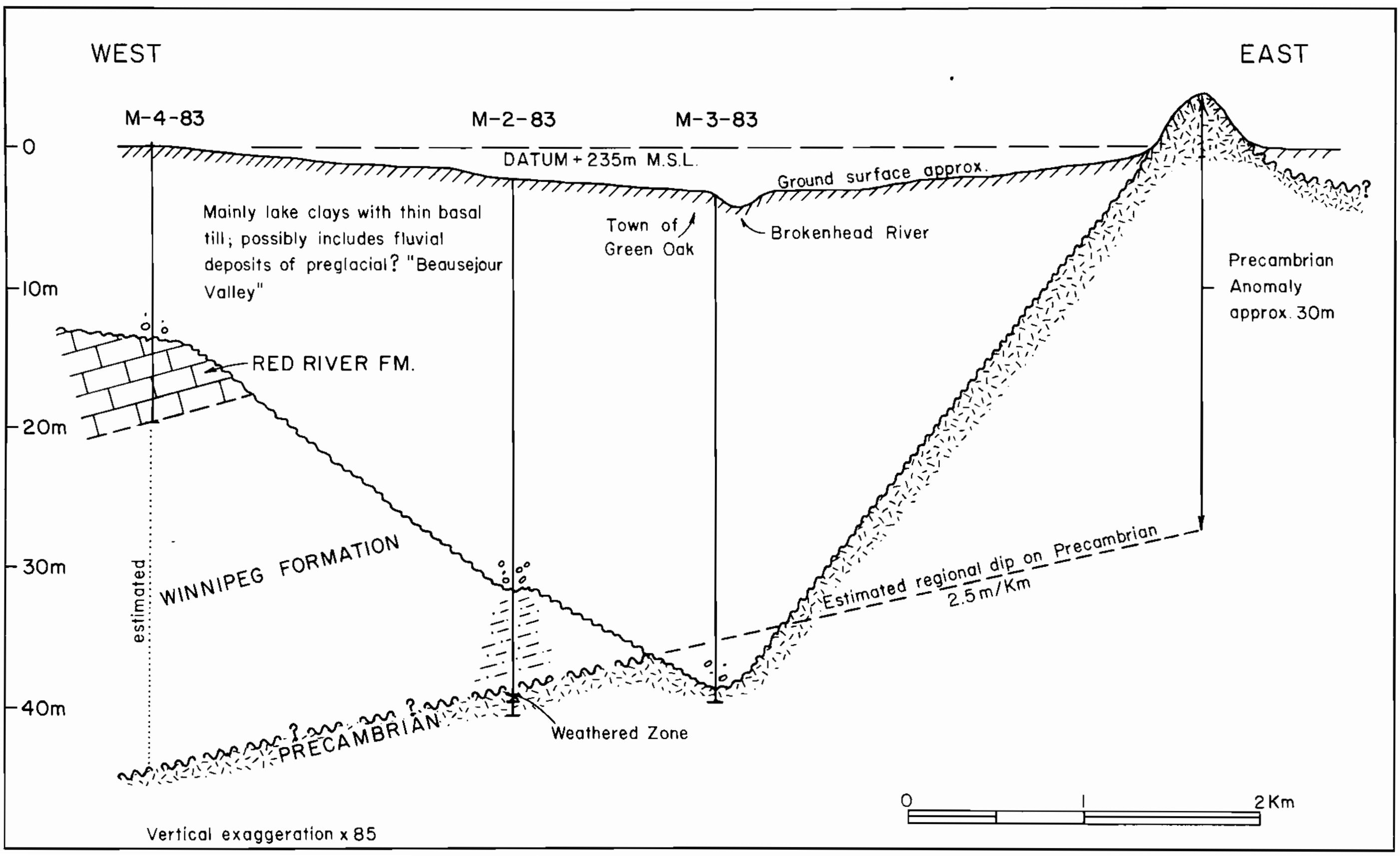

Figure GS-22-1: Structural cross-section, Green Oak area.

sequence of fine surficial deposits overlying a thin basal till which rests directly on partially brecciated shale, and fine argillaceous sandstones of the Winnipeg Formation. The Winnipeg section is only 7 m thick, and the sand content is considerably lower than normal for lower Winnipeg strata, with no development of a basal sandstone unit. Brecciation of the shale possibly reflects Pleistocene ice-push deformation The weathered zone at the top of the Precambrian is only 0.4 m thick. Elevation of Precambrian basement (+ 196 m) is close to that predicted by regional extrapolation, possibly 5 m high.

The above drill results are difficult to relate to the seismic pattern. Certainly the writer's initial interpretation as to the origin of the reflections is incorrect. Detailed evaluation of the seismic and drill hole results by the GSC, possibly supplemented by additional refraction seismic data, will be necessary to correctly interpret the seismic profile.

The second core hole, M-3-83, was located beyond the limits of the well developed multiple seismic reflections, where it was expected that Paleozoic strata would be eroded. This interpretation proved to be correct, as the hole intersected Precambrian basement directly, with no Paleozoic cover, at an elevation approximately the same as hole M-2-83. Only a thin, 3 cm zone of weathering is present at the Precambrian surface, indicating at least minor glacial erosion. Lithology of the basement rocks in both holes M-2-83 and M-3-83 is the same as in the granite outcrop - a massive pink granite typical of plutonic rocks in the Lac du Bonnet area.

Because the expected Paleozoic sequence had not been intersected in hole M-2-83 the third test hole was located approximately 1700 m west of the western end of the seismic line, where water well data indicated that Paleozoic limestone strata are present. The intention was to drill to Precambrian basement, through a complete section of Winnipeg Formation. This would have provided additional structural control for the Precambrian surface, and the thickness of the Winnipeg Formation would have reflected any paleotopographic relief on the Precambrian surface (e.g. thinning on the flank of a Precambrian high). Unfortunately drill rods jammed in a shale bed close to or at the top of the Winnipeg Formation, and the hole could not be completed to target depth. In Figure GS-22-1 the probable position of the Precambrian surface in hole M-4-83 has been estimated using the indicated regional dip on the Precambrian surface and projecting this westward from hole M-2-83. This extrapolation indicates a possible 25 m of Winnipeg Formation, which seems "normal" relative to the regional isopach trends of the Winnipeg Formation (McCabe, 1973). The Precambrian surface thus appears to be close to normal or regional at least as far east as hole M-3-83. East of this, an abrupt rise of at least 43 m occurs over a distance of less than 2.8 km. Regional dips are less than 3 m/km.

The origin of the anomalous Precambrian high cannot be determined from presently available data, and the deep Pleistocene or pre-Pleistocene erosion between the granite outcrop and the Paleozoic strata virtually precludes any direct interpretation. The earlier suggestion by the writer (McCabe, op. cit.) that the Precambrian high constituted a structural/topographic island during early Paleozoic (Winnipeg) time, and drastically affected deposition of the Winnipeg strata, still seems to be a valid interpretation. The abruptness of the feature, and the almost complete lack of other erosional relief on the Precambrian surface elsewhere in southern Manitoba strongly suggests that the Green Oak paleotopographic high is structurally (fault?) controlled, and furthermore that the structure most likely developed during late Precambrian or even early Paleozoic time, otherwise the structure would have been truncated by pre-Ordovician erosion.

Although the apparent association of the Precambrian high and the prominent lithofacies anomalies in the Winnipeg Formation argues for a cause and effect relationship, the possibility remains that structure may in part be younger, or that an earlier structure has been reactivated. The Green Oak area is not the only place along the present Paleozoic edge where anomalous relief is evident on the Precambrian surface. A similar feature is present in the Narrows area of Lake Winnipeg, but lithofacies data are not available to determine if anomalous depositional patterns are associated with this Precambrian high. Anomalous relief in The Narrows area is approximately 21 m over a distance of 2.2 km.

3) DOLLY BAY AREA: Hole M-5-83, located just north of the Lake Manitoba Narrows, was drilled to obtain data as to the high-calcium limestone deposits in the area (B.B. Bannatyne, GS-24, this report), and also to obtain additional basic stratigraphic data. The hole intersected a thin, 4.8 m upper unit of granular, vuggy thick-bedded dolomite, correlated with the Winnipegosis Formation. This is underlain by 26.4 m of Elm Point limestone containing a thin dolomitized interbed near the top. The Elm Point consists of a mottled, slightly to moderately dolomitic limestone - a sparse biomicrite. The mottling, which is variable throughout the section, directly reflects the degree of secondary dolomitization.

Early mapping of ditch outcrops along the Dolly Bay road (Baillie, 1951) had reported an alternation of "Winnipegosis" dolomite and "Elm Point" limestone. The reason for the apparent alternation of supposedly different stratigraphic units was not clear, because of limited exposure, but it was suggested that it was due to gentle structural doming. The presence of the dolomite interbed in the upper part of the Elm Point section, however, suggests that the noted outcrop alternations may merely reflect the interbedding of the two lithologies, and that structural effects are not necessarily involved.

The indicated 26.4 m of Elm Point section is somewhat surprising. The only other core hole in the area to have completely penetrated the Elm Point (hole M-1-72 located 7 km southwest, in the old Rosehill quarry) intersected only 20 m of Elm Point beds beneath dipping reef-flank dolomites. The considerable difference in Elm Point thickness between holes M-5-83 and M-1-72 suggests that the Elm Point/ Winnipegosis (i.e. limestone/dolomite) contact is not a stratigraphic marker. Either the Elm Point platform beds show a considerable primary thickness variation, or the dolomite/limestone contact merely reflects a dolomitization front, possibly related to an overlying or adjacent reefal development. No direct evidence is yet obtainable as to the factors controlling the degree of dolomitization of Elm Point strata. Poorly defined westward dips of up to 20° noted in outcrop, suggest that both lithologies may represent reef-flank deposits.

4) LAKE ST. MARTIN AREA: A total of 5 holes were drilled in the area of the Lake St. Martin crater structure (probable meteorite impact feature) to define more accurately the nature and distribution of the crater fill, and thereby provide a more accurate model of the crater configuration and mode of deformation (McCabe and Bannatyne, 1970; McCabe, 1977).

Hole M-6-63 was drilled to a depth of 25 m, but failed to intersect bedrock. The overburden thickness is the greatest so far reported for this part of the crater structure.

Hole M-7-83 was located near the southwestern corner of the gypsum quarry. An earlier hole, M-17-77, drilled about 3 km to the north, intersected what appeared to be a Precambrian basement high, indicating that the crater may comprise a ring-type complex impact structure. The location of hole M-7-83 was chosen to check on the southward (concentric) extension of this basement high. The hole penetrated a post-crater sequence of 26.6 m of Jurassic evaporites and red beds unconformably overlying crater fill (St. Martin Series) consisting of granitic microbreccia - fine to coarse granitic fragments of variable lithology in a fine matrix of angular quartz feldspar and biotite grains. Core recovery, however, was poor (10 - 40%). It seem unlikely that much granite was ground during coring, and the core loss probably resulted from washing out of the fine, friable granitic microbreccia matrix. Below a depth of about 80 m, no microbreccia was recovered, and this material is referred to as a granite breccia. The core loss, however, suggests that some microbreccia matrix may still

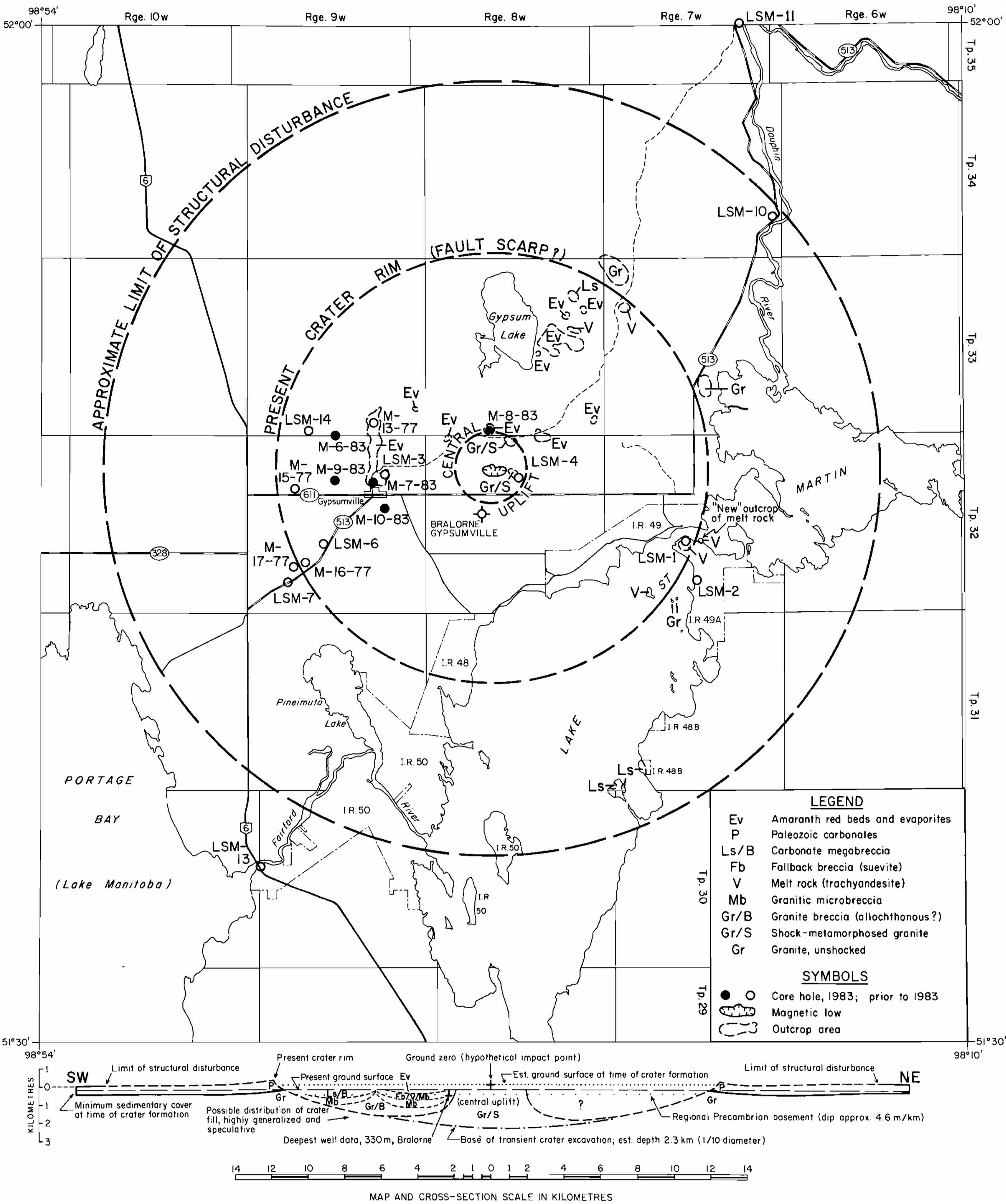

Figure GS-22-2: Geology and core hole locations, Lake St. Martin area, with true-scale structural cross-section.

be present. It is thus uncertain if the lower portion of the hole is in microbreccia or brecciated basement. The lithology of the granitic fragments becomes more uniform towards the bottom of the cored interval, and most fragments did not appear, in hand specimen, to be highly shocked.

Although the results of hole M-7-83 are not diagnostic, they nevertheless seem to confirm a limited extent for a "basement" ring uplift within the crater, at a point approximately halfway between the central uplift and the present crater rim (0.6R). In the descriptive system proposed by Wood and Head (in Robertson and Sweeney, 1983), for meteorite impact structures, the Lake St. Martin crater would be described as a "central peak basin" type.

Hole M-8-83 was located in the now abandoned Elephant Hill quarry, 6.4 km northeast of Gypsumville, at a point just beyond the postulated outcrop limit of the central basement uplift. This hole penetrated 37.5 m of post crater evaporites and red beds overlying crater fill of the St. Martin Series. The upper 20 m of the crater fill consist of granitic microbreccia similar to that intersected in hole M-7-83 (but much better recovery), overlying 7.6 m of "melt rock" - a dark red, somewhat vesicular, aphanitic material with abundant fine granitic inclusions. This in turn grades downward through a thin microbreccia zone into what appear in hand specimen to be extremely shock-metamorphosed granitic rocks with several bands or veinlets of melt (pseudotachylite) and microbreccia. The granitic fragments are moderately variable in lithology in the upper part of the granitic unit, but become relatively uniform towards the bottom of the cored interval, so it is not clear if the hole bottomed in "in-situ" shocked basement or an allochthonous breccia. Of all of the core and outcrop samples obtained to date, these shocked granites appear to represent the material formed closest to the original excavated floor of the crater.

A brief ground check of the central granitic uplift area showed that the southern occurrence consists of almost continuous outcrop or near outcrop over a distance of about 0.8 km. Although actual exposure is rather poor, the granitic rocks appear to be coherent, **in situ** material rather than discrete (allochthonous) basement blocks, unless the blocks are truly gigantic. Coherence or lithologic continuity also was suggested by an earlier drill hole at this site, although the rocks are admittedly highly disturbed and shocked.

Hole M-9-83 was located between the postulated basement ring high and the area of thick carbonate breccia development extending inward from the crater rim (location approx, 0.85 R). Previous drilling had shown that the carbonate breccia beds extend to depths considerably below the elevation of the basement ring high. Beneath a thin, 15 m, drift cover, hole 9 intersected an upper 27 m section of granitic breccia and microbreccia (St. Martin Series). This is underlain by 157 m of carbonate microbreccia to megabreccia, containing fragments at least as large as 10 m. Fragments consist of limestone, dolomite and shale, most of which are **not** lithologically correlatable with any of the present Ordovician and Silurian country rocks, but probably represent stratigraphically higher Devonian, or even younger, rocks derived by slumping from the uplifted crater rim contemporaneous with crater formation, when a thick cover of Devonian strata extended through this area.

The occurrence of granitic microbreccia above the carbonate breccia in hole 9 appears to be an inversion of the "normal" stratigraphic sequence, if any such thing as a normal sequence can be indicated for the crater fill. A possible explanation of the distribution of both the carbonate and granitic breccias and the medial basement ring is that this medial portion of the crater fill, including the basement ring high, may have been formed where two piles of debris flow converged, one consisting primarily of carbonate debris formed by inward slump faulting from the unstable crater rim, and the second consisting of granitic debris shed from an equally unstable central uplift. The basement ring high would thus result from the pile-up of largely centrally derived basement debris against the peripherally derived carbonate breccias, with some interfingering or overlapping of the two lithologies as shown in hole 9. Some granitic material also was undoubtedly supplied by rim slumping.

Evidence from early drilling (McCabe, 1977) showed that rim-derived slump breccias retain some semblance of stratigraphic organization, at least for that portion of the slumped material immediately within the present rim. The carbonate breccia in M-9-83 did not show any recognizable stratigraphic organization, other than that most most material appears to be derived from structurally/stratigraphically higher beds (Devonian?). This suggests that the cored intersection may represent only the top of a much thicker breccia pile, with Lower Paleozoic and basement breccias occurring at depth.

The latest core hole data have largely completed a preliminary profile across the western half of the crater structure. Information on the eastern half, however, is still limited because of access problems. The 1983 drill program was initially planned to obtain data from the northeastern portion of the crater, but extremely wet conditions during the early part of the field season precluded such drilling. Future drilling will have to be directed towards this northeastern area, where preliminary data indicate that the nature of the crater fill is markedly different, with a much higher content of melt rock, and a much lower content of carbonate breccia.

No follow-up drilling was done with respect to the 1982 GSC reflection seismic profiles in this area, because interpretation of the seismic profiles was not yet available.

Limited field checking was carried out on the southeastern shore of Lake St. Martin, in the vicinity of The Narrows. A previously unreported outcrop of melt rock was mapped immediately east of The Narrows (approx. NE5-15-32-7W). Since melt rock is interpreted to be limited to the area within the present-day crater rim, this indicates a diameter for the crater structure slightly larger than that indicated by McCabe and Bannatyne (1970) or McCabe (1977), and may represent the first occurrence of rocks that do not fit within the idealized circular configuration of the crater rim. An attempt also was made to locate several previously reported Paleozoic rim outcrops a short distance southeast of the above location. It was hoped that these outcrops would provide some indication of the nature and extent of the rim uplift, which is not well known. Unfortunately shallow water conditions prevented access at this time.

Hole M-1 0-83 was located in a small "gravel" pit just south of the town of Gypsumville. The upper part of the quarry beds consists of poorly consolidated sandy gravel, but large blocks of hard, well-cemented, moderately well sorted, sandy breccia-conglomerate had been excavated from the floor of the quarry, which was water filled at the time of drilling. The core hole intersected 26.5 m of relatively uniform conglomerate beds identical to those obtained from the quarry floor. Size of the fragments ranges up to at least 15 em, and fragments are angular to subrounded. The cementing material throughout appears to be coarsely crystalline gypsum.

The frag ments show a moderate range of litholog ies. Grey-buff sublithographic dolomite (Silurian?) is most common; limestone fragments seem to be absent. Granitic fragments also are common, but no other types of basement-derived fragments were noted. Fragments of "melt rock" were seen as well as rare soft badly weathered or altered fragments similar to the suevite or fallback breccia intersected in several drill holes. Fragments of gypsum, possibly derived from post-crater Jurassic evaporites also were noted, although at least some of these "fragments" may represent replacement of other fragments. The matrix consists of medium, angular sand-size grains consisting mostly of quartz feldspar and biotite.

The rather limited lithologic assemblage strongly suggests that the conglomerate beds are not of glacial origin, and that the source area is local, with all lithologies being represented in the immediate crater area. The fairly high degree of sorting and lamination indicate high-energy water-laid deposits.

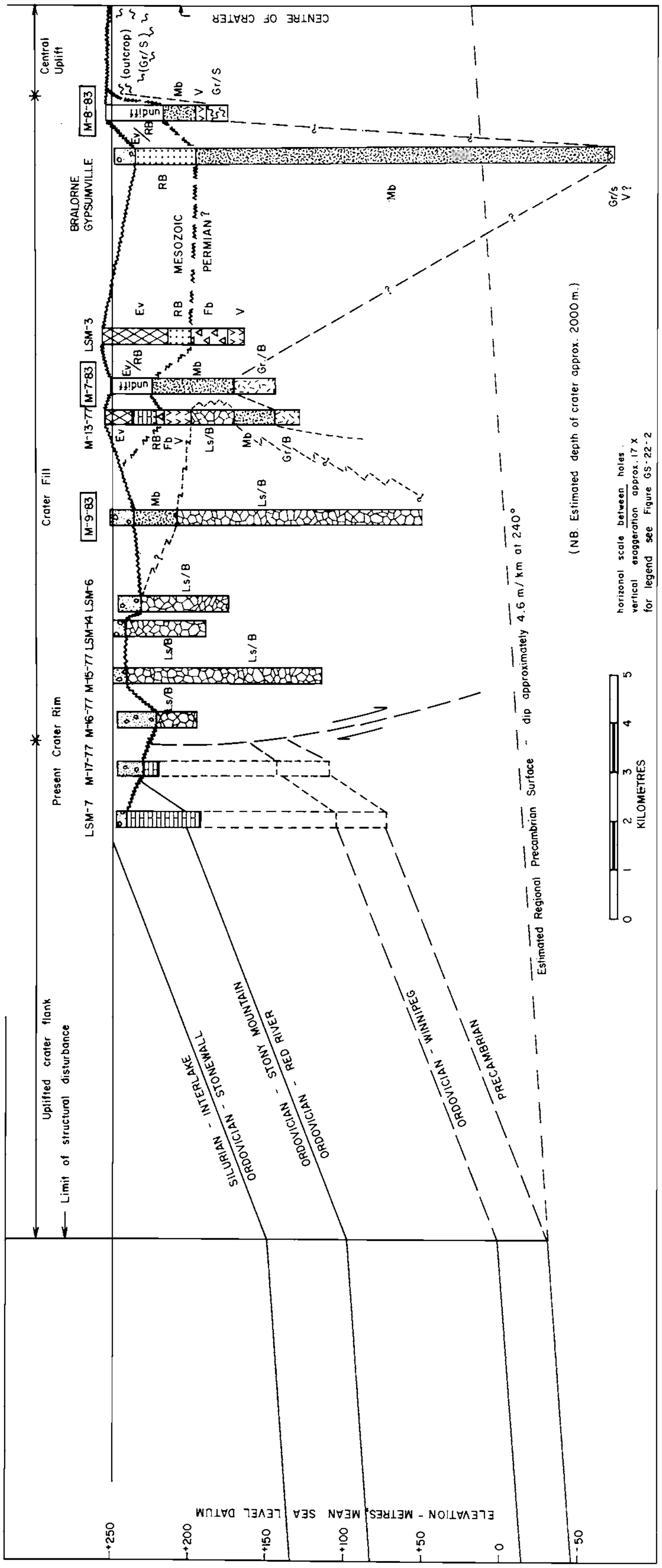

Figure GS-22-3: Detailed structural cross-section, Lake St. Martin Crater.

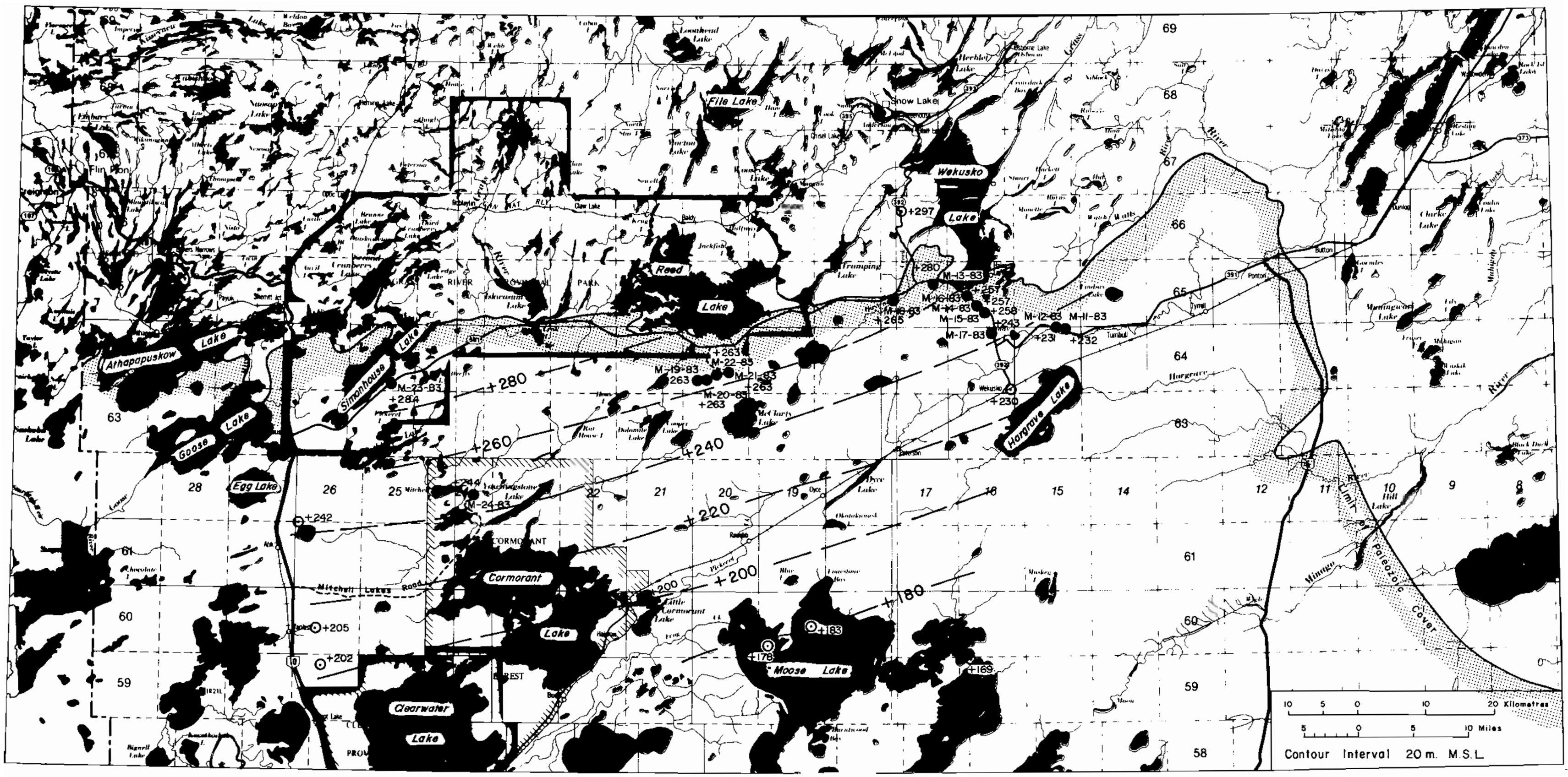

Figure GS-22-4: Geology. core hole locations and structure contour map, Simonhouse Lake-Wekusko Lake area.

TABLE GS-22-1
SUMMARY OF CORE HOLE DATA

Hole No.	Location and Elevation (metres)	System/ Formation/Member	Interval (metres)	Summary Lithology
M-1-83	4-9-11-2E			
	+ 239.028	Ordovician-Stony Mountain	0 - 4.65	Overburden
		Gunton	4.65 - 6.0	Dolomite, mottled, slightly argillaceous
		Penitentiary	6.0 - 12.2	Dolomite, argillaceous, greenish orange
		Gunn	12.2 - 31.8	Calcareous shale and fossiliferous limestone, dark purplish grey
		Red River-Fort Garry	31.8 - 33.5	Limestone
			33.5 - 45.05	Dolomite, cherty
			45.05 - 47.75	Limestone
			47.75 - 69.6	Dolomite, micritic, buff to reddish
		Selkirk	69.6 - 70.8	Limestone
			70.8 - 74.1	Limestone, cherty
			74.1 - 84.5	Dolomitic limestone, mottled
M-2-83	NE13-5-14-8E		0 - 29.7	Overburden
	+ 233	Ordovician-Winnipeg	29.7 - 368	Shale, sandy shale, and argillaceous fine to medium sandstone. Shale partly brecciated
		Precambrian	36.8 - 377	Highly weathered granite
			37.7 - 38.85	Granite, massive, pinkish grey
M-3-83	NW13-4-14-8E		0 - 35.3	Overburden: clay, basal till
	+ 231.6	Precambrian	35.3 - 36.31	Granite, massive, pinkish grey: 3 cm weathered zone at top
M-4-83	NE16-1-14-7E		0 - 13.8	Overburden
	+ 235	Ordovician-Red River	13.8 - 19.75	Limestone, light grey, biomicrite, dense, argillaceous stringers and bands
M-5-83	NE13-34-24-9W	Devonian-Winnipegosis	0 - 4.8	Dolomite, yellowish buff, highly granular, fossiliferous
	+ 253	Elm Point	4.8 - 31.2	Limestone, dolomite mottled, biomicrite
		Ashern	312 - 42.68	Argillaceous dolomite and dolomitic shale, greyish red to orangy buff. minor intraformational breccia, 5 cm basal breccia
		Silurian-Interlake	42.68 - 47.90	Dolomite, buff, dense to granular, shale as fracture infill
M-6-83	NE16-33-32-9W		0 - 25.0	Overburden
M-7-83	C5-26-32-9W	Jurassic-Amaranth	0 - 26.6	Evaporite and red beds, undifferentiated
	+ 251	Permian(?)-St. Martin Series	26.6 - 102.85	Granitic microbreccia grading downward to brecciated granite(?) at approx. 80 m
M-8-83	NE4-4-33-8W	Jurassic-Amaranth	0 - 37.5	Evaporite and red beds undifferentiated
	+ 254.5	Permian(?)-St. Martin Series	37.5 - 57.31	Granitic microbreccia
			57.31 - 64.9	"Melt rock" with abundant granitic inclusions, slightly vesicular
			64.9 - 77.85	Shock-metamorphosed granite with pseudotachylite veinlets
M-9-83	NE8-28-32-9W		0 - 15.5	Overburden
	+ 251	Permian(?)-St. Martin Series	155 - 42.8	Granitic breccia and microbreccia
			42.8 - 200.4	Carbonate microbreccia to megabreccia; limestone, dolomite, shale
M-10-83	C7-23-32-9W + 257.5	(?)	0 - 26.5	Conglomerate, gypsum-cemented; dolomite, granite, gypsum(?), and melt-rock fragments
M-11-83	SC15-35-64-15W		0 - 11.4	Overburden
(Site 12)	+ 262	Ordovician-Red River	11.4 - 29.4	Dolomite, mottled, buff, nodular
			29.4 - 30.2	Dolomite, pyritic, sandy
		Precambrian	30.2 - 39.0	Hornblende and biotite-bearing tonalite-tonalite/ diorite An_{39} Sporadic sections of pink pegmatite
M-12-83	NC-13-35-64-15W		0 - 12.2	Overburden
(Site 11)	+ 262	Ordovician-Red River	12.2 - 31.1	Dolomite, mottled, minor chert
			31.1 - 31.4	Dolomite, sandy, pyritic
		Precambrian	31.4 - 38.85	Granite and biotite-bearing quartz diorite with significant sphene, magnetite and apatite

TABLE GS-22-1 (continued)
SUMMARY OF CORE HOLE DATA

Hole No.	Location and Elevation (metres)	System/ Formation/Member	Interval (metres)	Summary Lithology
M-13-83	NC3-26-65-17W	Ordovician-Red River	0 - 2.27	Dolomite, buff
(Site 6)	+ 282		2.27 - 2.5	Dolomite, sandy, pyritic
		Precambrian	2.5 - 11.25	Fine grained hornblende gabbro with sub-ophitic texture and tabular zoned plagioclase An_{48}
M-14-83	SWl-16-65-16W		0 - 2.2	Overburden
(Site 8)	+ 280	Ordovician-Red River	2.2 - 23.3	Dolomite, buff, mottled. Basal 0.1 m sandy
		Precambrian	23.3 - 32.65	Foliated to actinolite-bearing intermediate/mafic volcanic with sericitic alteration of plagioclase megacrysts
M-15-83	CII-I0-65-16W	Ordovician-Red River	0 - 23.0	Dolomite, nodular, purplish red, cherty
(Site 9)	+ 282		23.0 - 23.35	Dolomite, sandy
		Precambrian	23.35 - 32.55	Actinolite, talc? ultramafic, and melagabbro with rare matrix plagioclase. Altered metagreywacke sections
M-16-83	NC9-17-65-16W		0 - 5.8	Overburden
(Site 7)	+ 270	Ordovician-Red River	5.8 - 12.72	Dolomite, nodular
			1272 - 12.86	Dolomite, sandy; vuggy and pyritic at base
		Precambrian	12.86 - 21.45	Layered metasediment with carbonate/quartz- and magnetite/chlorite-rich layers
M-17-83	SE12-35-64-16W		0 - 113	Overburden
(Site 10)	+ 273	Ordovician-Red River	11.3 - 30.0	Dolomite, purplish to buff, slightly nodular
		Precambrian	30.0 - 31.23	Alaskite/granite; microcline-rich with isolated magnetite and chlorite. Zircon inclusions in biotite
M-18-83	SW3-20-65-17W	Ordovician-Red River	0 - 4.5	Dolomite, buff, thin bedded
(Site 5)	+ 274		4.5 - 9.5	Dolomite, purplish red, nodular, sandy at base
		Precambrian	9.5 - 20.4	Fine grained greywacke with green grey argillite layers
M-19-83	W2-29-64-20W		0 - 4.1	Overburden
(Site 1)	+ 293	Ordovician-Red River	4.1 - 28.8	Dolomite, purplish red to reddish buff, partly stromatolitic; **Receptaculites**
			28.8 - 29.6	Dolomite, sandy, pyritic
		Precambrian	29.6 - 41.4	Metagreywacke; well and thinly layered
M-20-83	W4-28-64-20W		0 - 11.3	Overburden
(Site 2)	+ 293	Ordovician-Red River	113 - 29.5	Dolomite, mottled buff to reddish, minor chert, stromatolitic at base
			29.5 - 30.0	Dolomite, sandy, pyritic, vuggy
		Precambrian	30.0 - 38.75	Hornblende-bearing gabbro, melagabbro and thin ultramafic? sections. Layered gabbro intrusion
M-21-83	C12-26-64-20W		0 - 11.2	Overburden
(Site4)	+ 293	Ordovician-Red River	11.2 - 28.8	Dolomite, greyish buff, reddish towards base, minor chert
			28.8 - 29.5	Dolomitic sandstone
		Winnipeg (?)	29.5 - 29.73	Sandstone, quartzose
		Precambrian	29.73 - 3865	Ultramafic actinolite/talc rock and gabbro
M-22-83	C8-28-64-20W		0 - 14.35	Overburden
(Site 3)	+ 293	Ordovician-Red River	14.35 - 28.1	Dolomite, greyish buff, medium bedded
			28.1 - 28.7	Dolomite, sandy, pyritic (lost core 28.7-29.6)
		Precambrian	29.6 - 38.78	Hornblende diorite-gabbro with sporadic quartz, feldspar and biotite-bearing pegmatite veins
M-23-83	SW16-3-64-25W		0 - 2.3	Overburden
(Site 14)	+ 296	Ordovician-Red River	2.3 - 11.4	Dolomite, buff, mottled
			11.4 - 11.6	Dolomite, sandy
		Precambrian	11.6 - 17.45	Layered hornblende- and biotite-bearing arkosic gneiss with thin orange granite segregations
M-24-83	C15-14-62-24W	Ordovician-Red River	0 - 24.7	Dolomite, buff, mottled, nodular to thick bedded
(Site 13)	+ 270		24.7 - 25.2	Dolomite, sandy
		Precambrian	25.2 - 42.8	Pink coarse-grained microcline granite cutting darker equigranular medium-grained tonalite, and intermediate biotite-bearing granite-granodiorite

The only similar lithology known to occur in the crater area is a thin conglomeratic zone intersected in the middle of the Jurassic(?) red bed section (Hole LSM-3). The lithologic similarity suggests a similar origin, and probably a relatively early age for the conglomerate, at a time when the relict paleotopographic relief related to the crater structure was still sufficiently well developed to provide the noted range of lithologies. By the same token, the lack of limestone fragments in the conglomerate precludes a very early, pre-Amaranth age for the conglomerate. The initial crater rim contained a high component of Devonian(?) limestones, as shown by the carbonate breccias (M-7-83), and any early-formed, rim-derived conglomerates would have contained such limestone fragments.

The conglomerate beds intersected in hole M-10-83 possibly represent a marginal facies of the Lower Amaranth red beds, and the thin conglomerate in LSM-3 may be a tongue of rim-derived detritus extending into the red bed depositional basin. The occurrence of gypsum "fragments", however, is difficult to explain on this basis, as the only apparent source for such fragments would seem to be the Upper Amaranth evaporite beds. The emplacement of the gypsum cement, however, would be easily explained. as the evaporite beds would have directly overlapped the conglomerate beds.

If the gypsum inclusions are true fragments, and are derived from erosion of the Upper Amaranth evaporite beds, then the conglomeratic beds in hole M-10-83 must represent some later, post- Middle Jurassic- pre-Glacial event, and more precise dating is not possible with available information.

5) OPERATION CORMORANT: A total of 14 shallow core holes were drilled in the general Simonhouse Lake-Wekusko Lake area (Fig.GS-22-4), primarily to determine the nature of the Precambrian basement beneath thin Phanerozoic cover. Hole locations were determined by W.D. McRitchie (GS-25, this report) on the basis of recent Federal/Provincial airborne gradiometer surveys. The holes were sited so as to ground truth the gradiometer response and provide lithologic correlation with the adjacent Precambrian outcrop area, with the ultimate aim of helping to evaluate the economic potential of the buried Precambrian rocks.

Target locations, determined from the gradiometer maps, were limited to road accessible points to allow for reasonable drill access. Detailed ground magnetometer profiles were then run for approximately 600 m along the access routes and across the target. Precise locations were based on these ground magnetic profiles (Scintrex Proton Precession Magnetometer-MP-2, total field). Optimum locations could not always be utilized because of limited access.

Summary results are presented in Table GS-22-1. In addition to the Precambrian data, the Phanerozoic portion of the core provided valuable data for the dolomite resources project (B.B. Bannatyne, GS-24, this report). Useful stratigraphic data also was obtained.

All core holes intersected dolomite strata comprising the lower portion of the Ordovician Red River Formation. No correlatable stratigraphic markers were observed in the dolomite section, although most holes showed a thin basal zone of sandy dolomite, ranging up to 0.8 m in thickness. One hole, M-21-83, intersected a thin, 0.23 m section of basal sandstone, probably correlative with the Winnipeg Formation. If the basal sandy beds represent a stratigraphic marker rather than merely a sandy facies, the slight thickness variations of this unit may indicate only slight paleotopographic relief on the Precambrian erosion surface.

A plot of the structural elevations on the Precambrian surface (Fig.GS-22-4), based on the 1983 drilling, as well as other data from mineral exploration test holes, is relatively uniform. The uniformity of the "structural" pattern tends to confirm the suggested uniformity of the Precambrian erosion surface, based on the stratigraphy. This is particularly evident for closely spaced holes where depths to Precambrian show only minor variation. The only anomalous value is shown by hole M-13-83 which may be as much as 15 m higher than regional. In general, Precambrian (i.e. pre-Phanerozoic) paleotopography appears to be limited to a maximum of about 15 m.

The strike on the Precambrian basement surface, and presumably also the strike of the overlying Phanerozoic strata, is N70° E. As noted previously by the writer (McCabe, 1971) this trend is markedly discordant to the regional structural trends of the Williston Basin, and appears to result from a post-Ordovician synclinal flexture, designated the Moose Lake Syncline. This feature is closely coincident with the Churchill-Superior boundary, and appears to result from slight renewed tectonic activity (subsidence) along this major structual feature.

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GS-23 THE ASHVILLE SAND (EARLY CRETACEOUS) OF SOUTHERN MANITOBA

by Frank Simpson[1]

The Ashville Sand is a poorly known, shaly sandstone sequence, occurring in the lower part of the dominantly argillaceous Ashville Formation of southern Manitoba. The study area is that part of southern Manitoba, delimited by the Saskatchewan-Manitoba border, the Forty-Ninth Parallel of Latitude and the erosional edge of the Ashville Formation (Fig.GS-23-1). Available data on the Ashville Sand and associated strata mainly take the form of geophysical well logs from boreholes, drilled to deeper targets, and cored sections of these rocks are relatively scarce.

The present account is a preliminary report with a two-fold purpose: 1) to describe and explain the distribution of lithologies referable to the Ashville Sand and the enveloping argillaceous strata; and 2) to comment on the hydrocarbon potential of the Ashville Sand. Lithologic descriptions of cored sections from the Ashville Sand and associated strata, stored in the University of Manitoba Drill-Core Library of the Manitoba Department of Energy and Mines, are presented in Appendix I.

REGIONAL SETTING

The Ashville Formation (Cretaceous) rests on the sandstones of the Swan River Formation and is overlain by the interbedded, calcareous shales, shaly chalks and bioclastic limestones of the Favel Formation (Fig.GS-23-2). The base of a widespread marker unit, the Fish-Scale Zone, divides the Ashville Formation into lower and upper parts and also is taken as the contact between Lower and Upper Cretaceous strata. The Ashville Sand occurs in the middle of the lower part of the largely argillaceous Ashville Formation. The Ashville Sand is composed of white and light grey, fine-to coarse-grained sandstone and interbedded, dark grey shale (Kirk, 1930: Wickenden, 1945). The unit is of widespread distribution in the subsurface of southern Manitoba. Maximum thickness values in the range 6 to 37 m are obtained in an irregular northwest-southeast belt, some 3 to 13 km wide, extending from Twp. 13, Rge. 27 WPM, to Twp. 4, Rge. 14 WPM (Bannatyne, 1970; McCabe, 1971). To the northeast of this belt, the unit is a blanket sand, 3 to 6 m thick, whereas to the southwest it is replaced by shales and mudstones of the Lower Ashville succession. The approximate equivalents of the Ashville Sand and associated strata in adjacent parts of Saskatchewan and North Dakota are shown in Figure GS-23-2.

The dispersal of the Ashville Sand appears to have been controlled to some extent by the trends of basement linear features and erosional irregularities of the sub-Mesozoic uncomformity. The belt of variable and anomalously high isopachous values for the Ashville Sand extends southeastwards from the vicinity of the Birdtail-Waskada axis to a series of magnetic anomalies, located to the north of Pelican Lake (Fig.GS-23-3). These features in turn are coincident with gravity anomalies (McCabe, 1978, Fig. 10, p. 19) and therefore may reflect basement structures, which exerted an influence on Ashville Sand sedimentation. A smaller area of relatively thick Ashville Sand (Bannatyne, 1970, Fig. 19, p. 37) is associated with the Nelson River gravity high to the south of the Porcupine Forest Reserve and another gravity high with a similar northeasterly trend, located farther east. The main belt of relatively thick Ashville Sand is also coincident with a series of erosional irregularities of the sub-Mesozoic unconformity, mapped by McCabe (1971, Fig. 15, p. 183), which are associated with the erosional edge of Mississippian strata, shown in Figure GS-23-4 It is also noteworthy that the solution edge of Prairie Evaporite salt (Middle Devonian) crosses the area of greatest thickness variation of the Ashville Sand.

LITHOLOGY

The dominant lithologies of the Lower Ashville succession are medium dark grey (N4) to dark grey (N3) mudstones and shales, which are typically non-calcareous and with variable silt content. These argillaceous rocks are commonly laminated. The mudstones and shales incorporate alternating sequences of sandstones and mudstones, which produce characteristically serrated responses on spontaneous potential and resistivity logs. The sandstones are commonly fine- and very fine-grained, quartzose, micaceous and kaolinitic They occur in lenses and continuous layers, ranging in thickness from a few millimetres to several centimetres and exhibiting gently Inclined lamination. These sandstones and associated siltstones of similar petrology are very light grey (N8) to light grey (N7) and yellowish grey (5Y 8/1) and are interbedded with mudstones and shales, which are frequently of comparable thickness. The sandstone and siltstone layers also occur sporadically throughout sequences, composed almost entirely of shale and mudstone. Sandstone and siltstone intercalations of the type described above occur between 612.6 and 617.5 m in the Anglo Ex Souris Valley Smart 4-1-1-26 well (Lsd 4-1-1-26 WPM). The primary stratification of some sandstone layers is disrupted by extensive bioturbation. Also noteworthy are dusky yellow green (5 GY 5/2), fine-grained, quartzose, glauconitic and micaceous sandstones and siltstones, which also occur regularly interbedded with mudstones and shales, as well as in sporadically distributed layers in dominantly argillaceous sequences. Glauconitic sandstones are found between 594.7 and 596.5 m in the Anglo Ex Dando No. 32-3 well (Lsd 3-32-1-25 WPM) and between 477.0 and 480.1 m in the Cal Standard Hartney No. 16-33 well (Lsd 16-33-5-24 WPM). Thin, sideritic concretionary layers in the order of a few centimetres thick and irregular segregations of pyrite were observed near the base of the Lower Ashville succession

Direct observations on the lithologic associations of the Ashville Sand were made with respect to cored sections between 350.5 and 352.0 m in the Imperial Blossom 3-17-12-24 well (Lsd 3-17-12-24 WPM) and between 371.7 and 374.3 m in the Imperial Normal 4-27-13-23 well (Lsd 4-27-13-23 WPM). In the former well, the total thickness of Ashville Sand penetrated is 6.0 m and the top 1.5 m was cored; in the latter, the entire Ashville Sand sequence (2.6 m) is represented in the cored section. The uppermost sandstones of the thicker section are light grey (N7) to medium light grey (N8) and yellowish grey (5 Y 8/2), quartzose. micaceous, and kaolinitic. They are fine- to medium-grained, with scattered coarse sand grains. The coarse grains are relatively scarce and some of them, which appear to be composed of chert. commonly display a black patina. The sandstones are very friable and exhibit closely spaced, irregular mudstone partings, typical for bioturbated deposits. The uppermost part of the Ashville Sand sequence, recovered from the Imperial Blossom 3-17-12-24 well, includes a layer of mudstone, at least 0.3 m thick and containing subordinate, thin intercalations of very fine-grained sandstone and siltstone. The serrated electric-log responses of all subsurface occurrences of the Ashville Sand, regardless of the total thickness of the unit, indicate that mudstone intercalations are common throughout

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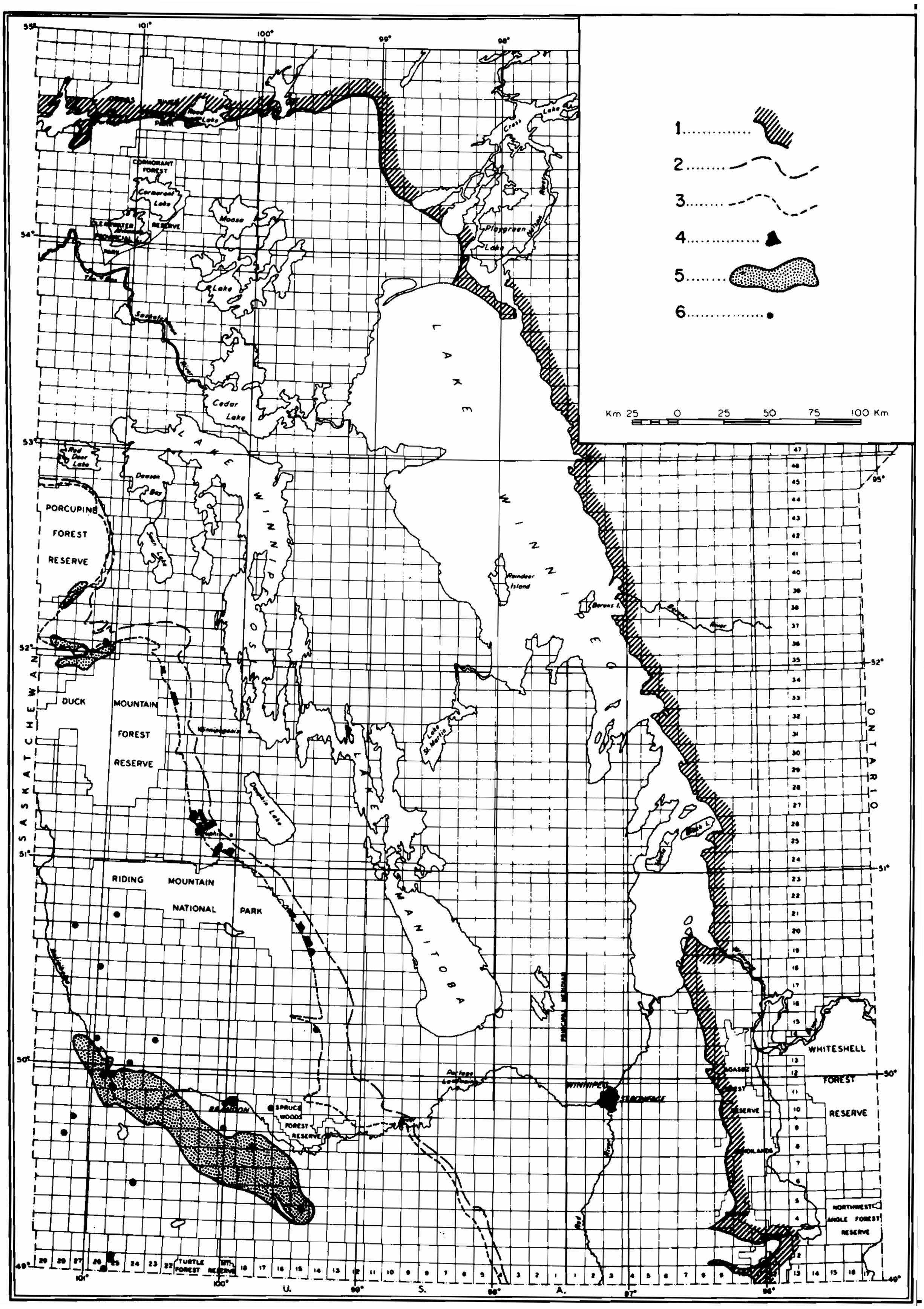


Figure GS-23-1: Sketch map showing location of study area: 1) southwestern perimeter of Precambrian Shield; 2) northeastern limit of Ashville Formation; 3) northeastern limit of Favel Formation; 4) area where Ashville Formation exposed; 5) area of thick Ashville sand; 6) location of wells with cored sections from Ashville Formation.

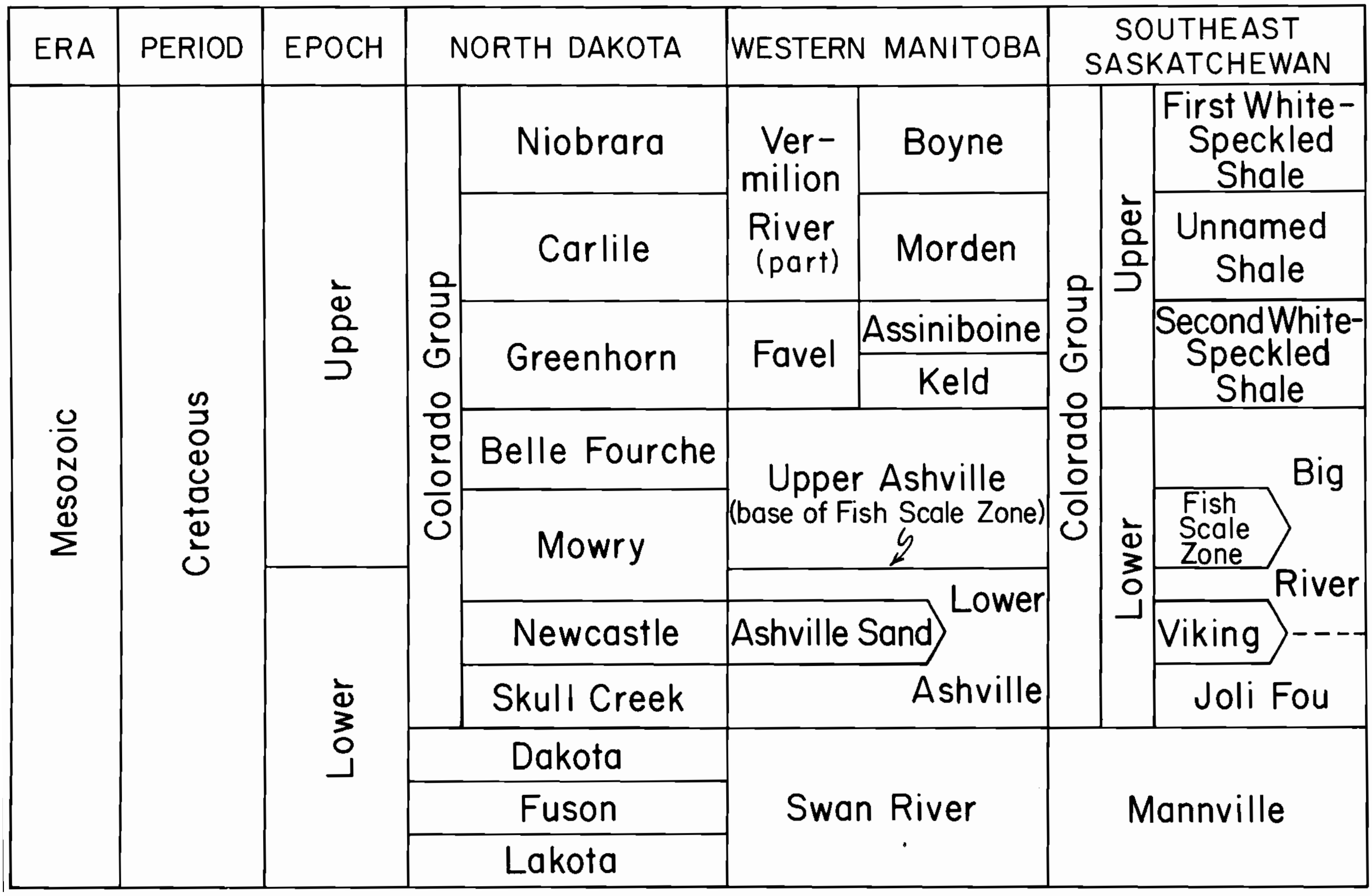


Figure G5-23-2: Main lithostratigraphic subdivisions of the Ashville Formation (Cretaceous) and equivalent strata in western Manitoba and adjacent areas.

the succession. The Ashville Sand sequence, cored in the Imperial Norman 4-27-13-23 well (Lsd 4-27-13-23 WPM), consists of alternating layers of siltstone and shale. The siltstones are light olive grey (5 Y 6/1), quartzose and micaceous and occur in layers up to several millimetres thick. Gently inclined lamination is the typical intrastratal structure. The siltstones alternate in vertical sequence with mudstone and shale layers of generally subordinate thickness.

The typical electric-log responses for the most widely encountered, "blanket" mode of occurrence of the Ashville Sand are sharply defined, serrated signatures, with the unit base marked by a relatively sharp contact with the underlying argillaceous rocks and the upper part of the unit exhibiting varying degrees of gradation with the overlying strata. Preliminary examination of geophysical well logs, corresponding to the relatively thick Ashville Sand sections, indicates that the lithologic associations present are similar to those of the "blanket" facies. Relatively thick occurrences of the Ashville Sand display sharp basal contacts and variably gradational relations with the overlying shales and mudstones. Spontaneous potential signatures are strong and prominently serrated, whereas the corresponding resistivity responses are relatively low. The pronounced right excursions of spontaneous potential logs mark the positions of mudstone intercalations, delimiting sandstone bodies, which are stacked vertically in multistorey complexes.

Lower Ashville strata, occurring above the Ashville Sand, consist of medium dark grey (N4) and dark grey (N3), non-calcareous shales and mudstones with variable silt content and Intercalations of siltstone and fine-grained sandstone, similar to those seen in the basal part of the Ashville succession. This part of the Ashville sequence was seen, for example, in the Imperial Norman 4-27-13-23 well (Lsd 4-27-13-23 WPM) between 357.4 and 371.7 m. The Fish-Scale Zone, occurring between 350.8 and 357.4 m in the same well, is made up of mudstones and shales with intercalations of siltstone and fine-grained sandstone, closely comparable in lithology to the underlying Lower Ashville argillaceous rocks, but with abundant accumulations of fish-skeletal debris. The Upper Ashville strata, occurring above the Fish-Scale Zone, were not seen in any of the cores examined, but the presence of mudstones and shales with siltstones and sandstone intercalations, similar to the Lower Ashville argillaceous rocks, is indicated by closely comparable electric-log responses.

STRATIGRAPHY

The northwest-trending belt of thick Ashville Sand extends parallel to the strike of the Lower Ashville succession and also coincides with isopachous high values for the Lower Ashville sequence as a whole (Bannatyne, 1970, Fig. 19, p. 37). However, the thick sections of Ashville Sand rest upon Lower Ashville shale sequences of correspondingly reduced thickness (Fig.GS-23-5). This suggests that there was localized erosion prior to deposition of the thick Ashville Sand succession. The relationship between the Ashville Sand and the enveloping argillaceous strata is closely comparable to the depositional formats of the Viking-Newcastle succession of southeastern Saskatchewan (Simpson and O'Connell, 1979, Simpson, 1980; O'Connell,

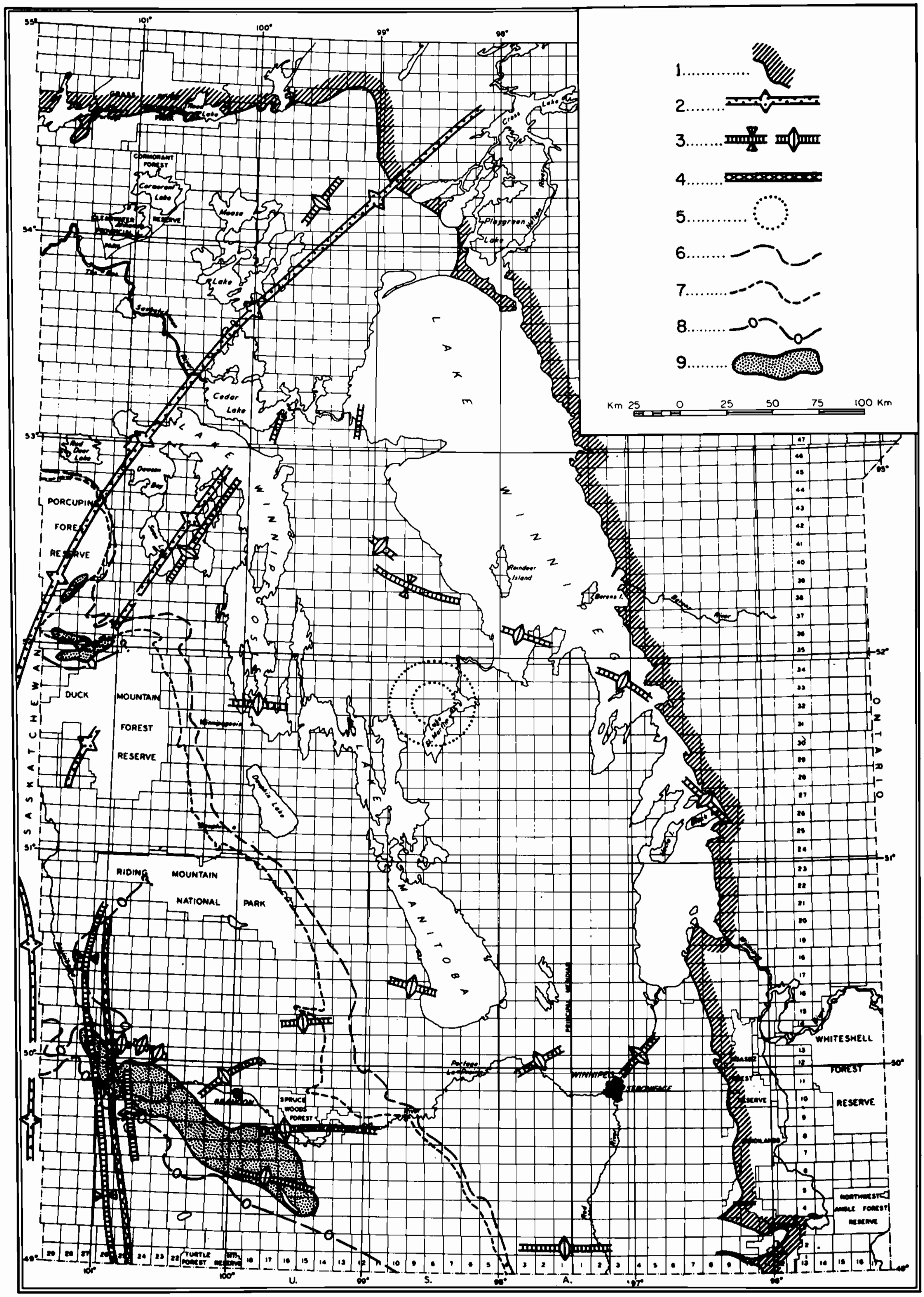


Figure GS-23-3: Sketch map showing main tectonic features of southern Manitoba in relation to occurrence of Ashville Sand: 1) southwestern perimeter of Precambrian Shield; 2) gravity anomaly (high); 3) magnetic anomaly; 4) Birdtail Lake-Waskada axis; 5) Lake St. Martin structure; 6) northeastern limit of Ashville Formation; 7) northeastern limit of Favel Formation; 8) depositional edge of Ashville sand; 9) area of thick Ashville sand.

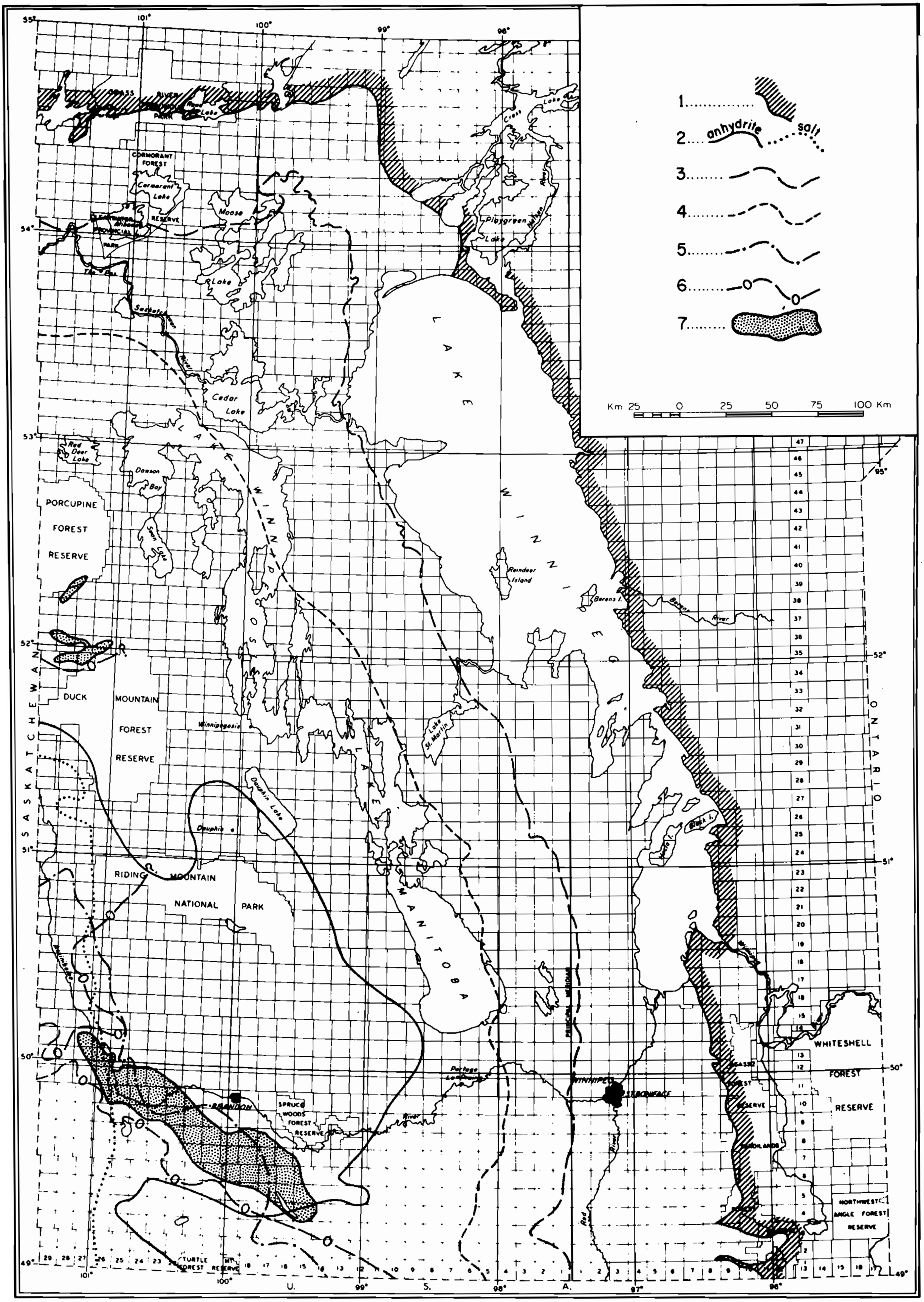
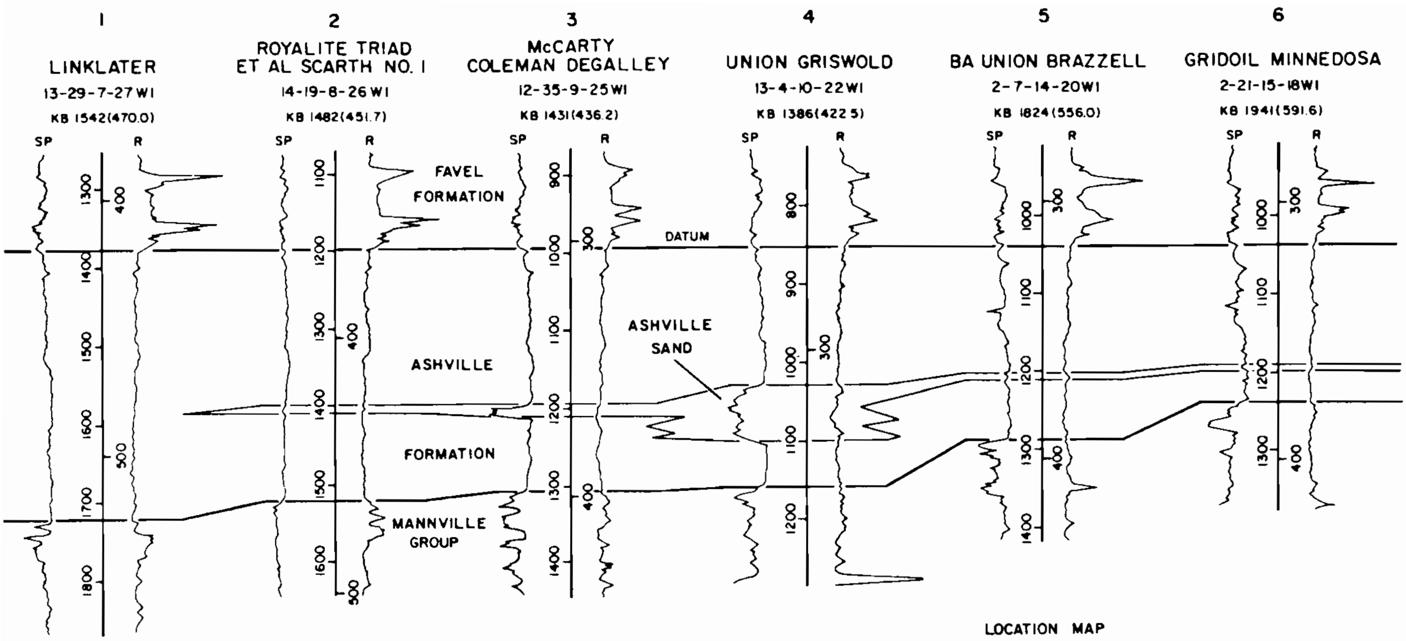


Figure GS-23-4: *Sketch map showing eastern limit of Prairie Evaporite and features of sub-Mesozoic unconformity in relation to occurrence of Ashville sand: 1) southwestern perimeter of Precambrian Shield, 2) edge of Prairie Evaporite (anhydrite/salt): 3) northeastern limit of Silurian strata: 4) northeastern limit of Devonian strata: 5) northeastern limit of Mississippian strata: 6) depositional edge of Ashville sand: 7) area of thick Ashville sand.*



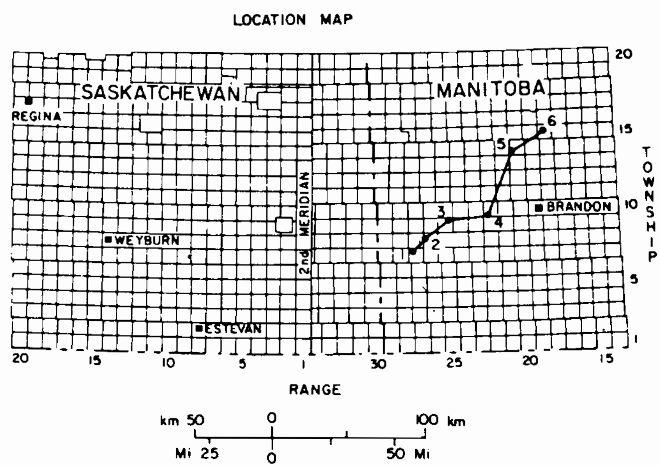


Figure GS-23-5:

Stratigraphic cross-section through the lower Colorado (Cretaceous) succession from the Linklater 13-29-7-27 well (Lsd 13-29-7-27 WPM) to Gridoil Minnedosa 2-21-15-18 well (Lsd 2-21-15-18 WPM), showing lithologic variation in Ashville Sand (Early Cretaceous) across south-western Manitoba.

1982) and the Newcastle Formation of the North Dakota (Hansen, 1955; Reishus, 1968; Anderson, 1969), both of which are characterized by abrupt, lateral facies change.

DEPOSITIONAL HISTORY

The blanket facies of the Ashville Sand was deposited on the shallow eastern shelf of an epeiric sea. The widespread occurrence of alternating sequences of sandstone and mudstone throughout the Ashville succession is closely comparable to that seen in the Colorado Group of Saskatchewan and is thought to be indicative of sediment dispersal by storm-generated currents (Simpson, 1975). The belt of thick Ashville Sand is considered to reflect deposition in a broad trough, which coincides in general with a belt of erosional irregularities at the sub-Mesozoic unconformity. The initiation of the trough probably came about as a result of differentiatial compaction of the underlying succession. This process may have been augmented by reactivation of basement linear features and the localized collapse of strata, associated with solution removal of the Prairie Evaporite.

HYDROCARBON POTENTIAL

Production of natural gas and crude oil has been obtained from approximately equivalent strata, referable to the Viking Formation of west-central Saskatchewan and the Muddy Formation of southeastern Montana respectively, but only minor showings of hydrocarbons have been recorded from the Ashville Sand of southern Manitoba. Although the Ashville Sand is penetrated by a large number of wells, drilled to deeper targets, it is probable that the full potential of the sequence for petroleum discovery remains to be realized. The shaly sandstones of the Ashville Sand are susceptible to plugging of porosity by drilling muds under pressure,[1] which would tend to preclude the detection of hydrocarbon showings, a drawback shared with low-permeability reservoirs throughout the marine Cretaceous succession of the northern Great Plains region.

[1]Ed. note: This type of plugging is believed to have occurred in the case of the Amaranth Red Beds of the Waskada area, where early exploratory wells drilled through this extensive new reservoir zone failed to produce significant oil shows.

The main hydrocarbon prospects are likely to be localized within the belt of thick Ashville Sand. Along the northeastern margin of the belt, capping lithologies are provided by the laterally equivalent Lower Ashville argillaceous rocks in updip settings and by interbedded shales and mudstones. Local reversals of dip resulting from solution-generated collapse of strata are also regarded as potential sites of hydrocarbon accumulation in the Ashville Sand.

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APPENDIX 1 GS-23

LITHOLOGIC DESCRIPTIONS OF SELECTED CORED SECTIONS FROM THE ASHVILLE FORMATION (CRETACEOUS) AND ASSOCIATED STRATA OF SOUTHERN MANITOBA

CALSTAN SPRUCE WOODS 13-12-10-17
Lsd 13-12-10-17 WPM KB 1260 ft. (384.0 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Lower Ashville Shale

740 - 742 (225.6 - 226.2)
Mudstone. Medium dark grey (N4) to dark grey (N3). silty in places, blocky, non-calcareous, with fish-skeletal debris; laminated. Core broken and disrupted throughout interval.

DOME BRANDON 3-5-9-19
Lsd 3-5-9-19 WPM KB 1373 ft. (418.5 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Ashville Shale (undifferentiated)

918-947 (279.8 - 288.6)
Shale. Medium dark grey (N4) to dark grey (N3), non-calcareous, laminated, fissile. Siltstone and sandstone intercalations are common, notably in basal 4 ft. (1.2 m). Sandstone light grey (N7) to medium light grey (N8), quartzose, micaceous, kaolinitic, in layers up to 2 cm thick, laminated. Sideritic concretionary layer, 10 cm thick, about 5 cm below interval top.

947 - 968 (288.6 - 295.0)
Shale. As in 918 - 947 ft. (279.8 - 288.6 m), but with greatly reduced proportion of siltstone and sandstone intercalations.

IMPERIAL NORMAN 4-27-13-23
Lsd 4-27-13-23 WPM KB 1686 ft. (513.9 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Fish-scale Zone

1151-1171 (350.8 - 356.9)
Shale. Medium dark grey (N4) to dark grey (N3). Increasingly silty below 1156 ft. (352.3 m). Variably fissile, becoming more blocky with increased silt content. Non-calcareous with common fish-skeletal debris. Lamination commonly visible. Scarce siltstone and very fine-grained sandstone intercalations up to several mm thick, light olive grey (5 Y 6/1), quartzose, micaceous, in gently inclined laminae. Bentonitic mudstone medium light grey (N6) in layer a few mm thick, laminated, at 1170 ft. (356.6m). Sub-horizontal, mud-filled, tubular burrows present. Gradational contact with

1171 -1172.5 (356.9 - 357.4)
Sandstone. Very light grey (N8) to light grey (N7) and yellowish grey (5 Y 8/1), fine-grained, quartzose, micaceous, kaolinitic, in layers up to several mm thick, with gently inclined lamination. Sandstones alternate in vertical sequence with mudstone layers of generally subordinate thickness. Mudstone as in main lithology of 1151-1171 ft. (350.8 - 356.9 m); layers commonly in gradational contact with underlying sandstones.

Lower Ashville Shale

1172.5 - 1219.5 (357.4 - 371.7)
Shale and mudstone. Main lithology as in 1151 - 1171 ft. (350.8 - 356.9 m), but with generally increased silt content and scarce fish-skeletal debris. Fissility poorly developed. Gradational contact with

Ashville Sand

1219.5 - 1228 (371.7 - 374.3)
Shale and siltstone. As in 1151 - 1171 ft. (350.8 - 356.9 m), with increased silt content and scarce fish-skeletal debris.

CAL STANDARD HARTNEY NO. 16-33
Lsd 16-33-5-24 WPM KB 1420 ft. (432.8 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Lower Ashville Shale

1530 - 1550 (466.3 - 472.4)
Shale. Medium dark grey (N4) to dark grey (N3), silty in places, non-calcareous, laminated, fissile. Siltstone and sandstone intercalations occur sporadically. Sandstone light grey (N7) to medium light grey (N8) and yellowish grey (5 Y 8/1), fine-grained, quartzose, micaceous, kaolinitic, in layers up to a few mm thick, laminated.

1550 - 1565 (472.4 - 477.0)
No core.

1565 - 1575 (477.0 - 480.1)
Shale. As in 1530 - 1550 ft. (466.3 -472.4m), but also incorporating thin layers of glauconitic sandstone. Sandstone dusky yellow-green (5 GY 5/2), fine-grained, quartzose, glauconitic, in irregular lenses up to 1 cm thick.

1575 - 1587 (480.1 - 4837)
Mudstone. As in 1530 - 1550 ft. (466.3 - 472.4 m), but with fissility less developed, notably in top 5 ft. (1.5 m) where common intercalations of glauconitic sandstone and

	siltstone occur. Latter lithology as in 1565-1575 ft. (447.0 - 480.1 m). Gradational contact with
1587 - 1628 (483.7 - 496.2)	Shale. As in 1530-1550 ft. (466.3 - 472.4) Sideritic concretionary layer about 4 cm thick at 1620 ft. (493.8 m).
1628 - 1683 (496.2 - 513.0)	Mudstone and siltstone. Main lithologies as in 1530-1550 ft. (466.3 - 472.4 m), but with abundant intercalations of siltstone and fine-grained sandstone as layers up to a few mm thick, separated by mudstone layers of similar thickness.

SWAN RIVER FORMATION

1683 - 1688 (513.0 - 514.5)	Sandstone. Very light grey (N8) to light grey (N7) and light greenish grey (5 GY 8/1), fine-grained, quartzose, kaolinitic, with calcite cement, in planar cross-laminae.

IMPERIAL BLOSSOM 3-17-12-24
Lsd 3-17-12-24 WPM KB 1551 ft. (472.7 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Lower Ashville Shale

1120 - 1150 (341.4 - 350.5)	Mudstone. Medium dark grey (N4) to dark grey (N3), silty in places, blocky, non-calcareous, laminated. Scarce siltstone and sandstone intercalations becoming increasingly common downwards. Sandstone very light grey (N8) to light grey (N7) and yellowish grey (5 Y 8/1), very fine-grained, quartzose, micaceous, kaolinitic; in layers up to several mm thick, but commonly less than 1 mm in thickness, laminated. Gradational contact with

Ashville Sand

1150 - 1155 (350.5 - 352.0)	Sandstone. Light grey (N7) to medium light grey (N8) and yellowish grey (5 Y 8/1), fine-grained, medium-grained in places near interval top, with scattered coarse grains (quartz and grains with black patina, possibly chert), quartzose, micaceous, kaolinitic; appears to be bioturbated in places, very friable. Mudstone with subordinate siltstone and sandstone intercalations in layer at least 1 ft (0.3 m) thick at about 1153 ft. (351.4 m). Mudstone as in 1120 - 1150 ft. (341.4 - 350.5 m). Recovery 3.5 ft. (1.1 m).
1155 - 1201 (352.0 - 366.1)	No core.

Lower Ashville Shale

1201-1212 (366.1 - 369.4)	Mudstone. As in 1120 - 1150 ft. (341.4 - 350.5 m). Sideritic concretionary layer 4 cm thick at interval top. Sandstone and siltstone intercalations a few mm to 2 cm thick; in form of cross-laminated lenses, separated by mudstone.

ANGLO EX DANDO NO. 32-3
Lsd 3-32-1-25 WPM KB 1154 ft. (473.7 m)

ASHVILLE FORMATION

Depth below KB in It (m)

Lower Ashville Shale

1951 - 1957 (594.7 - 596.5)	Mudstone. Medium dark grey (N4) to dark grey (N3), non-calcareous, silty, laminated; blocky, fissile in places. Siltstone and sandstone intercalations occur sporadically. Sandstone light (N7) to medium light grey (N8), very fine-grained, quartzose, micaceous; also dusky yellow green (5 GY 5/2), fine-grained, quartzose, glauconitic, micaceous; in layers up to a few mm thick, laminated.
1957 - 1959 (5965 - 597.1)	No core
1959 - 1967 (597.1 - 599.5)	Mudstone. As in 1951 - 1957 ft. (594.7 - 596.5 m), but without glauconitic intercalations. Irregular segregations of pyrite present.

SWAN RIVER FORMATION

1967 - 1978 (599.5 - 6029)	Sandstone. Very light grey (N8) to light grey (N7), and yellowish grey (5 Y 8/1). Medium- to fine-grained, coarse-grained in places, quartzose, kaolinitic; with irregular lamination, extensively bioturbated, especially in top 6 ft. (1.8 m) of interval.

ANGLO EX SOURIS VALLEY SMART 4-1-1-26
Lsd 4-1-1-26 WPM KB 1527 ft. (465.4 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Lower Ashville Shale

2010 - 2026 (612.6 - 617.5)	Shale. Medium dark grey (N4) to dark grey (N3), silty in places, non-calcareous, laminated, fissile. Siltstone and sandstone intercalations of sporadic occurrence. Sandstone light grey (N7) to medium light grey (N8), line-grained, quartzose, micaceous, kaolinitic, in layers up to a few mm thick, laminated. Extensively bioturbated layer of fine-grained sandstone, 4 cm thick, at 2013 ft. (613.6 m), strongly indurated with abundant calcite cement; sand-lined, mud-filled burrows of variable orientation. Sideritic concretionary layer, 2.5 cm thick, at 2014 ft. (613.9 m). Sharp contact with

SWAN RIVER FORMATION

2026 - 2029 (617.5 - 618.4)	Sandstone Very light grey (N8) to light grey (N7), coarse-grained, quartzose, kaolinitic, with abundant calcite cement; in inclined, planar laminae; bioturbated near top of interval. Mudstone intercalations generally less than 1 cm thick, as in 2010 - 2026 ft. (612.6 - 617.5 m).

IMPERIAL BIRTLE 1-27-17-26
Lsd 1-27-17-26 WPM KB 1791 ft. (545.9 m)

FAVEL FORMATION

Depth below KB in ft. (m)	
976 - 988 (297.5 - 301.1)	Calcareous siltstone. Medium light grey (N6) to medium grey (N5), quartzose, micaceous, with calcite cement; laminated, with irregular mudstone partings and thin intercalations occurring sporadically. Mudstone medium dark grey (N4), calcareous, silty, with abundant coccolithic aggregates giving speckled appearance. Scattered fish-skeletal debris and pelecypod **(Inoceramus)** fragments are common.
988 - 1093 (301.1 - 333.1)	No. core.

ASHVILLE FORMATION

Fish-scale Zone

1093 - 1098 (333.1 - 334.7)	Mudstone. Medium dark grey (N4) to dark grey (N3), silty in places, non-calcareous, laminated. Fish-skeletal debris concentrated in layers one clast thick in places. With sporadically occurring intercalations of siltstone and very fine-grained sandstone, medium grey (N5), quartzose, micaceous, in layers a few **mm** thick, laminated, grading upwards into mudstone.

CHEVRON WOODNORTH PROV 5-18-9-27
Lsd 5-18-9-27 WPM KB 1598 ft. (487.1 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Lower Ashville Shale

1564 - 1573 (476.7 - 479.5)	Shale. Medium dark grey (N4) to dark grey (N3), silty in places, variably fissile, non-calcareous, laminated. Sporadically occurring siltstone and sandstone intercalations. Sandstone very light grey (N8) to light grey (N7) and yellowish grey (5Y 8/1), fine-grained, micaceous, kaolinitic, in layers up to several mm thick, with gently inclined and horizontal laminae. Core extensively broken.

CHEVRON EWART PROV 4-14-8-28
Lsd 4-14-8-28 WPM KB 1310 ft. (399.3 m)

ASHVILLE FORMATION

Depth below KB in ft. (m)

Ashville Shale (undifferentiated)

1695 - 1703 (516.6-5191)	Shale. Medium dark grey (N4) to dark grey (N3), non-calcareous, laminated, fissile. Sporadically occurring siltstone and sandstone intercalations. Sandstone light grey (N7) to medium light grey (N8) and light olive grey (5Y 6/1), fine-grained quartzose, micaceous, kaolinitic, in lenses and continuous layers up to several mm thick, laminated.
1703 - 1773 (519.1-540.4)	No core.
1773-1778 (540.4 - 541.9)	Shale. As in 1695 - 1703 ft. (516.6 - 519.1 m). Core broken.

GS-24 INDUSTRIAL MINERALS INVESTIGATIONS, 1983 (NTS: VARIOUS)

by Barry B. Bannatyne

1) DOLOMITE IN SOUTHERN MANITOBA

Mapping of the dolomite resources of Manitoba continued in 1983. Field work was concentrated

a) in the Interlake area from Riverton to Fisher Branch and Mantagao Lake, and

b) in the northern part of the dolomite belt, at Wekusko, Cormorant Lake and Clearwater Lake. In both areas, traverses were made across the Ordovician and Silurian outcrop belts. Sufficient data are now available for preparation of a report on the dolomite resources of Manitoba, south of 54°40' latitude.

Compilation of data on several NTS sheets (parts of NTS 62N, 620, 62P. 63B. 63C) was completed and additions and revisions to the combined map of Grand Rapids-The Pas (NTS 63F, G, J, K) were made. The maps show the locations of dolomite outcrops, quarries. areas where dolomite is possibly present within a metre or so of the surface (based on soil-map data) and available data from various sources on the depth to bedrock.

Vast resources of dolomite are present in the Interlake area north from Inwood to Lake St. Martin, and west to Lake Manitoba; and in the approximately triangular area bounded by Grand Rapids-Ponton-Namew Lake. Other important reserves occur in the Stonewall-Gunton area (of immediate economic importance to the dominant market region around Winnipeg), in the Garson area for Tyndall stone, in Devonian rocks around The Narrows of Lake Manitoba, and elsewhere. Quarry locations are shown on the Mineral Map of Manitoba (Map 80-1), and also listed on Index Map 12: Industrial Minerals Producers, both available from the Mineral Resources Division.

The outcrops and quarries in the Wekusko-Snow Lake area were examined in detail in order to determine their stratigraphic position. Additional information was obtained from drill core from holes M-11-83 to M-22-83 (Table GS-22-1), and hole M-7-79 at Wekusko. The dolomite exhibits various textures, e.g. burrow-mottled, bioturbated, solution-compacted nodular, and bioclastic, that are similar to textures illustrated by Kendall (1976, 1977) from Ordovician carbonates in southern Manitoba and southeastern Saskatchewan. Other diagenetic features (e.g. pyritized hardgrounds, solution porosity, desiccation cracks), the occurrence of fossils (corals, Receptaculites, stromatolites) and the presence of layers and nodules of chert at intervals in the section, are useful in correlating strata in some parts of the area. However, it is evident that lateral changes in texture are present, and correlations between some parts of the area are as yet uncertain. All the dolomites are believed to be Red River Formation, with the possible exception of those exposed in the "Wekusko North" and "Sunday Lake" quarries - these are believed to be either uppermost Red River or outliers of the Stony Mountain Formation. Subdivision of the Red River strata into the Dog Head-Cat Head-Selkirk-Fort Garry sequence of southern Manitoba is a possibility, but will be difficult and further detailed work is necessary. McCabe (1980) indicates that the Cat Head Member may not be distinguishable from the Dog Head and Selkirk Members in this area.

Basal sandstone is present only as a layer less than 1m thick, or as dolomitic sandstone. A time-transgressive stratigraphic relationship probably exists with the Winnipeg Formation. Both lithologies are absent in some places, especially between Wekusko Lake and Wekusko where dolomite, which may include some sand grains. lies directly on top of weathered Precambrian rock.

The Ordovician strata form a 25 to 30m escarpment, as well as outliers, in the Wekusko Lake area. Spectacular cliffs with deep ice-bottomed crevices, as well as massive blocks of toppled dolomite, occur at Hales Landing (follow east road to start of posted trail to Observation Point) at the southeastern corner of Wekusko Lake.

The dolomites are variably coloured reddish, purplish red, olive or buff. and take a good polish. Some of the rock may be suitable for some dimension stone uses (e.g. small ornaments, window sills) but detailed testing is required as hairline cracks and fractures are common in polished specimens from quarries. Drill core samples appear to be more coherent, and in some holes much of the rock is thick bedded.

2) ELM POINT LIMESTONE, DOLLY BAY AREA

High-calcium limestone of the Elm Point Formation is progressively dolomitized towards the Elk Point Basin. The dolomitization is evident through increases in both the Mg-content and the amount of matrix surrounding high-Ca mottles. The facies transition to dolomite of the lower Winnipegosis Formation is completed over a distance of a few kilometres (Bannatyne, 1975: Norris et al. 1982). The outcrop belt east of Lake Manitoba is the source of high-calcium limestone for Portland cement and lime in the Faulkner-Steep Rock area, and similar stone was once quarried at Spearhill and Lily Bay. Magnesium limestone has been quarried for crushed stone north of Lily Bay and for lime at Oak Point.

Between Dog Lake and Moosehorn Bay several outcrops of limestone show a range in MgO content from 0.35% to 6.63% (Fig.

TABLE GS-24-1
DOLOMITIC AND MAGNESIAN LIMESTONE, ELM POINT FORMATION: DRILL HOLE M-5-83, DOLLY BAY (14-34-24-9W)

Depth in m	5.6-10.6	10.6-15.6	15.6-20.6	20.6-25.6	25.6-29.3	29.3-30.7
SiO_2	0.83	0.90	0.96	1.05	1.36	0.91
Al_2O_3	0.3	0.4	0.3	0.5	0.5	0.3
Fe_2O_3	0.18	0.16	0.14	0.14	0.29	1.10
CaO	43.17	47.34	42.21	49.73	49.73	49.20
MgO	10.20	6.97	10.99	4.29	4.16	4.58
Na_2O	0.06	0.04	0.03	0.02	0.02	0.03
K_2O	0.08	0.11	0.14	0.15	0.21	0.12
TiO_2	0.00	0.00	0.00	0.00	0.00	0.00
P_2O_5	0.01	0.01	0.01	0.02	0.02	0.01
MnO	0.02	0.02	0.02	0.02	0.02	0.03
LOI	45.20	44.59	45.18	43.89	43.59	43.82
Total	100.05	100.54	99.98	99.81	99.90	100.10
Calculated						
$CaCO_3$	77.05	84.49	75.34	88.76	88.76	87.81
$MgCO_3$	21.33	14.58	22.99	8.97	8.70	9.58
Carbonate	98.38	99.07	98.33	97.73	97.46	97.39

Analyses by Geological Services Branch Analytical Laboratory.

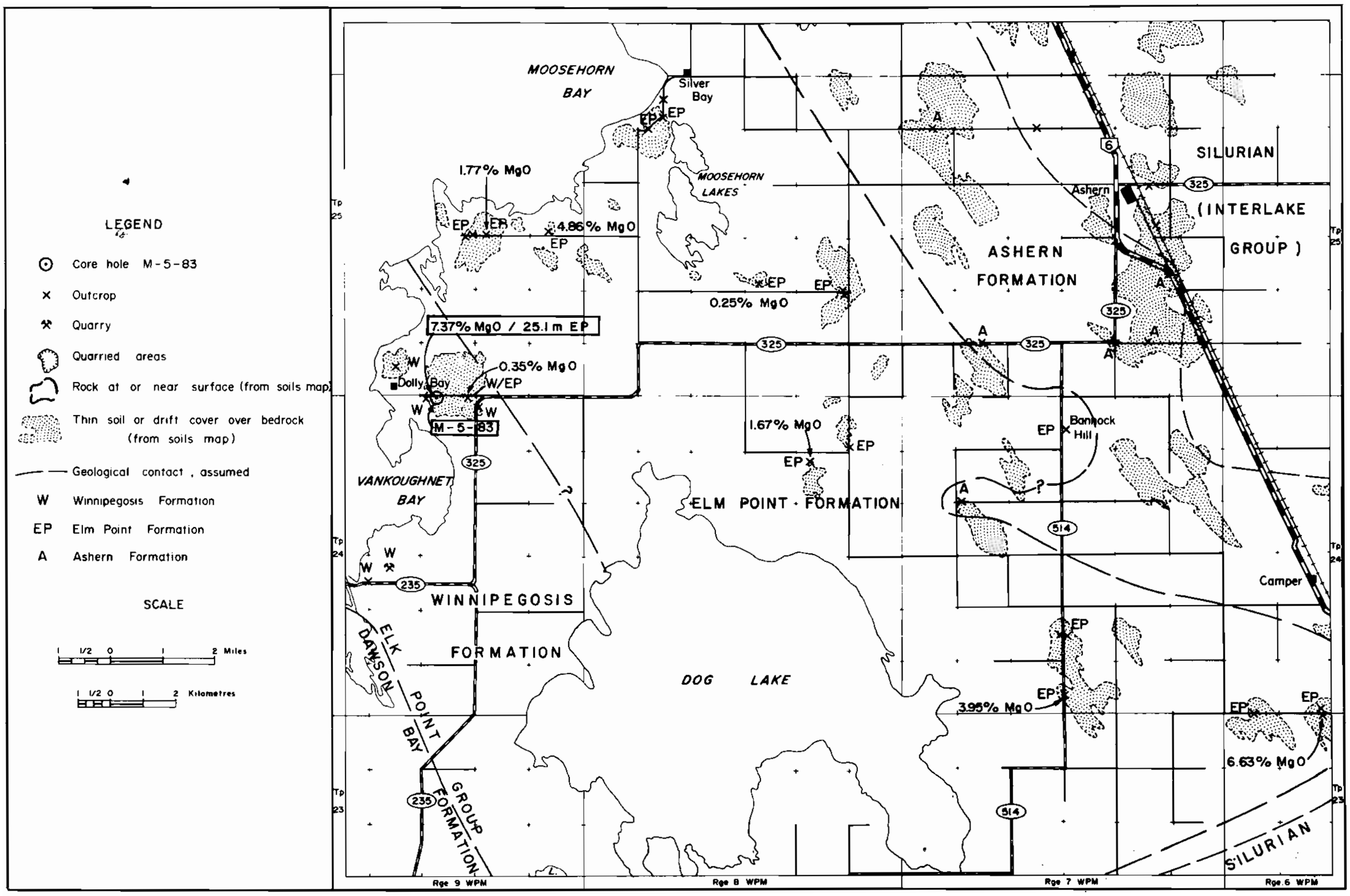

Figure GS-24-1: Limestone in the Elk Point Formation, Dolly Bay area.

8S-24-1). The outcrop of high-Ca limestone in 16-34-24-9W, east of Dolly Bay, is overlain by dolomite of the Winnipegosis Formation. Drill hole M-5-83, sited on dolomite 1km west of the limestone outcrop, intersected 4.8m of Winnipegosis dolomite, and the complete thickness of 26.4m of Elm Point Formation. Stain tests indicated the upper 0.55m consists of high-Ca stone, correlated with the outcrop stone that contains 99.4% $CaCO_3$ and 0.7% $MgCO_3$ (0.35% MgO). This layer is separated by a 0.3m interbed of porous dolomite from the remainder of the formation. Stain tests showed the stone has a variably dolomitized matrix, and samples were submitted for chemical analysis (Table 8S-24-1).

The results indicate an average content of 82.88% $CaCO_3$ over 25.1m. MgO content averages 7.37%. being higher in the upper 15m. and averaging 4.28% MgO in the lower 10.1 m. Some parts of the lower section appear to be high-Ca stone, and thus, because experience in the Lily Bay area has demonstrated that the change from dolomite to limestone can occur over a short distance, the Dog Lake-Dolly Bay-Moosehorn Bay area is considered to have some potential for high-Ca limestone.

Detailed exploration would be required to determine reserves suitable for production. The formation thins eastward across range 8, at about 1.9m/km. The thickness of 26.4m of Elm Point Formation is significant as it indicates a thickness 10m greater than that previously reported in the outcrop belt. e.g. 16.1 m present near Elm Point on Lake Manitoba. where the upper part of the formation has been eroded.

3) POTASH

Open File Report 82-3 on the potash deposits in the Devonian Prairie Evaporite was completed in 1983. Results of 8 potash test holes drilled in 1980 and 1981 are included, as they have been released from confidential status Reserves of potash in the St. Lazare-McAuley area are calculated as 650 million tonnes grading 20.9% K_2O in sylvite. using a cutoff grade of 16% K_2O in sylvite. The report includes a summary of potash intersections in 33 potash test holes, as well as indications of potash in oil exploration holes from McAuley south to the International Boundary.

In 1983, Amax Minerals released preliminary results of their drilling in the area southwest of Russell. indicating a good grade of potash. In September 1983 the company, now Canamax Resources Inc. began drilling 5 additional holes on ground covered by their exploration permit.

The Esterhazy Member contains a 2.44m (8-foot) layer of medium to coarsely crystalline halite and sylvite, with accessory carnallite and minor green dolomitic clay and anhydrite It is similar to the potash quarried in the Esterhazy and Rocanville areas across the border in Saskatchewan.

4) **CHROMITE IN THE BIRD RIVER SILL**

The detailed re-mapping of the chromite deposits in the Bird River Sill, in the vicinity of the Chrome and Page deposits north of Bird River, was undertaken as part of the 'Chromite Project' (see reports GS-12 and GS-20, this volume).

Preliminary results show that the sill is more complexly faulted than previously known. and that a total of 26 chromite layers or concentrations are present and are sufficiently recognizable to be correlated along this portion of the sill. Previous ore reserve calculations (Bateman, 1943; Davies, 1958; Bannatyne and Trueman, 1982) considered only the Main Upper and/or the Lower North seams. The current work indicates that analyses of the total chromite-bearing zone, including the serpentinized sill material between the chromite layers, are required, and that the possibility of mining the upper 60m width of chrome-bearing material by open-pit methods should be investigated. Problems related to mining of complexly faulted zones would be eliminated, although the grade of material would be lowered considerably.

Analysis of the chromite material is in progress.

5) **OTHER INDUSTRIAL MINERALS WORK INVOLVED:**

a) an examination and sampling to determine distribution of sphagnum peat in a previously located bog in southeastern Manitoba.
b) a visit to the Giroux bog, where production began in the spring of 1983 by Premier West Limited. The bog was located during the 1976-77 peat survey.
c) drilling of the gypsum deposit at Gypsumville as part of the Lake St. Martin crater study (details held confidential at request of the producer).
d) field work at Lake St. Martin.
e) kaolin-silica deposit, sample examination; field examination around old shaft for "lignite".
f) a granite quarry investigation
g) examination of a few selected pegmatites in the Tooth Lake, Cat Lake, and Falcon Lake areas.
h) sampling of dolomite and granite quarries with C.Jones (see report AR-4, this volume) as part of a continuing program of evaluation of bedrock formations for aggregate.

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GS-25 GEOPHYSICAL AND GEOCHEMICAL SURVEYS

by W.D. McRitchie and I. Hosain

a: AIRBORNE VERTICAL GRADIENT MAGNETOMETER (GRADIOMETER) SURVEYS

Gradiometer surveys in 1983 were conducted by the Geological Survey of Canada as one of the programs under the cost-shared Federal/Provincial Interim Mineral Agreement (1983-85). A total of 5 200 line kilometres were scheduled for the Barrington Lake area (Fig. GS-25-1) as an extension of the program initiated at Lynn Lake in 1982. As in previous years the survey specifications required the aircraft to fly at a height of 152 m along north-south flight lines spaced 305 m apart. Complete coverage was obtained for the area between latitudes 56 degrees 45 minutes and 57 degrees north, and longitudes 100 degrees and 100 degrees 45 minutes west. The results of the surveys will be issued early in 1984 as total field and vertical gradient 1:20 000 scale black and white contoured maps and as 1:50 000 scale coloured Applicon plots.

Analysis of the gradiometer information from the 1982 test survey indicated that the increased resolution of the vertical gradient system was extremely useful in delineating low relief anomalies. Accordingly, the surveys provide a coherent and consistent data base that facilitates the reliable extrapolation and tracing of individual lithologies and stratigraphic packages throughout this region of poor and sparsely exposed bedrock.

Previous surveys in the Lynn Lake and McClarty Lake area were released at 1200 hr COT June 30, 1983 as GSC Open Files 936 and 937. Copies may be obtained at user's expense from Campbell Reproductions, 880 Wellington Street, Ottawa, Ontario, K1R 6K7. Digital magnetic tapes containing the edited recorded data and gridded aeromagnetic data for both Open Files are available from the Geological Survey of Canada, Room 567, 601 Booth Street, Ottawa, Ontario, K1A OE8, at the user's expense on a cost recovery basis.

On July 15, 1983, 1:50 000 scale Experimental colour Total Field and Gradiometer Maps of the Flin Flon district were released for the areas indicated below:

	Total Field	Total Field
63K/5 - N.E. quarter	C20345G	C40087G
63K/6 - north half	C20342G	C40083G
63K/7 - north half	C20340G	C40081 G
63K/10 - full sheet	C20341G	C40082G
63K/11 - full sheet	C20343G	C40084G
63K/12 - east half	C20347G	C40088G
63K/13 - east half	C20348G	C40089G
63K/14 - full sheet	C20344G	C40085G
63N/3 - east half	C20345G	C40086G

Contour maps at a scale of 1:20 000 covering the above area were released as G.S.C. Open Files 756, 876, 877 and a portion of 937. Aeromagnetic digital data from the open files were interpolated at the nodes of a regular grid covering the survey area. Each grid cell was 0.08 cm square. A colour code was assigned to each cell according to the aeromagnetic values within the cell. The data matrix was output on an APPLICON colour jet plotted to produce interval map, using 39 shades of colour. To facilitate colour printing a colour separation was made automatically with the plotter to give the yellow, blue and red components of the map on separate sheets.

This represents the first publication release of fully processed data from the Project Cormorant area (Fig. GS-25-2). Complete total field and vertical gradient data for the Precambrian Shield south of Flin Flon and Snow Lake, including an extensive segment covered by Paleozoic limestone, will become available with the publication of the coloured Applicon plots of the 1:50 000 scale McClarty Lake maps scheduled for 1984.

During the summer of 1983, 14 holes were drilled to an approximate depth of 30 metres to test magnetic anomalies of unknown parentage in the Project Cormorant area (see Report GS-22, Fig. GS-22-4 and Table GS-22-1). Data from this "scout drilling" program will extend the control provided from exploration drilling and other geophysical data, and will be incorporated into 1:250 000 scale geological compilations of the sub-Paleozoic basement in the area. Of particular interest, three holes south of Reed Lake in a sub-circular magnetic anomaly, encountered a layered complex of norite, gabbro, melagabbro (with cumulate plagioclase) and ultramafic, with associated biotite, carbonate and epidote-rich derivatives.

Interpretation of the airborne magnetic gradiometer surveys of the Goose Lake-McClarty Lake area (Fig. GS-25-2) is being carried out by Ifti Hosain of the Geoscience Data Section, Manitoba Mines Branch. The drill hole information from the assessment files are being used to determine the gradient signatures produced by the different rock types and to trace the lithologic units below the Paleozoic limestones and dolomites. Geophysical information from the assessment files is being used to determine if any correlation exists between the conductors and the gradient anomalies. Generally rock types which have large susceptibility contrasts like granites and gabbros are easily recognizable. Rock types which have smaller susceptibility contrasts like granites and granodiorite require careful examination as their range of susceptibility overlaps. In some instances, recognition of the subtle differences may not be reliable as a rhyolite containing sulphides may produce a volume susceptibility which may fall within the range of a basalt or diorite. By using the results of an E.M. survey the problem may be resolved. The gradiometer together with the total field is fairly reliable in outlining faults and unravelling the structure. Therefore, by using the drill hole information together with the various geophysical surveys an attempt is being made to unravel the geology below the Paleozoic.

The assistance of Dr. Arthur Darnley and Dr. Peter Hood (GSC) in arranging for the implementation and administration of the surveys, under less than ideal circumstances, is gratefully acknowledged as are the valuable contributions made by Dr. Les Kornik in providing guidelines for undertaking the analysis of the resultant data.

b: REGIONAL LAKE SEDIMENT GEOCHEMICAL SURVEYS

A helicopter-supported Regional Lake Sediment Geochemical Survey was implemented in the Lynn Lake area as one of the many new thrusts being brought to bear on the region under the umbrella of the Interim Mineral Agreement. Complete coverage was obtained for NTS area 64C with a sample density of one per 13 km^2 in the southern (gneissic) half of the region (64C/1-8) and one per 7 km^2 in the northern half over the greenstone terrain (64C/9-16). Water samples (1 ,445) were split, one set being analyzed by the Technical Services Laboratory of the Manitoba Department of Environment and Workplace Safety and Health, as part of the Environmental Management Services Branch program to assess the potential impact of acid rain on the Province. The second set of water samples and the sediment samples are being analyzed respectively by Acme Analytical Laboratories Ltd. and Chemex Labs Ltd., both of Vancouver, for a broad spectrum of

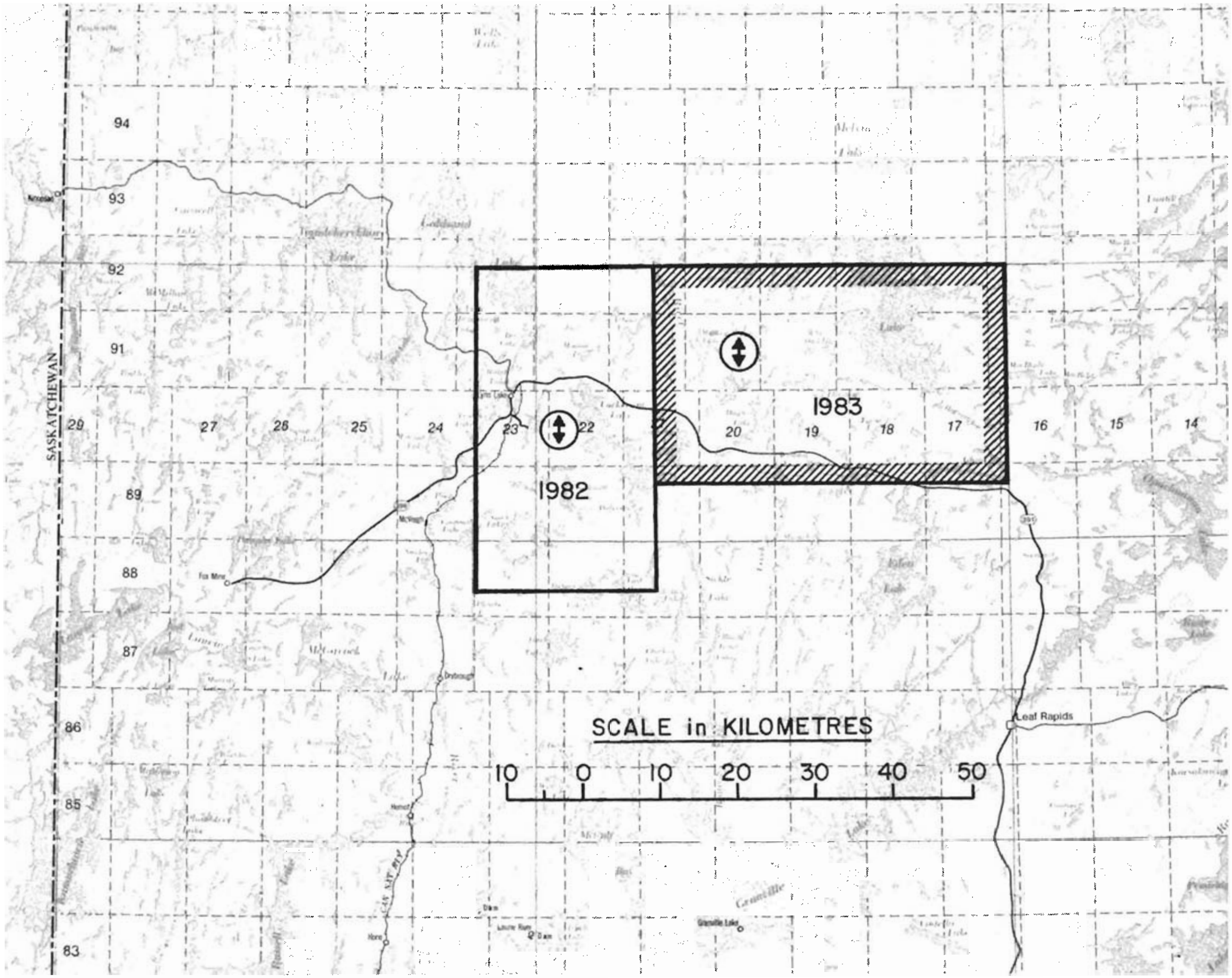

Figure GS-25-1 Gradiometer surveys in the Lynn Lake region.

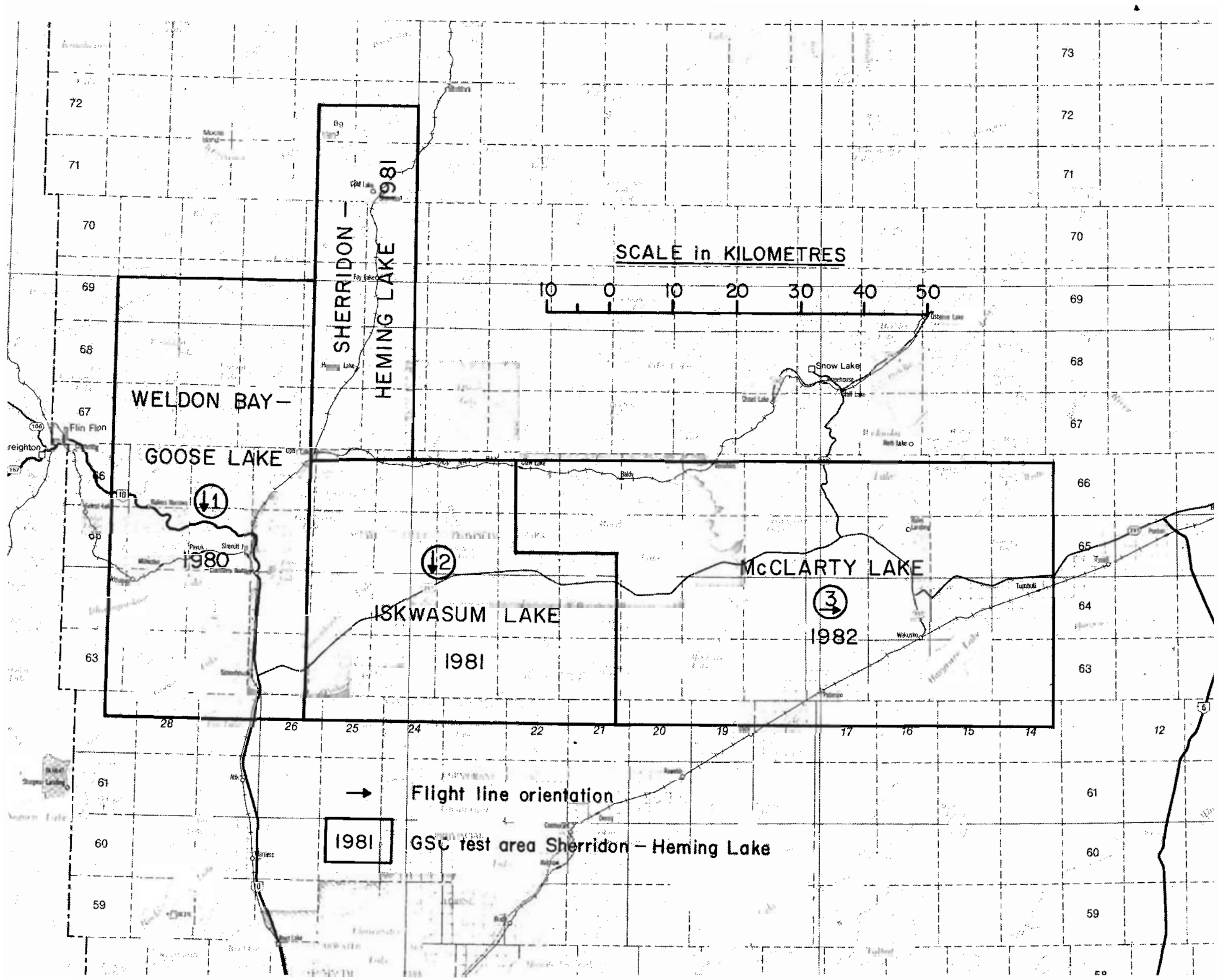

Figure GS-25-2: Gradlomeler surveys in lhe Project Cormoranl area, major and minor elements with joint Open File publication of results by the Manitoba Mineral Resources Division and the Geological *Survey* of Canada (as 1:250 000 scale, element abundance and ratio maps) scheduled for early 1984.

Analysis of the geochemical data in the context of both the bedrock and surficial geological settings will be facilitated by the provisional 1:250 000 scale bedrock compilation of the area (H.V. Zwanzig, Manitoba Geological Services Branch, Open File, in prep.) and by the recent surficial mapping and basal till studies undertaken respectively by R. DiLabio (GSC) and E Nielsen (MGSB) (see report GS-16, this volume).

ACKNOWLEDGEMENTS

The Branch is indebted to all students who acted in an assistant capacity during the summer field program. Increased restraints to this aspect of the Division's work has clearly indicated the pitfalls attendant in mounting field surveys with skeletal support staff, as well as enhancing the permanent staff's awareness of the valuable contributions being made by these trainee geologists.

The large number of reports contained in this year's release demonstrates the high level of output being maintained by the Division's professional staff at a time when operational funds are limited and the mineral industry is particularly in need of additional data and guidance in targetting its mine-finding efforts. It is more than ever encumbant upon the Geological Survey that its contribution to the mineral exploration and development scene continue to be relevant, and full acknowledgement is made to those who contributed reports, comments and/or recommendations that have led to appropriate and pragmatic programming.

The scope of this year's activities has been increased significantly by contributions from the Geological Survey of Canada, made possible under the aegis of the Canada/Manitoba Interim Mineral Agreement. Joint programming in the Lynn Lake area continues to demonstrate the advantages to be gained through combining, in a complementary manner, the expertise and resources of the Federal and Provincial Surveys, and a more widespread and prolonged application of such endeavours will undoubtedly yield benefits fundamental to the future well being and growth of the mineral sector.

During the early part of 1983 the Division acquired a Word Processing capability and subsequently Shirley Weselak and Barbara Thakrar undertook the extensive training program and familiarization that ultimately facilitated the preparation of this report. Both are to be congratulated on making the transition into the new era of manuscript production and for processing the numerous early drafts of the component manuscripts.

This year's report contains an increased number of technical diagrams, figures and photographs which, together with the preliminary maps, reflect the continued and much valued services provided by the staff of the drafting section.

W.D. McRitchie

MINES BRANCH

GEOSCIENCE DATA AND AGGREGATE RESOURCES SECTIONS

GD-1 DIAMOND DRILL CORE COLLECTION PROGRAM IN MANITOBA

by Peter J. Doyle

INTRODUCTION AND HISTORY

The Department of Energy and Mines, specifically the Geoscience Data Section, has been collecting Precambrian diamond drill core for systematic storage since the early 1970's. Before 1970 the then Mines Branch had collected some core mainly for research on certain projects. This early core was stored at the University of Manitoba.

The 1970's program was the responsibility of the Resident Geologist in The Pas. Core sheds were built in The Pas in 1972, in Thompson 1973 and Lynn Lake 1974. In Winnipeg part of the Geological Branch rock laboratory was allocated for core storage in 1980.

Between 1971 and 1977 B. Esposito (1970-74) and R. Gonzalez (1975-77) collected 72600 metres of core. The Resident Geologist position was discontinued in The Pas in 1977. From 1978 to 1982 15 900 metres of core was periodically collected by various members of the Department (Mining Recorder, Geologists, etc.) and also delivered by private companies. During the 1970's emphasis was given to core collection, therefore because of limited staff and budget, comprehensive cataloguing wasn't possible. The total amount of core collected to the end of 1982 was 88300 metres.

In January 1983 the province's core program was reactivated with the hiring of a permanent drill core geologist. In 1983, although core was collected, the emphasis was on reorganization and cataloguing of existing core inventories for efficient public use, especially in the libraries at The Pas and Lynn Lake.

1983 PROGRAM

This year's core program involved two elements; the accomplishments that were achieved through the Thompson job creation program which ran from January to April and the work done by Departmental staff over the summer field season. Five of the eight mineral-related job creation projects were for the core program. They included building racks and an inspection room in the Thompson shed, core rack modules for future assembly elsewhere, repairs to the shed in The Pas and in particular the collection of about 26000 metres of core mainly from the Nickel Belt. These projects, which created 576 man-days of work, helped during the Inco winter shut-down.

The objective of the Section's summer field party, which consisted of the Drill Core Geologist and one to two assistants, was organization, inventory and cataloguing of existing core, mainly at The Pas and Lynn Lake, to facilitate public use of these valuable geological data. Some core collection was done (about 19700 metres) and work on the Thompson library was postponed because this small shed is full to overflowing and its Nickel Belt core comes from fewer localities and companies.

The reorganization at The Pas and Lynn Lake required the physical manhandling of about 15,000 core boxes, re-racking all the core into "logical groups" by drilling areas, companies and projects, standardizing and numbering rack and section layout, complete inventory and tagging every box with a unique identification number.

A Master List of all inventory will be completed this Fall followed by a card index by drilling area and company. It is planned over the Winter to plot all drill locations on 1:50000 and/or 1:250000 maps and later to enter the index on computer, and correlate this with the assessment report file number which contains the detailed logs and plans.

PRESENT HOLDINGS IN CORE LIBRARIES

The total present holdings in all facilities including Winnipeg is 134000 metres of core.

(A) The Pas Shed

This library contains 64000 metres of core collected from the Flin Flon-Snow Lake base metal district. The present facility with an estimated capacity of 67000 metres has little storage room left Proposals have been made for an additional building.

Examples of core in this facility include:

Hudson Bay Exploration, 6 projects, 218 holes
Granges Exploration, 6 projects, 192 holes
Manitoba Minerals, 6 projects, 49 holes
Canamax, 46 holes
Camflo, Inco, Shell, Espina, Pronto, etc.

(B) Lynn Lake:

This facility contains 24300 metres of core from the Lynn Lake greenstone belt, northern part of the Kisseynew basin and northern Manitoba in general. With a capacity of about 55000 metres this shed is less than half full. A new confidential enclosure was built this summer.

Examples of holdings include:

Granges Exploration, 2 projects, 98 holes
Hudson Bay, 2 projects, 55 holes
SMDC, 33 holes
Gods Lake Mines, 36 holes
Selco, 17 holes
Mcintyre, Falconbridge, Manitoba Minerals, Cyprus, Knobby Lake, Rock Ore Exploration, and others.

(C) Thompson:

This shed with a capacity of about 27500 metres is filled and overflowing with 34100 metres of core. About 1400 core boxes are stacked neatly and weather-covered outside. Complete reorganization similar to The Pas is required and an additional building is proposed.

Holdings include Nickel Belt core mainly from Canamax, Inco, Cominco and Hudson Bay.

TABLE GD-1-1
SUMMARY - CORE PROGRAM

Library Location	Core Collection (in metres) 1970-1982	1983	Present Inventory
The Pas	62 500	1 500	64 000
Lynn Lake	18 700	5 600	24 300
Thompson	2 600	31 500	34 100
Winnipeg	4 500	7 100	11 600
Totals	88 300	45 700	134 000

(D) Other

About 11600 metres of Precambrian core from SE Manitoba is stored in Winnipeg at the Geological Branch core and rock storage library on Brady Road. About 7100 metres was collected in 1983.

Seven core sites are presently identified in the field with about 30000 metres awaiting collection. It is hoped that retrieval of this core and construction of new facilities will take place in the near future.

HOW TO USE THE CORE LIBRARIES

The sheds at The Pas and Lynn Lake are now in excellent order for use by industry and the public. Well lit, heated inspection rooms with core splitters are provided. Although the facilities at Thompson and Winnipeg are not yet completely organized any requests for core inspections will be accommodated.

None of the Department's core libraries are permanently manned therefore all enquiries and permission for access requests must be made to:

P. Doyle, Drill Core Geologist
or
B. Esposito, Supervisor-Drill Core Program
Geoscience Data Section
Department of Energy and Mines
993 Century Street
Winnipeg, ManitobaR3H OW4
Phone: (204) 944-8204

Arrangements will then be made with appropriate local Government representatives who have keys to the northern libraries.

These are:

The Pas: Mr. F.H. Heidman - Mining Recorder
Provincial Building, 3rd and Ross Avenue
The Pas, ManitobaR9A 1M4
Phone: (204) 623-6411

Lynn Lake: Conservation Officer
Department of Natural Resources
675 Halstead Street
Lynn Lake, Manitoba
Phone: (204) 356-2413

Thompson: Mr. H. Schumacher or Mr. W. Comaskey
Department of Energy and Mines
Mining Engineering Section
Provincial Building, 59 Elizabeth Drive
Thompson, ManitobaR8N 1X4
Phone: (204) 778-4411

Note: Do not contact these people direct, phone the Winnipeg office first.

Access to confidential core is only through written permission from the company which holds the ground. This written permission must be presented to the Drill Core Geologist or Supervisor.

Core boxes will not be removed from the core libraries. If sampling of core is desired, prior consideration and permission is required from Winnipeg.

Library users must be prepared to physically handle the core boxes and return them to the racks.

Local representatives will not give out door keys to core libraries. In special cases involving major inspections the Drill Core Geologist will travel to the northern facility to assist the user.

Drill logs and plans and other geological data respecting open file assessment reports are available for inspection in Winnipeg.

Figure GD-1-1

Drill core collection crew outside The Pas Core Library.

AR-1 SURFICIAL GEOLOGY AND AGGREGATE RESOURCE INVENTORY OF THE RURAL MUNICIPALITY OF WHITEMOUTH

by R.V. Young

INTRODUCTION

Surficial geology mapping was carried out within the R.M. of Whitemouth with the following objectives:

1. To map the surficial geology at a scale of 1:50 000; and
2. Determine quality and reserves of available aggregate resources.

The municipality is located east of Winnipeg between latitudes 49°48'N to 50° 07'N and longitudes 95°49'W to 96°05'W, and between Townships 10 to 13 and Ranges 11 and 12 East of Principal Meridian. The surficial geology of the municipality is shown on Preliminary Map 1983 WM accompanying this report

BEDROCK GEOLOGY

The municipality is underlain by Precambrian bedrock. The central portion is underlain by Archean granite and minor granodiorite, while the bedrock in the northeast and southwest is metamorphosed early intrusive rocks including tonalite, minor granodiorite, granite and related gneiss. Detailed geology of the northern portion of the municipality is presented by McRitchie and Weber (ed. 1971) and the eastern portion by Lamb (1975) and Janes (1976).

SURFICIAL GEOLOGY

The surficial geology and an interpretation of Quaternary events were previously mapped and described by McPherson (1968, 1970) and Fenton (1974) for the area west of Rang 11 East at scales of 1:250 000. Mapping by these authors inCluded stratigraphic interpretations based upon numerous drill logs. A brief description of the Quaternary geology north of the Whitemouth River was previously presented by Nielsen (1977).

Post glacial deposits include alluvium along the Whitemouth and Birch Rivers and extensive areas of swamp (Fig. AR-1-1) which includes standing water and organic deposits. Bannatyne (1964, 1980) describes in detail the potential for commercial peat development of several bogs within the municipality

Late glacial deposits include beach ridges, littoral sand and gravel and lacustrine clay. A notable beach ridge (deposit 2801) representing a major stillstand of Lake Agassiz is located south of Lewis at an elevation of 297 m.a.s.l. A second prominent strand line occurs in the Scotts Hill area (deposit 2808). Minor strandlines are located at elevations of 189 m and 282 m a.s.l. Extensive deposits of littoral sand (deposits 2802 and 2803) are located along the western boundary of the municipality within the Contour Bog. Extensive lacustrine clay deposits are found along the Whitemouth River. The clay occurs either as a massive unit greater than 10 m thick or as a thin veneer less than 1.0 m thick overlying till. Numerous iceberg scours are located within this clay plain in the northwestern portion of the municipality.

Glacial deposits consist of one glaciofluvial sand and gravel deposit and extensive till deposits. Deposit 2810 is a wave-washed glaciofluvial sand and gravel deposit flanked by fine grained littoral sand. Two tills were identified - a carbonate rich clayey till in the western portion of the municipality and a sandy discontinuous till unit associated with the bedrock along the eastern portion of the municipality.

Extensive bedrock outcrops are located along the eastern portion of the municipality and numerous isolated outcrops were observed along the Whitemouth River during periods of low water. Minor outcrops were also observed along the Winnipeg River and especially at the Seven Sisters hydro dam site. The bedrock unit consists of a wave washed bedrock with minor sandy till, sand and clay deposits as a veneer overlying the bedrock. Extensive swamp deposits are located between the bedrock knolls.

AGGREGATE RESOURCES

Only two sand and gravel deposits have economic significance for the region. Glaciofluvial deposit 2810 located in 25-12-12 E.P.M., consists of cobbles and pebbly sand (Fig. AR-1-2). This deposit exceeds 10.0 m in depth and has been utilized for municipal and fireguard road maintenance. The second deposit (deposit 2809) is a minor strandline located in 4-12-12 E.P.M. This deposit is 3.0 m deep and gravel is currently being extracted below the water table by a dredge. This deposit is comprised of bedded sand and gravel.

Other potential aggregate sources include low quality, very fine sand beach ridges and littoral deposits. These deposits are comprised entirely of fine sand with the coarse fraction greater than 19.1 mm between 0-1 per cent. Two additional minor deposits - 2806 and 2807 -have been identified but the close proximity of the water table to the surface (less than 0.5 m) requires dredging for mineral extraction.

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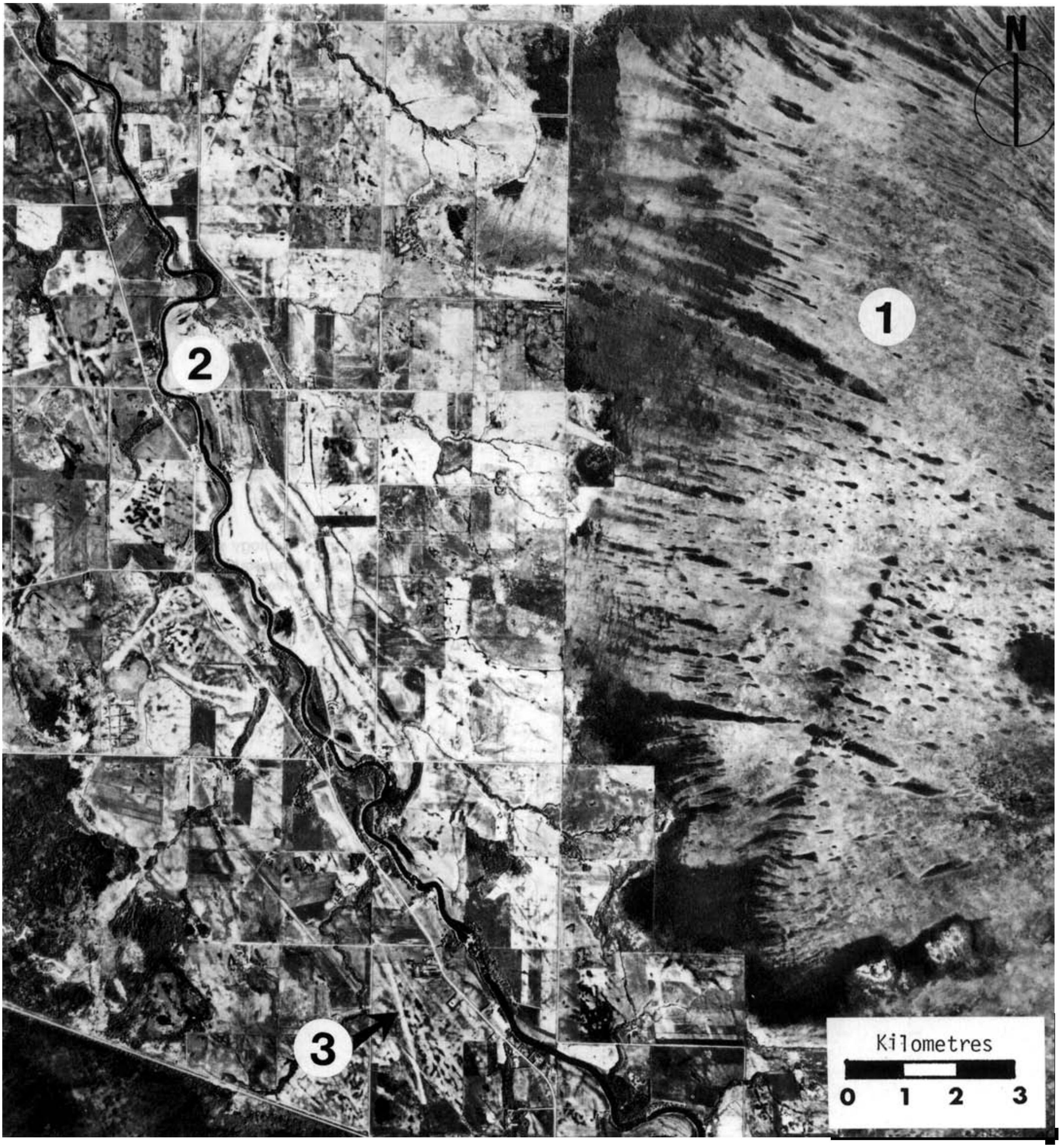

Figure AR-1-1: Airphoto at a scale of 1:50 000 illustrating: (1) Whitemouth Bog; (2) Whitemouth River alluvium. and (3) iceberg scours in clay plain.

Figure AR-1-2:

Glaciofluvial deposit 2810 illustrating grain size variations of the sand and gravel. Survey rod is divided into one foot units

McRitchie, W.D. and Weber, W. (ed.)
1971: Geology and Geophysics of the Rice Lake Region, Southeastern Manitoba; Manitoba Mines Branch Publication 71-1,430 p.

Nielsen, E.
1977: Quaternary Geology of Selected Portions of Eastern Manitoba; Manitoba Mineral Resources Division Report of Field Activities, p. 143-146.

AR-2 AGGREGATE RESOURCES IN THE L.G.D. OF ALEXANDER AND THE R.M. OF LAC DU BONNET

by G. Matile and H. Groom

INTRODUCTION

Sand and gravel inventories were carried out in the L.G.D. of Alexander and the R.M. of Lac du Bonnet in order to provide detailed aggregate information for development plans of the areas. The area east of the Winnipeg River has been mapped previously by the Mines Branch at a scale of 1:100 000 (E. Nielsen, unpublished) and was not reassessed this year.

The Belair and Milner Ridge Moraines (Fig. AR-2-1) contain over 95% of the total granular reserves of the area. Much of this material is sand and emphasis was placed on delineating gravel deposits within the moraine system. All sand and gravel pits were tested and areas with economic potential were further sampled with a backhoe. The Milner Ridge Moraine was tested in co-operation with the Materials Branch of the Department of Highways.

BEDROCK

The study area is underlain by two distinct bedrock types; intrusive granites and gneisses of the Precambrian Shield in the central and eastern portions, and Paleozoic carbonates of the Manitoba Lowlands along the western edge of the map area. The Paleozoic Winnipeg Formation is found at the contact of these two rock types (Fig. AR-2-1). It is a fine-grained quartz sandstone and is the probable source of much of the sand in the morainal system. The presence of these contrasting bedrock types within the study area makes the lithologies of the glacial units important in the geological interpretation of the Quaternary deposits.

INTERLOBATE MORAINES

The Belair and Milner Ridge Moraines are the most prominent morphological features of the area. They are discontinuous, north-south trending ridges, commonly rising 60 metres above prairie level. Milner Ridge lies 40km east and south of the Belair moraine. The moraines are believed to be interlobate, formed at the confluence of the northeastern ice-sheet (carrying Precambrian-rich drift) and the northwestern icesheet (carrying carbonate-rich drift) (Teller and Fenton, 1980). General stratigraphy found in the moraines is depicted in Fig. AR-2-2 and discussed below. Outside the moraines, surficial sediments include bedrock and till outcrops, Lake Agassiz silts and clays and extensive areas of swamp.

STRATIGRAPHY OF THE INTERLOBATE MORAINES

GLACIOLACUSTRINE

There are four facies of the glaciolacustrine sediments: sand and gravel, sand, silt and rhythmically bedded clayey silt. The sand is by far the most common facies; the other three are rarely seen in section.

The sand facies is white in colour. It is well sorted and has a mean grain size between 2 and 3 phi. It usually appears massive although there can be heavy mineral concentrations along bedding planes. In a few sections it is cross-bedded with paleoflow directions centering around 140°. Often the sand is faulted and occasionally folded.

The glaciolacustrine sand is the most extensive unit in the morainal system, reaching thicknesses of greater than 30m. Where present in section it forms the basal unit although McPherson's (1970) borehole data indicates a discontinuous Precambrian-rich till underlying it at depths of 20 to 25m. The sand is overlain, at various sites, by all the other units in the system: till, boulder, cobble and gravel lags, glaciofluvial and lacustrine gravels. Contacts are sharp and there is often white sand stringers or rip-ups in the overlying sediments.

GLACIAL

There are two discontinuous diamicton units found in the moraines. They are very thin, generally less than 2m thick. The two units can be differentiated by the sand content of the matrix and the per cent Precambrian clasts in the pebble fraction. Preliminary analysis indicates an average composition of the matrix of 60% sand, 28% silt and 3% clay for the lower unit and 42% sand, 40% silt and 18% clay for the upper unit. Within the 4-16mm pebble fraction, lithologies are 90% Precambrian clasts for the lower unit and less than 50% for the upper unit.

The diamictons are overlain by glaciofluvial gravels, lacustrine sediments or aeolian sand.

GLACIOFLUVIAL

Glaciofluvial gravels cap portions of the moraine (Fig. AR-2-1). Although the deposits vary in depth, bedding and grain size, pebble lithology is consistantly greater than 75% Precambrian clasts; deposits average 89% Precambrian.

The gravels overlie both the diamicton units orthe glaciolacustrine sand; they are occasionally overlain by carbonate-rich beach deposits. Depths can exceed 15m.

Grain size ranges from granules to cobbles and small boulders (long axis up to 45cm). Where cobble gravel predominates, bedding is usually massive to crudely horizontal. The gravel is in clast support and the matrix is coarse sand and pebbles. In the smaller grain sizes, the gravel is often cross-bedded and paleoflow is southerly (155° to 196°). Occasionally, the gravels fill channels eroded into the glaciolacustrine sand or lower beds of glaciofluvial gravel. Channel direction varies from south to south- east. White sand rip-ups (Fig. AR-2-3) and clasts of stony clay are infrequently present within the finer facies of the gravels.

Ridges of coarse Precambrian-rich gravel are included in this unit. The ridges are 2 to 3 metres high, sharp crested and are randomly oriented. The material is very coarse cobble gravel and is massively bedded. The ridges seem to start in a concentration of boulders and there is some fining distally.

LACUSTRINE

Lake Agassiz completely covered the area during the retreat of the last ice sheets from Manitoba. During regression, the lake reworked much of the surficial sediments, depositing beaches, spits and littoral sands (Fig. AR-2-4). Much of the original till cover was reduced to a boulder lag (Fig. AR-2-5).

The majority of the beach ridges in the area flank or overlie the sediments of the moraine system. At lower elevations, they overlie till, clayey silts or flank bedrock highs. The deposits are generally 2 to 3m of moderately sorted sand and gravel; some are quite coarse and

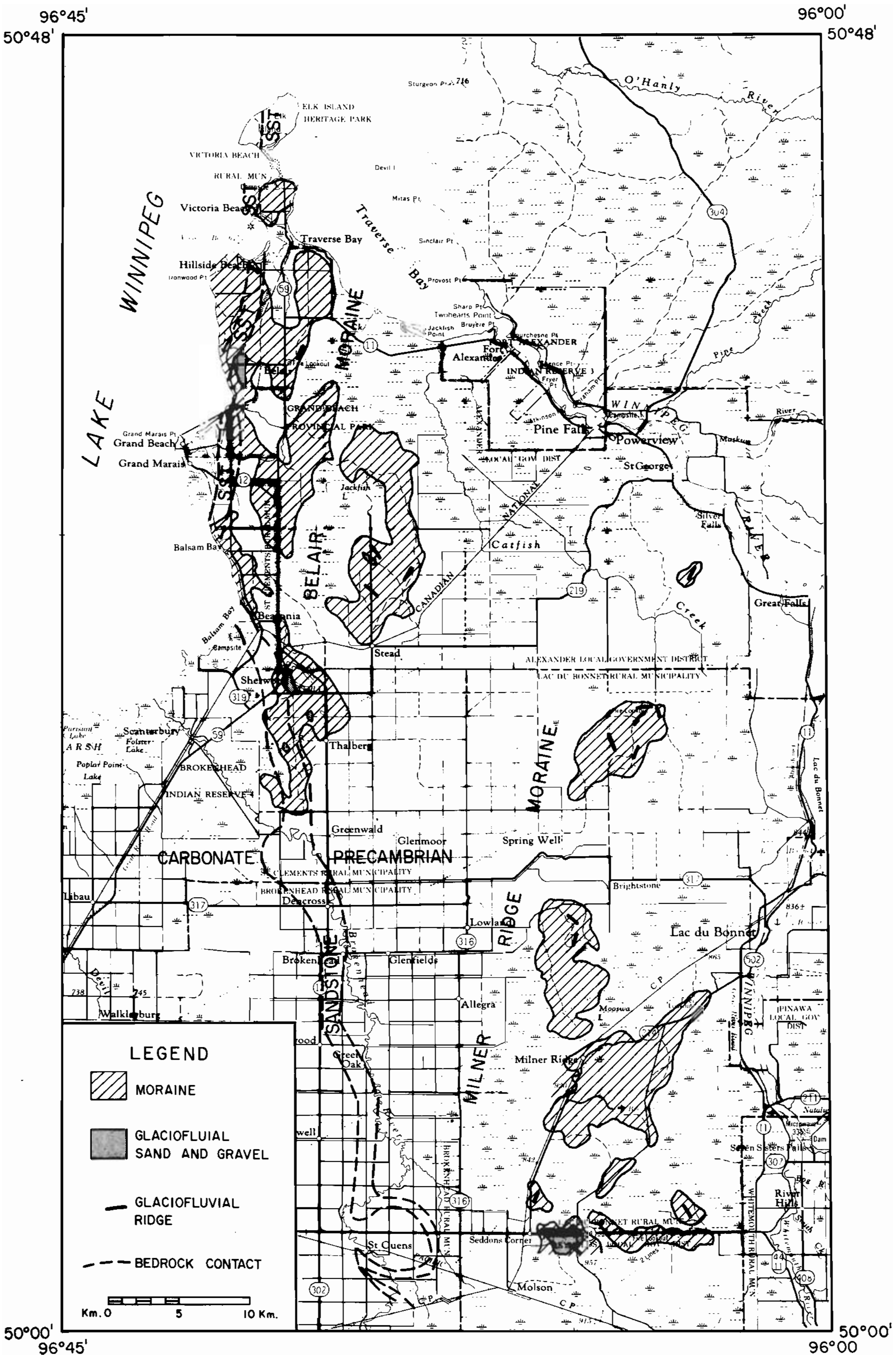

Figure AR-2-1: Location of the Belair and Milner Ridge Moraines.

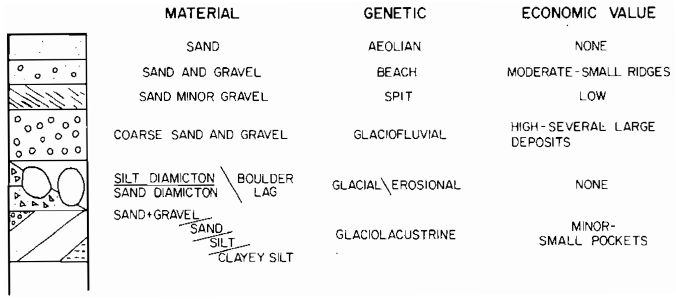

Figure AR-2-2:

Generalized stratigraphy of the Belair and Milner Ridge Moraines.

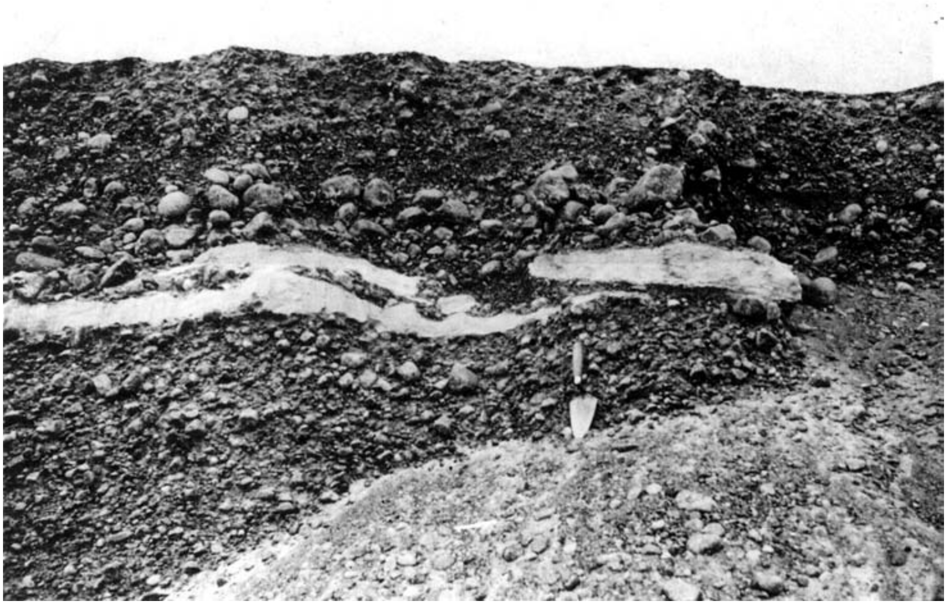

Figure AR-2-3:

Glaciofluvial gravel, wIth white sand rip-ups.

Figure AR-2-4.·

Section showing carbonate-rich lacustrine gravel (A) overlying Precambrian-rich glaciofluvial gravel (B).

Figure AR-2-5.

Boulder lag resulting from lacustrine erosion of the surface till.

approach cobble gravel. Lithologies in the beach ridges are generally less than 50% Precambrian clasts, indicating their formation from eroded silt till.

AEOLIAN

Sand dunes are present over several parts of the moraine system. The dune sands are fine grained (median=1.9phi), moderately well sorted (Δ=.59 phi) and grain size distribution is symmetrical to fine-skewed. Large boulders are often present in the dune areas. The dunes are stabilized by vegetation and often support stands of pine trees.

There is a thin sand unit overlying much of the gravel in the area. The beds are massive, stone-free and usually 0.1 to 0.5m thick. Where present, they are always the surface unit. The sand is oxidized, slightly coarser than the dune sands (median=1.3 phi), slightly less well sorted (Δ=.74 phi) and grain size distribution is symmetrical. The unit is presumed to be of aeolian origin.

ECONOMIC GEOLOGY

The glaciofluvial gravels are the major sources of granular material being mined in the area. Most deposits have active pits and several are extensive. The Winnipeg Supply pit at Gull Lake is 20m deep and over 0.5km long.

There are small pits in most of the beach ridges. With one or two exceptions, they are used on a temporary basis and most are revegetated. These deposits are of minor economic importance due to the major pits in the glaciofluvial gravels.

There is an extreme scarcity of gravel deposits east of the Winnipeg River and several small granite bedrock quarries have been opened to provide aggregate for road construction and riprap along the Winnipeg River.

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AR-3 SAND AND GRAVEL RESOURCES OF THE SELKIRK AND DISTRICT PLANNING AREA

by Phyllis Mitchell

During the summer of 1983 a study was undertaken to evaluate the aggregate resources of the Selkirk and District Planning Area which includes the R.M. of St. Andrews and part of the R.M. of St. Clements. This area was previously mapped in 1976 and 1977 as part of the Quaternary Geology of the Winnipeg Region preliminary map series (Ringrose, Large and Duyf, 1976 and 1977). The study area lies north of Winnipeg and encompasses Ranges 3E.P.M. to 6E.P.M. and Townships 13 to 17. The objectives of this study were:

1. to delineate the gravel bearing deposits
2. to assess their quality
3. to determine which gravel pits are active, inactive or depleted and
4. to provide aggregate information for land use planning purposes in the form of a preliminary aggregate inventory map. (Preliminary maps 1983SD-1 and 1983SD-2).

BEDROCK GEOLOGY

The study area is underlain by Ordovician limestone and dolomite of the Red River Formation (Geological Map of Manitoba 79-2). Two quarries were noted in the area. Crystal Springs, north of Garson, has been depleted and subsequently converted to a recreational site. The other quarry is located at the western boundary of the study area, south of Highway 223. The quarry is inactive at the present time, but potential reserves still remain.

SURFICIAL GEOLOGY

The study area is characterized by easterly trending buried eskers and southerly trending beach ridges.

During a southeasterly ice advance, linear buried eskers were deposited. These deposits are generally 4-5 metres deep and show little or no surface relief. There is a gradual fining of sediments to the east.

As the ice receded from the study area, approximately 11,100 years B.P. (Clayton and Moran 1981), it acted as a dam to the north and east, and the Red River Basin was filled with meltwater forming Lake Agassiz. During a stillstand of Lake Agassiz, approximately 8500 years B.P., the discontinuous Gimli Beach was deposited at elevations of 244 m.a.s.l. in the west and 242 m.a.s.l. in the east (Johnston 1946). As deglaciation continued, Lake Agassiz eventually drained about 8000 years B.P. (Nielsen, personal communication) leaving the present Lake Winnipeg.

AGGREGATE RESOURCES

Sand and gravel resources in the study area are confined to buried eskers and discontinuous beach ridges.

The 4-5 m. deep esker deposits are largely depleted but some are still being excavated on a small scale for local use. Gravel thicknesses range from 1.5 m to 4.0 m and are overlain by approximately 1 m. of till. In some places up to 1m. of sand overlies the gravel and underlies the till. The gravel is unsorted, has angular clasts and generally tends to be coarser than the beach sediments. Gravel quality ranges from low (0-20% gravel content) to medium high (60-80% gravel content). Pebble counts of the 4-16mm fraction show the lithology to be 80-90% carbonate clasts and 10-20% Precambrian crystallines.

Beach ridge deposits in the area are southerly trending and discontinuous. The length of the beaches ranges from a few hundred metres to more than 4 km. These ridges have a maximum surface relief of 3 m. and gravel thickness ranges from 0.5-2 m.

The beach deposits are largely depleted, but some reserves do remain. There is no evidence of recent excavation.

Gravel in the beach deposits has rounded clasts and tends to be less coarse than the glaciofluvial deposits. Gravel quality of the beach deposits ranges from low (0-20% gravel content) to medium (40-60% gravel content). Pebble counts of the 4-16mm fraction show the lithology to be 80% carbonate clasts and 20% Precambrian crystallines.

CONCLUSION

At one time aggregate resources were abundant in the study area. Close proximity to the Town of Selkirk and the City of Winnipeg and the building and maintenance of highways and roads has caused rapid depletion of reserves. Although none of the depleted pits appear to have been rehabilitated, many have alternate land uses. Deposits 4002, 4010, and 4113 are used as garbage dumps and the west portion of deposit 4110 is a trout stocked area for use by local fishermen.

Due to the scarcity of gravel in the area, aggregate is imported from the Gull Lake and Birds Hill areas.

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AR-4 A PRELIMINARY ASSESSMENT OF SELECTED BEDROCK RESOURCES FOR AGGREGATE POTENTIAL

by C.W. Jones arid B.B. Bannatyne

INTRODUCTION

The bedrock sampling program, initiated in 1982, to determine the quality of selected bedrock sources in Manitoba, has been expanded in 1983 to include carbonates of Silurian and Devonian age as well as Precambrian granites. The objectives of the program are outlined below:

(1) to define the potential quality of bedrock as a source of aggregate based on engineering and geological properties:

(2) to assess selected outcrops and quarries in Manitoba and thus provide data required for aggregate resource management purposes; and

(3) to aid in evaluating potential sites for new quarries.

In 1983, 10 bulk samples of carbonate rock were collected from selected outcrops and quarries in Manitoba as well as 2 bulk samples of Precambrian granites. Engineering tests to determine potential end uses are described below:

(1) Los Angeles Abrasion Test (C131) - The test is a procedure for testing sizes of coarse aggregate smaller than 1 1/2 in. (37.5 mm) for resistance to degradation using the Los Angeles testing machine. The Los Angeles test is a measure of degradation of mineral aggregates of standard grading resulting from a combination of abrasion, impact and grinding. The test is widely used as an indicator of the relative quality or competence of various sources of aggregate having similar compositions (C131-81).

(2) Sodium Sulphate Soundness Test (C88) - The test determines the resistance of aggregates to disintegration by saturated solutions of sodium sulphate or magnesium sulphate. It furnishes information helpful in judging soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of material exposed to actual weathering conditions.

(3) Absorption Test (C127) - The test covers the determination of bulk specific gravity, apparent specific gravity, and absorption of coarse aggregate (see C127-81). Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate whereas apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles which is accessible to water.The tests were conducted in accordance with A.S.T.M. standards. The results and potential end uses of each sample, as determined by Underwood, McLellan Ltd., are outlined in Table AR-4-1.

BEDROCK SAMPLING IN MANITOBA

Ten carbonate bedrock samples of Ordovician, Silurian and Devonian age as well as two samples of Precambrian granites were collected to determine their suitability as a source of aggregate (see Figure AR-4-1). The samples collected represent portions of the geologic members or formations, and rock of differing quality may be present elsewhere in the unit. The location and description of samples are given below.

CJ-83-1 3.6 m of Siluran Cedar Lake Formation, dolomite from SW. corner of Mulvihill quarry (4-7-23-5W)

TABLE AR-4-1
PHYSICAL PROPERTIES AND POTENTIAL USES, ORDOVICIAN TO DEVONIAN CARBONATES, AND PRECAMBRIAN GRANITES

	1	2	3	4	5	6	7	8	9	10	11	12
Los Angeles abrasion loss %	44.1	29.4	35.1	29.0	25.8	36.1	30.4	22.9	30.4	38.7	36.4	22.3
Bulk Specific Gravity	2.54	2.63	2.42	2.73	2.75	2.59	2.73	2.82	2.65	2.55	2.62	2.67
Apparent Specific Gravity	2.69	2.69	2.68	2.81	2.83	2.79	2.82	2.86	2.71	2.78	2.66	2.69
Absorption	2.25	0.94	4.02	1.03	1.06	2.71	1.18	0.50	0.83	3.22	0.57	0.34
Porosity	5.71	2.47	9.73	2.80	2.96	7.02	3.23	1.14	2.19	8.20	1.49	0.90
Soundness Loss												
a) 1 1/2" to 3/4"	1.1	5.9	3.7	1.3	2.2	7.9	15.6	1.9	0.4	44.7	0	0
b) 3/4" to 1/2"	0.6	8.3	2.0	1.1	1.3	9.1	15.9	1.7	0.5	29.0	0	0
c) 1/2" to 3/8"	7.3	14.0	4.6	3.3	2.2	11.5	26.6	2.5	4.8	42.7	0.2	0.5
Potential Uses												
Concrete aggregate	—	Yes	—	Yes	Yes	—	—	Yes	Yes	—	Yes	Yes
Bituminous aggregate	—	Yes	—	Yes	Yes	—	—	Yes	Yes	—	Yes	Yes
Base Course A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Base Course B	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Surfacing Gravel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ballast	—	—	—	—	marg. poor	—	—	Yes	—	—	—	Yes

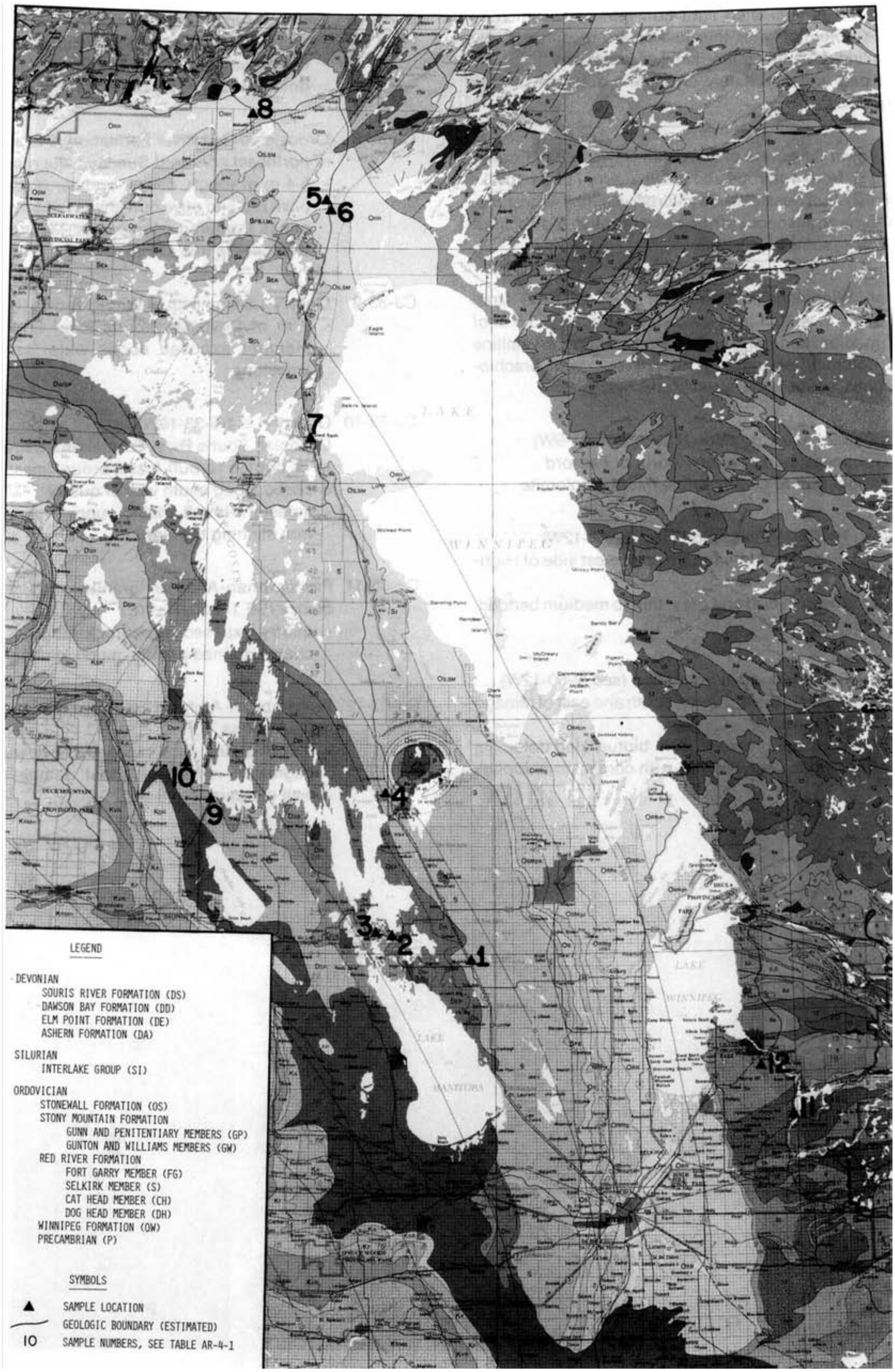

Figure AR-4-1: *Sample collection sites in Manitoba.*

- upper part is laminated light buff reefoid fossiliferous porous dolomite, with thin interlayers of dense finely crystalline dolomite; minor films of green clay
- lower part is dense, finely crystalline dolomite, in thin flaggy beds

CJ-83-2 slabs of lower limestone of Devonian Dawson Bay Formation, unit B, from outcrops and small quarry (13-24-10W)
- brownish buff fossiliferous microcrystalline limestone, with some argillaceous streaks and purplish red flecks of iron oxide; somewhat brittle

CJ-83-3 Devonian Winnipegosis Formation (3-21-24-10W) from centre of north wall of the Narrows West quarry. 3.6 m of thick to medium bedded, tough, coarsely vuggy, crystalline reefoid dolomite; abundantly fossiliferous, with brachiopods, corals, gastropods, stromatoporoids

CJ-83-4 Silurian Cedar Lake Formation (NW 1/4-19-31-9W)
- from northwest part of quarry north of Fairford
- 4 m of light buff to cream, brittle micritic dolomite

CJ-83-5 Ordovician Red River Formation (sec. 22-60-12W)
- from quarry north of Minago River on west side of Highway 6
- 2.6 m of brownish buff and grey, thin to medium bedded, fairly dense stone

CJ-83-6 Ordovician Stony Mountain Formation (sec. 2-60-12W)
- from face near centre of quarry, south and east of Minago River and Highway 6
- 3 m of thin, flaggy brownish buff, bioturbated dolomite; somewhat brittle; fossiliferous, with corals, brachiopods

CJ-83-7 Silurian Moose Lake Formation (NW 1/4-34-48-13W)
- quarry face in southeast corner of Grand Rapids quarry
- 6.0 m variably dense micritic to finely crystalline buff dolomite; upper part with abundant stromatolitic layers.

CJ-83-8 Ordovician Red River Formation (SW 1/4-30-64-15W)
- northeast corner of Sunday Lake quarry
- 5.4 m of tough, dense, nodular dolomite, variably purplish red and olive buff shades. Interval from 1.94 to 2.16 m has scattered coarse vugs Medium to thick bedded, weathers to thin slabs.

CJ-83-9 Quarry 1.8 km north of Winnipegosis (ls.14, 15-9-31-18W)
- 2 m of Devonian Souris River Formation; Sagemace Member exposed above water table, high-calcium limestone.

CJ-83-10 Quarry (l.s. 1-5-33-19W)
Devonian Souris River Formation - Sagemace Member - 2 m of orange to buff fossiliferous limestone and dolomite exposed along south wall of quarry
- limestone is soft, friable, vuggy in part, thick bedded with iron staining throughout

CJ-83-11 Precambrian-Archean granite, with minor granodiorite quarry (SE 1/4-33-15-11 E)
- quarry exposed in bedrock outcrop, pink, medium to coarse grained granite, much jointing in rock

CJ-83-12 Precambrian-Archean tonalite, minorgranodiorite, granite, related gneiss
- 4 m of quarry face exposed above water table, granitic pegmatite veins throughout; sample taken from north wall of quarry (1-18-9E)

AR-5 AGGREGATE RESOURCE MANAGEMENT IN MANITOBA

by C.W. Jones

INTRODUCTION

Aggregate resources are an essential ingredient in most construction related activities, This resource, under present engineering technology, has no suitable substitute and is required for several construction end uses including concrete aggregate, asphalt aggregate, ballast, and for fill purposes, Aggregate resources are a high bulk, large volume, low cost mineral resource for which one can identify a continuing demand and a diminishing availability, In time, as higher quality deposits become depleted or sterilized, alternate sites will be required to facilitae construction related activities,

In light of a limited supply, increased land use pressures around urban centres to restrict development, and expanding aggregate requirements for construction related activities, there has been a demonstrated need to manage and conserve Manitoba's aggregate resources, The Aggregate Resources Management Program, based upon Manitoba Provincial Land Use Policy #13, is directed to conserve aggregate resources for the present and future, through regional and municipal land use planning activities.

AGGREGATE RESOURCE MANAGEMENT PROGRAM

The Aggregate Resource Management Program has been designed to address the above noted resource management concerns, The program involves, initially, that an extensive aggregate resource inventory be undertaken (see Figure AR-5-1), The resource inventory includes mapping the surficial geology; evaluating quality and reserves; noting the ownership of surface and mineral underrights; and evaluating potential for future land use conflicts, Once completed, the regional supply as well as regional aggregate requirements can be assessed, Resource planning recommendations, based upon Manitoba Provincial Land Use Policy #13, concerning the protection of aggregate resources from sterilization are made. The recommendations are summarized in a background study, and submitted to the regional planning authority and the local municipal council for their review and consideration, The planning recommendations are incorporated into a Basic Planning Statement or Development Plan, and eventually, are reflected in provisions of subsequent zoning by-laws, The conservation of deposits of aggregate for present and future use is thereby achieved through the legal instruments of local land use planning and control development.

The Aggregate Resources Management Program is also actively involved in the subdivision review process and the Crown Surface Land Use transfers in order to protect high quality aggregate and quarry minerals from surface land uses that may sterilize them (see Figure AR-5-2),

Upon receipt of a subdivision application, the Manitoba Department of Municipal Affairs solicits comments from concerned government agencies, one of which is the Manitoba Department of Energy and Mines, The comments regarding the proposed subdivision application are summarized in a report to the local municipal council and the local District Planning Board and a decision concerning rejection or approval is made, If the application is rejected there is no appeal, however if the concerns expressed by a government agency have not been resolved, a forum for resolution is provided through the Provincial Planning Branch (see Figure AR-5-2),

Crown Land Transfers and surface use clearances are also reviewed to ensure that high quality aggregate or quarry minerals are not sterilized,

Over the past year several activities centred around aggregate resource management have been conducted, The highlights of these activities are:

- Aggregate Resource Management Proposals for the Eastern Interlake Planning District, R.M. of La Broquerie, R.M. of Woodlands for inclusion into Development Plans (see Figure AR-5-3).
- Aggregate Resources Inventories presently being conducted in the L.G.D. of Alexander, R.M. of Lac du Bonnet, R.M. of Whitemouth and the Selkirk and Area Planning District.
- Bedrock Sampling Program designed to determine the quality of bedrock as sources of aggregate.
- Review of 20 Development Plans and Basic Planning Statements to ensure compliance with background studies and Manitoba Provincial Land Use Policy #13, Manitoba Regulation 217/80 of The Planning Act.
- Review of approximately 1500 subdivision applications of which 10 per cent required detailed investigations and comments concerning aggregate resource management
- Review of approximatey 1000 surface land use clearance proposals and Crown Land Transfers.

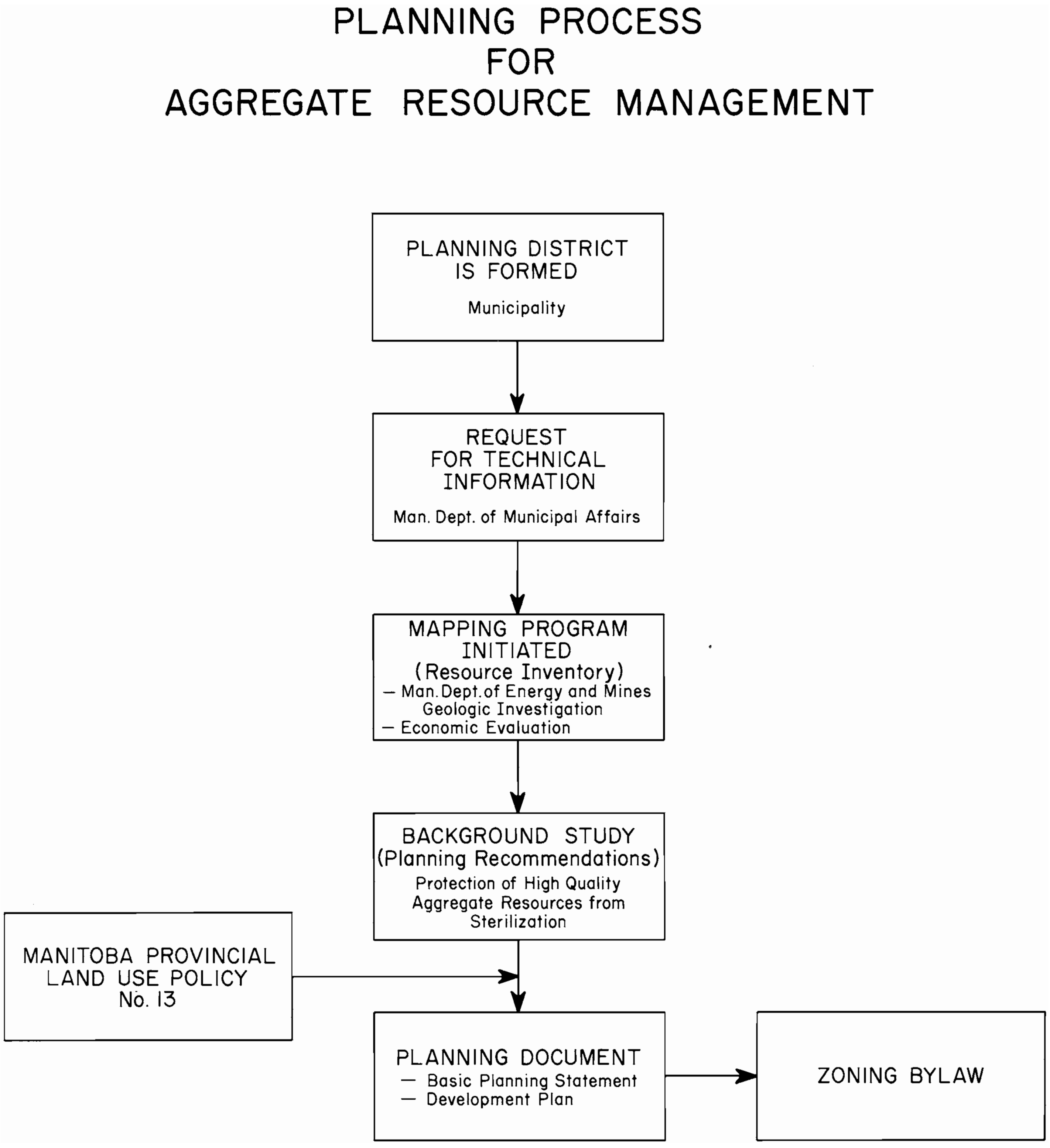

Figure AR-5-1: Planning Process in Manitoba.

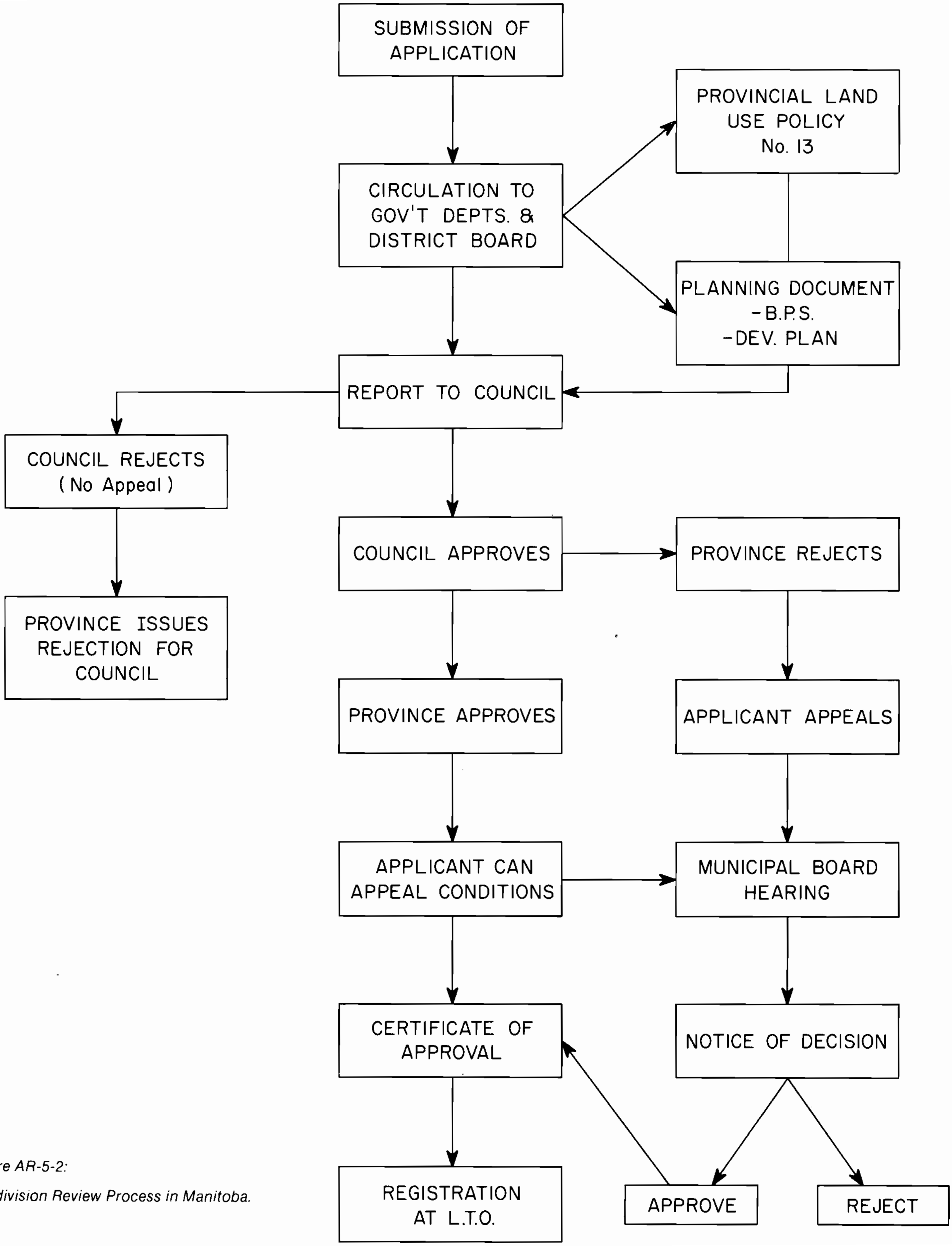

Figure AR-5-2:

Subdivision Review Process in Manitoba.

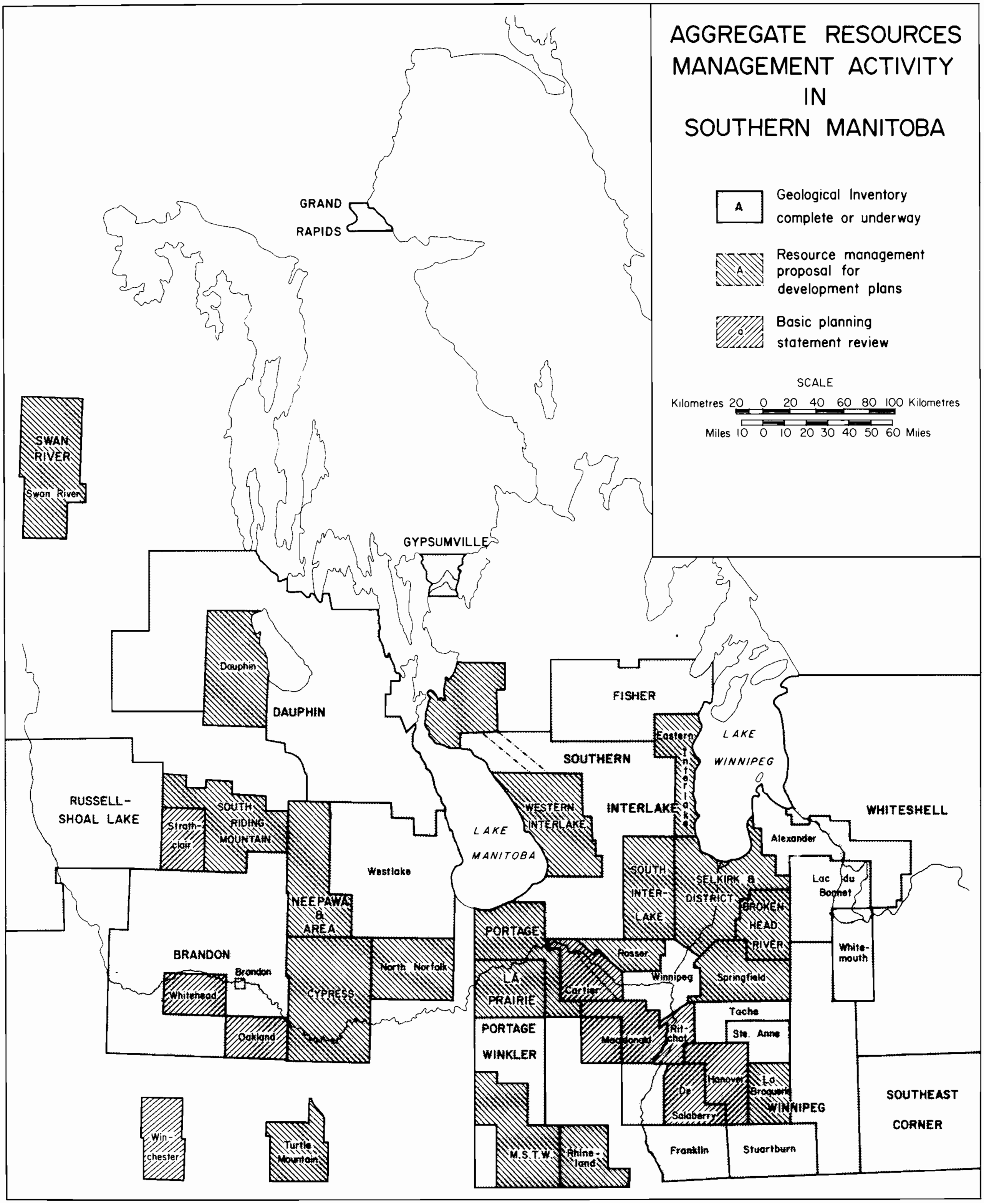

Figure AR-5-3: Aggregate Resources Management Activity in Southern Manitoba.

LIST OF PRELIMINARY MAPS - 1983

		Scale
PRECAMBRIAN SURVEYS		
1983M-1	Brochet-Big Sand Lake (64F and 64G west half) by D.C.P. Schledewitz	1:250 000
1983W-1	Flin Flon-Schist Lake (parts of 63K/12, 13) by A.H. Bailes and E.C. Syme	1: 20 000
1983K-1	Lobstick Narrows (parts of 63K/13, 14 and 63N/3, 4) by Herman V. Zwanzig	1: 20 000
1983N-1	Lawford Lake area (parts of 63 I/7, 9, 10) by K.C. Albino and J.J. Macek	1: 50 000
1983N-2	Cross Lake northeast (parts of 63 I/14, 15 by K.C. Albino, N. Barr, A. Grossjean and J.J. Macek	1: 50 000
1983N-3	Southeast Cross Lake-West Pipestone Lake by M.T. Corkery and P.G. Lenton	1: 20 000
1983 I-1*	Island Lake (53E/15SE and parts of 53E/16SW) by H.P. Gilbert, K.L. Neale, W. Weber, M.T. Corkery and C.R. McGregor	1: 20 000
	* Supercedes 1982 I-4	
1983 I-2	McGowan Lake (53E/16NE) by W. Weber	1: 20 000
1983 I-3	Krolman Lake (53E/16NW) by W. Weber	1: 20 000
AGGREGATE RESOURCES		
1983WM	Surficial Geology and Aggregate Resource Inventory of the Rural Municipality of Whitemouth (parts of 52E/13, 62H/16, 52L/4 and 62 I/1) by R.V. Young	1: 50 000
983SD-1	Sand and Gravel Resources of the Selkirk and District Planning Area, North portion (parts of 62 I/6,7) by Phyllis Mitchell	1: 50 000
1983SD-2	Sand and Gravel Resources of the Selkirk and district Planning Area, South portion (parts of 62 I/2,3) by Phyllis Mitchell	1: 50 000

LIST OF PUBLICATIONS RELEASED (November 1982 - November 1983)

		Price
NOVEMBER 18, 1982		
Report of Field Activities	Report of Field Activities, 1982; 106 p., 69 figures, 9 tables — Staff M.R.D.	$ 3.00
Geological Report GR79-1	Geology of the McKnight-McCallum Lakes Area; 31 figures, 10 tables, 3 maps — by P G. Lenton	$15.00
Geological Report GR81-1	Volcanic Rocks of the Fox River Belt, Northwestern Manitoba, 109 p., 38 figures, 3 tables, 97 plates, 1 map — by R.F.J. Scoates	$10.00
MAY 9, 1983		
Annual Report 1981-82	Annual Report 1981-82; 35 pages. Mineral Resources Division	No Charge
Geological Report GR77-1 (G.S C Memoir 392)	Devonian Rocks of the Lake Winnipegossis-Lake Manitoba Outcrop Belt, Manitoba; 280 pages, 111 figures, 15 tables, 45 photos. — A.W. Norris, T.T Uyeno and H. McCabe	$40.00
OF82-2	Open File Report, Aggregate Resource Management for Land Use Planning Within the South Interlake Planning District; 44 pages, 2 maps, 10 figures, 6 tables — R.V Young	$ 7.50
OF82-5	Open File Report, Aggregate Resource Inventory of the Rural Municipality of Brokenhead; 58 pages, 1 map, 11 figures, 6 tables. — R.V. Young	$10.00
OF83-1	Open File Report, Aggregate Resource Inventory of South Riding Mountain Area; 134 pages, 1 map, 9 figures, 3 tables — R.V Young	$15.00
OF83-2	Open file Report, Surficial Geology & Aggregate Resources Inventory of the Russell-Shoal Lake Area; 80 pages, 7 maps, 8 figures, 6 tables. — Gartner Lee Associates Limited	$60.00
JUNE 30, 1983		
Geological Report GR82-4	Quaternary Geology and Aggregate Resource Inventory of the Thompson Area; 24 pages, 11 figures, 5 tables and 4 maps — by R.V. Young	$10.00
Geological Report GR82-5	Aggregate Resource Inventory of the Churchill Area; 25 pages, 15 figures, 4 tables and 1 map — by R.V. Young	$ 5.00
JULY 6, 1983		
Geological Report GR82-6	Geology and Hydrocarbon Potential of the Lower Amaranth Formation, Waskada-Pierson Area, Southwestern Manitoba; 30 pages, 19 figures and 2 tables — by D Barchyn	$ 5.00
NOVEMBER 16, 1983		
OF83-2	Devonian Potash Deposits in Manitoba (Interim Report); 27 pages, 11 figures, 5 tables — by B.B. Bannatyne	$ 3.00

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Position	Personnel	Area of Current Involvement
Director	Dr. W.D. McRitchie	Manitoba
Senior Precambrian Geologist	Dr. W. Weber	Superior Province
Precambrian Geologists	Dr. A.H. Bailes	Flin Flon Belt, Rusty Lake Area
	H.D.M. Cameron	Lynn Lake region
	M.T. Corkery	Cross Lake-Northern Superior Province. Nelson and Churchill River Corridors
	H.P. Gilbert	Island Lake and Barrington Lake
	P.G. Lenton	Cross Lake-Churchill Province-granite and pegmatite-related projects
	Dr. J.J Macek	Walker Lake-Setting Lake
	D.C.P Schledewitz	Churchill Province north of latitude 57°. Molson-Kalliecahoolie Belt
	Dr. R.F.J. Scoates*	Fox River region, Thompson Belt, Bird River Sill
	E.C. Syme	Flin Flon and Lynn Lake Belts
	Dr. H.V. Zwanzig	Churchill Province
Mineral Deposit Geologists	Dr. G.H. Gale	Manitoba, specifically Flin Flon and Lynn Lake
	D.A. Baldwin	Lynn Lake-Ruttan region
	Dr. P. Theyer	Island-Gods Lakes, Bissett and Bird River Sill
	Dr. M.A.F. Fedikow	Gold in Lynn Lake region and S.E. Manitoba
Phanerozoic Geologist	Dr. H.R. McCabe	Southwest Manitoba and Interlake
Ouaternary Geologist	Dr. E. Nielsen	Lynn Lake region, Interlake and southern Manitoba
Industrial Minerals	B.B. Bannatyne	Potash, peat, pegmatite minerals, lignite, limestone and dolomite
	D.M. Watson	Silica, chromite, bentonite, building stone, gypsum, clays and shales
Mineralogist	C.R. McGregor	

"resigned Oct. 14th, 1983

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Director	W.A. Bardswich	Manitoba
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Section Head	R.V. Young	Aggregate inventory R.M. of Whitemouth
Quaternary Geologist	G. Matile	Aggregate inventory R.M. of Lac du Bonnet
	H. Groom	Aggregate inventory L.G.D of Alexander
Resource Management Geologist	C. Jones	Bedrock evaluation and aggregate resource management
Engineering Aid	P. Mitchell	Aggregate inventories R.M. of St. Clements and R.M of St. Andrews
GEOSCIENCE DATA		
Section Head	W.D. Fogwill	Monitors/promotes exploration in Manitoba
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Assessment Clerk	P.L. Carroll	Assists public use of Assessment Collection
Drill Core Geologist	P.J. Doyle	Collects/stores exploration drill core
Staff Geologist	I.T. Hosain	Regional compilation of assessment data
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MINERAL RESOURCES DIVISION

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Resource/Rehabilitation Planner	B. D. Bailey	944-6516
Rehabilitation Technician	C. Purdy	944-6512
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Quarry Inspector, S.W. and Interlake	L. Bilton	944-6513
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Mines Inspector	J. Haines	358-2392

* Departmental Consolidation at Eaton Place is provisionally scheduled for the Spring of 1984. Thereafter, the address of the Mineral Resources Division's Winnipeg offices will be 330 Graham Avenue, Winnipeg, Manitoba - R3C 4A5.

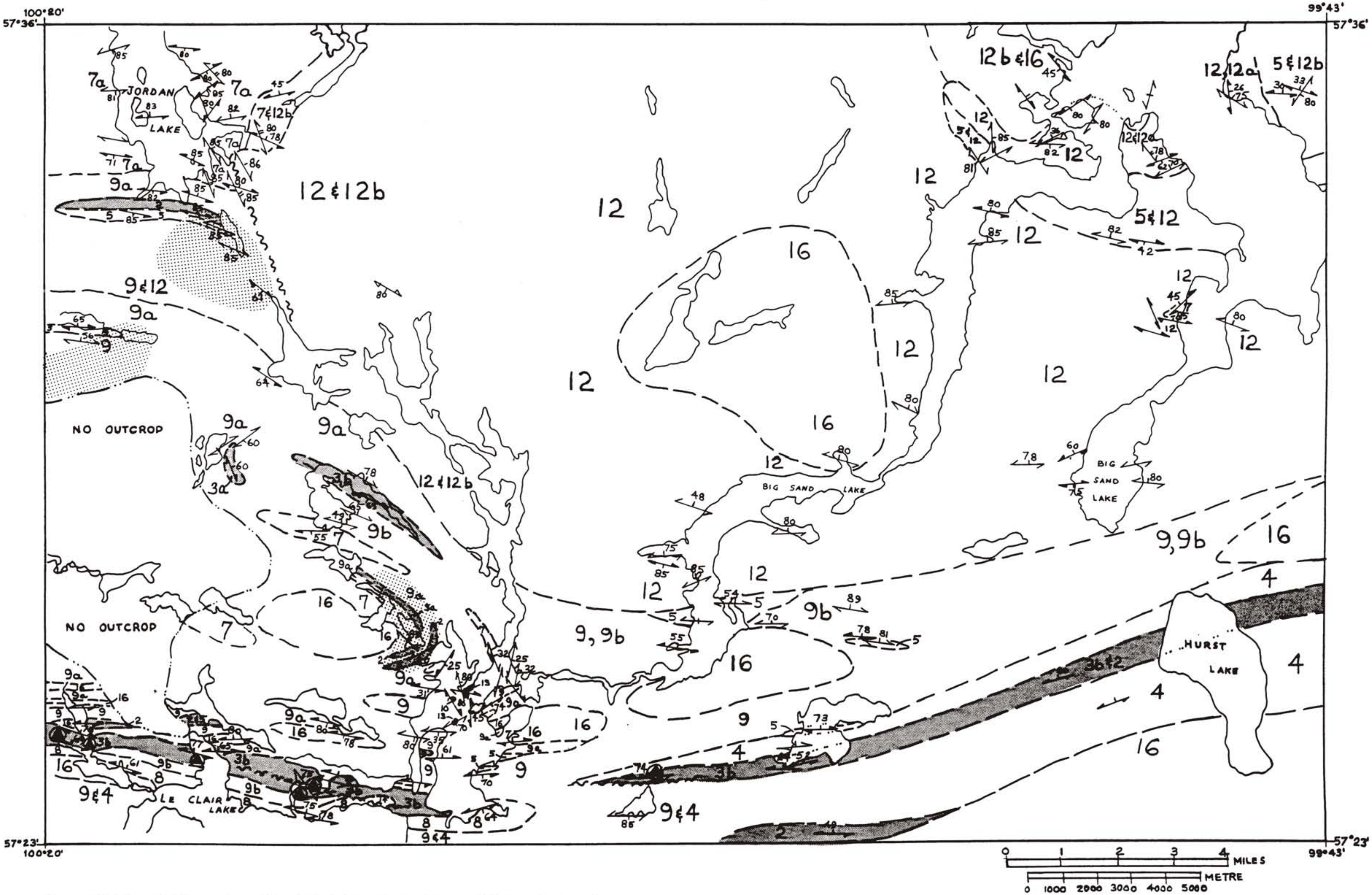

Figure GS-1-1: Outline geology of the LeClair Lake, Jordan Lake and Big Sand Lake regions.

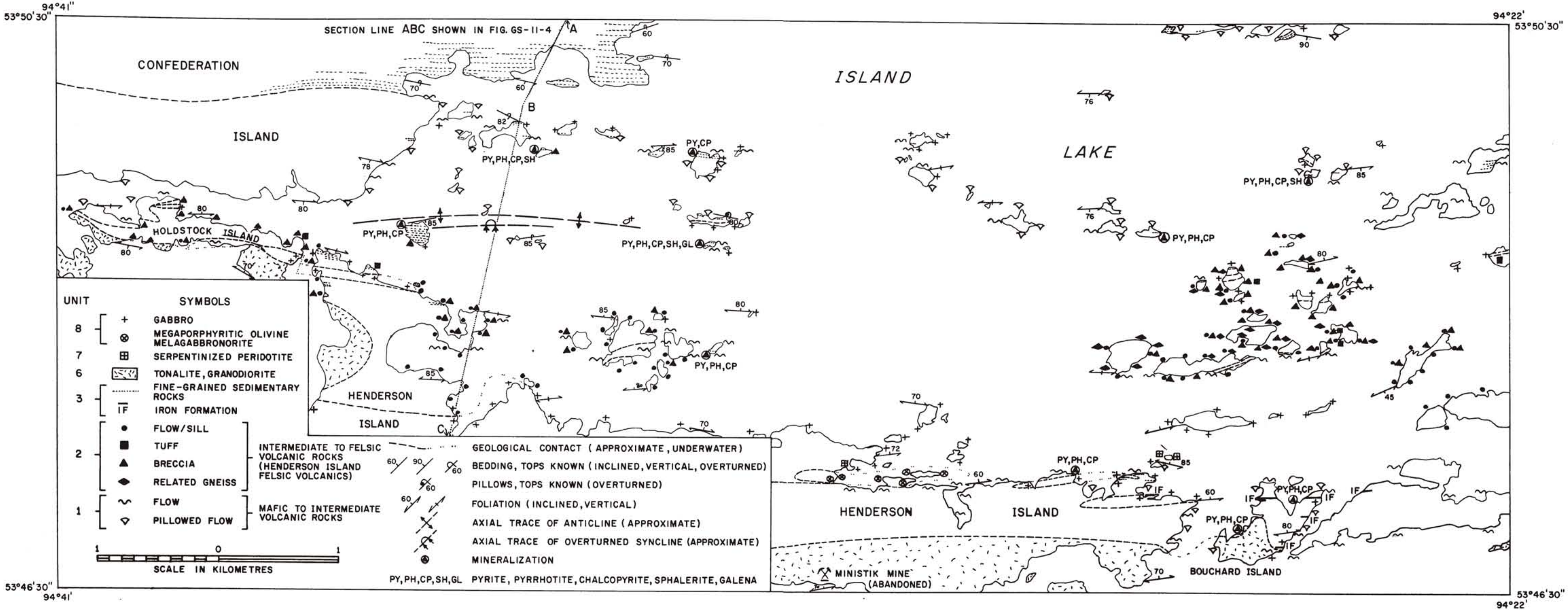

Figure GS-11-2: Geology of the area south and east of Confederation Island, Island Lake.