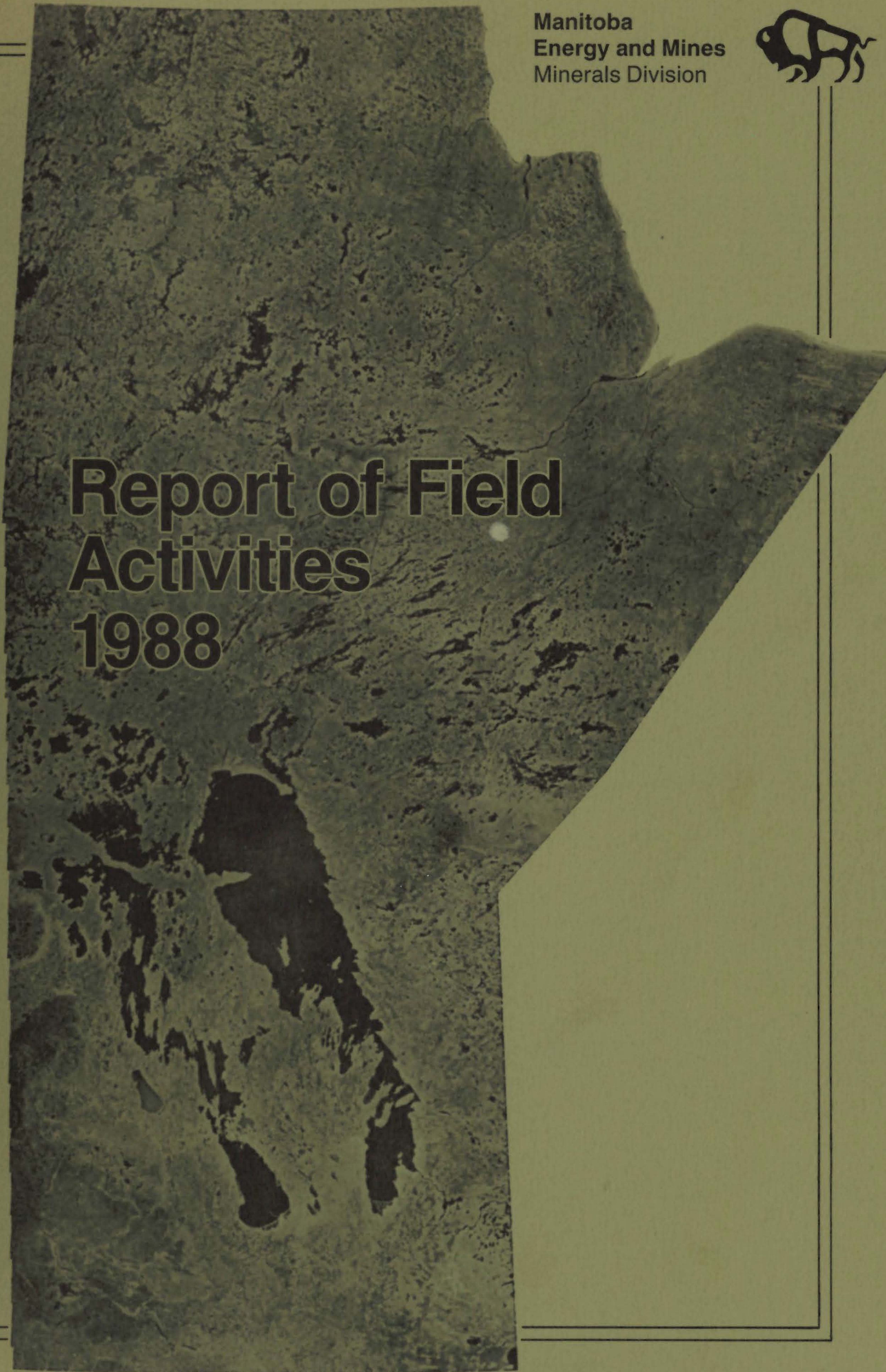
Manitoba
Energy and Mines
Minerals Division

Report of Field Activities 1988



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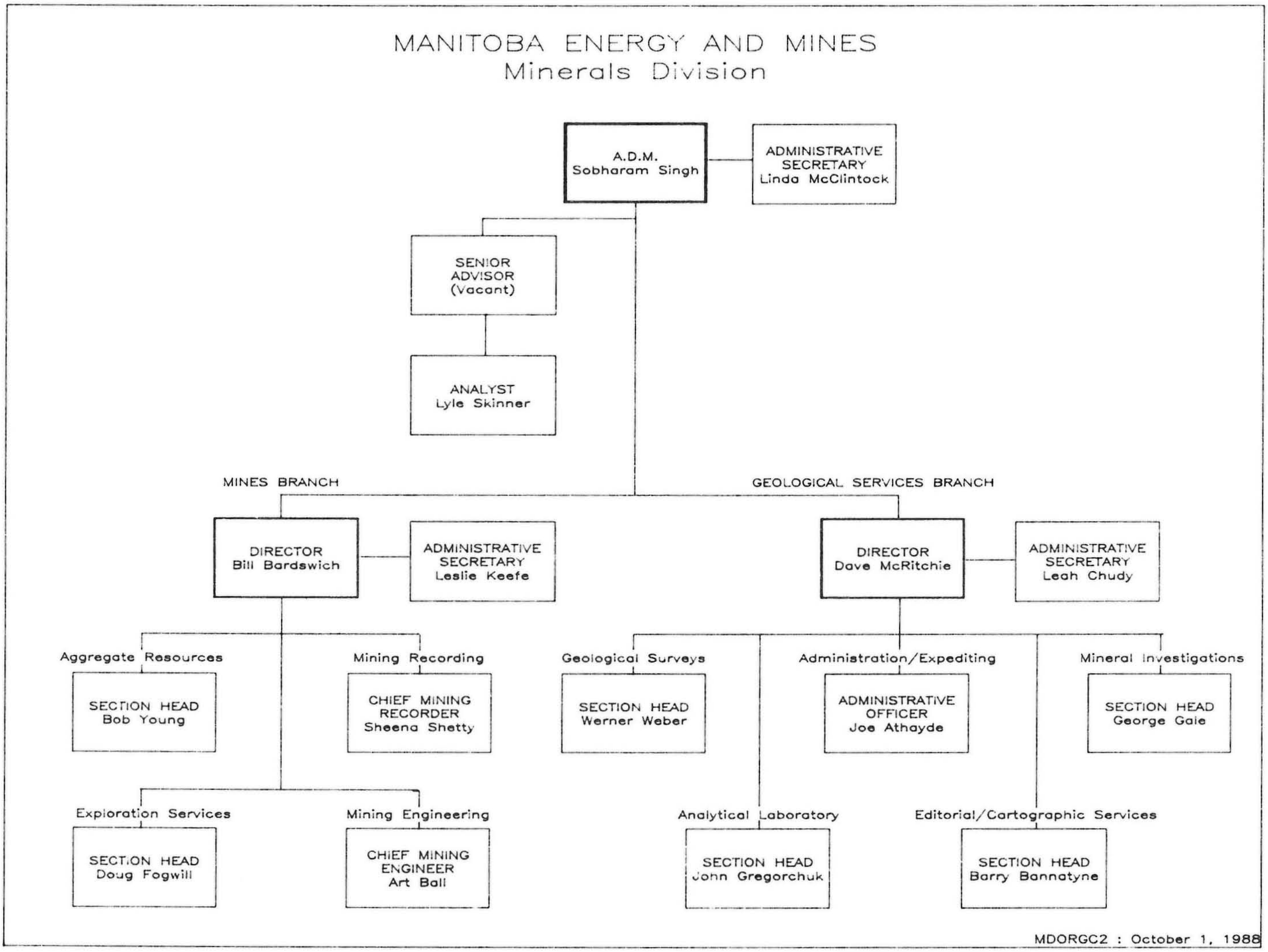
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MDORGC2 : October 1, 1988

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GEOLOGICAL SERVICES

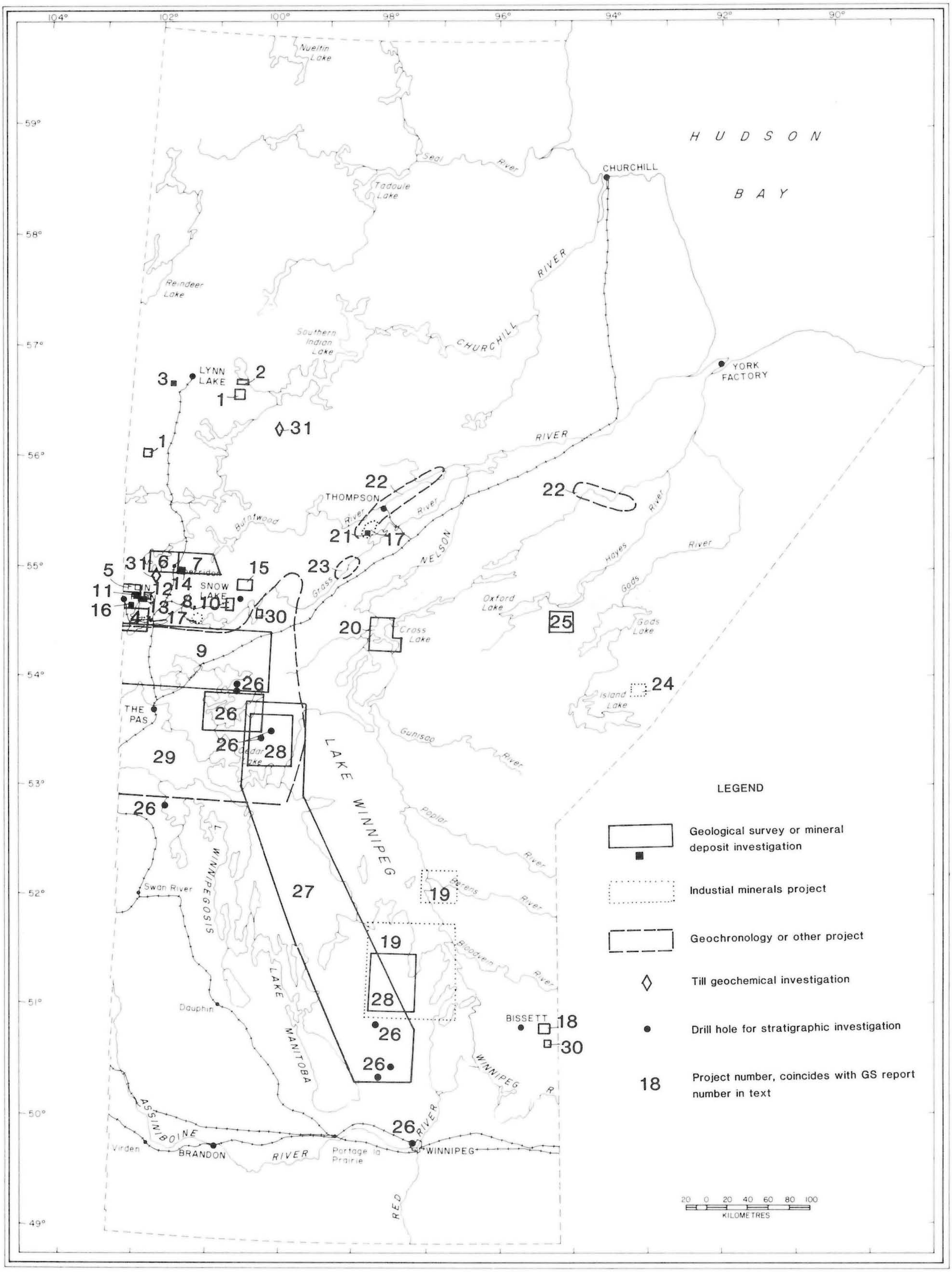

Figure GS-1: Location of field projects, 1988. (Numbers refer to 'GS' reports in this publication.)

INTRODUCTORY REVIEW
by W.D. McRitchie

In 1988 the main thrust of Provincial Sector A Geoscientific activities has been to conclude and document all investigations mounted over the previous four year term of the Canada-Manitoba Mineral Development Agreement (MDA).

The joint federal-provincial Workplan for Sector A was approved in March and copies distributed to members of the Mineral Exploration Liaison Committee. Briefing sessions were held in Winnipeg and several northern mining districts prior to the field season. A progress report for 1987-88 was released June 27, 1988.

Thirty-five projects were mounted by the Province (Fig. GS-1) including 17 geological mapping, 13 mineral investigations, 4 compilation, and 1 basal till investigation. A modest level of field work was maintained in all mining districts with an operational budget of $744.5K.

The majority of the 27 sub-projects and contracts carried out within the 20 federal (GSC) projects have their field studies completed and emphasis is now being directed toward documenting and publishing the resultant findings. This will include completion of seven Masters and three Doctoral theses in 1988-89, and two M.Sc. and one Ph.D. in 1989-90. Federal operational expenditures for 1988-89 will be $1131K.

LYNN LAKE-LEAF RAPIDS

Geological mapping at 1:5000 and geological sampling along the Agassiz Metallotect continued this field season. High-Mg volcanic rocks, a major component of the rocks within the Metallotect, were located at Arbour Lake, White Owl Lake and Barrington Lake.

In the Barrington Lake area the stratigraphy is consistent for approximately 5 km and is broadly similar to the stratigraphy of the Eagle Lake area mapped in 1987.

Several mineral occurrences were examined in the Arbour Lake area. Banded magnetite iron formations were mapped and sampled near Jim Lake and Muskeg Lake.

Till sampling in the Darrol Lake area south of Ruttan Mine revealed mainly background and abraded gold grains derived from extensive glacial erosion of volcanic and sedimentary rocks up-ice. Results from the Deep South Bay and Duval Lake area were similar but do not rule out the potential for gold mineralization up-ice towards the Kisseynew gneiss belt.

Vegetation geochemical studies are proceeding in the Dot Lake area, and the results of the Farley Lake remote sensing study are to be released forthwith as an Open File report.

Aegirine-augite and augite-bearing miaskitic alkaline intrusions at Eden and Brezden lakes were sampled and analyzed confirming the similarity of these bodies with that mapped at Burntwood Lake last year. Evidence of associated economic mineralization is not yet apparent.

FLIN FLON-SNOW LAKE

The Kisseynew Project mapping program was completed this year. Kississing Lake, Puffy Lake-Limestone Point Lake and Sherridon were mapped at 1:15 840 and compiled at 1:50 000. Revised names and relative ages have been suggested for the Sherridon and Nokomis Groups.

Mapping at Kississing Lake clarified the sequence of structural and metamorphic events, and confirmed previously inferred age relationships with aluminous graphite-bearing gneisses of the Burntwood Metamorphic Suite underlying the younger predominantly quartzofeldspathic rocks and gneissic conglomerates of the Missi Metamorphic Suite.

Geological mapping at 1:20 000 of the Tartan and Embury lakes areas traced faults and fault blocks defined in the White Lake-Flin Flon area north and west toward the Saskatchewan border, and showed that the Manistikwan-Bear Lake blocks can be clearly distinguished by the character of their mafic volcanic rocks. The proximity of Trout Lake mine massive sulphide orebodies to a major fault indicates the possible economic significance of the faults in localizing the orebodies in this region.

Field work in the Athapapuskow project completed a three-year study of the area. The principal findings were: the demonstration of dextral movement on all northeast trending faults and shear zones in the eastern half of the area; identification of a very wide (1 km) east-northeast trending zone of intense deformation in southern Athapapuskow Lake (possibly continuous into Elbow Lake); the resolution of nearly all faults in the area into a single master structure corresponding to a southwest trending magnetic linear detected in the sub-Paleozoic to the south; and the delineation of a major relatively late, unfoliated pyroxenite-peridotite in the West Arm-Athapapuskow region. An unusually thick (3 km) section of scoria-rich mafic pyroclastic material was discovered high in the Hook Lake block stratigraphy.

Trace element geochemistry has defined two major subdivisions of the Amisk Group: rocks with arc tholeiite affinity and basalts similar to those erupted in back-arc basins. A small but significant unit of volcaniclastic rocks contains clasts with shoshonite compositions, indicating a mature stage of arc development.

Samples collected from metavolcanic rocks in the Snow Lake (Chisel-Morgan lakes) area demonstrated a tholeiitic and island-arc chemistry matching that of the Flin Flon region. A distinctive REE and trace element chemistry was demonstrated for the footwall unit of the Chisel, Lost and Ghost Mine base metal zone; a chemical distinction is apparent between the Richard Lake and Sneath Lake plutons.

Pyroxene samples from weakly metamorphosed volcanic rocks in the Hook Lake block were analyzed by microprobe to determine their minor element compositions, Mg:Fe ratio, and by inference their tectonic affinity. Results thus far suggest that the primary magmas were sub-alkaline and that emplacement was in a tectonic environment similar to modern island arcs.

A six week mapping program was conducted over the Big Island Zinc property east of Manistikwan Lake to define the stratigraphic setting of the mineralization as well as the alteration and associated structure.

Detailed mapping to the north and west of that completed in 1987 continued to examine altered, folded felsic fragmental rocks in the Leo Lake-Flintoba Lake area. Mapping of the Baker Patton alteration zone identified a westward younging sequence including several newly identified felsic units, andesite flows and breccias, and a diatreme breccia. The role of faulting has a special significance in the interpretation of previous drill hole intersections.

Mineral occurrence documentation was completed in NTS areas 63J/12, 13, 63K/16 and 63-O/4. Mapping at 1:2500 of multi-element mineralization at Puella Bay, Wekusko Lake was completed and detailed maps prepared for the vicinity of the Zona Occurrence.

Mapping projects at 1:5000 were completed in the Puffy Lake area and initiated at Squall Lake. The Main Zone of mineralization at Puffy Lake appears to be close to or contiguous with the axial trace of a prominent F_2 fold.

Only some of the samples taken from the Moose-Horn, Ballast Mine, McCafferty vein and Ferro Mine in the Wekusko Lake area yielded anomalously high Pt, Au and Pd concentrations warranting further examination for PGE.

An examination of base and precious metal mineral potential of the Herblet and Pulver gneiss dome complexes was initiated this summer. Numerous zones of disseminated pyrite, pyrrhotite and chalcopyrite were examined. Areally extensive alteration zones were observed at Pulver Lake, and a zone of undetermined extent containing 2-5% disseminated chalcopyrite with associated anthophyllite-garnet alteration was identified at Dowling Lake.

Humus geochemical studies were continued in the Snow Lake and Flin Flon areas in association with Westfield Minerals and Hudson Bay Exploration and Development Ltd.

An U-Pb zircon age of 1889 + 8/-6 Ma on the Richard Lake tonalite is very close to the 1886 Ma age obtained for Amisk Group volcanism supporting previous proposals that the hydrothermal systems active during base metal volcanogenic sulphide deposition in the Snow Lake area were associated with and driven by the synchronous subvolcanic felsic plutonism.

Six additional holes were drilled through the Paleozoic carbonates south of Flin Flon to provide further control for the ongoing compilation of basement maps in NTS areas 63K, 63J, 63F and 63G.

Industrial mineral activities included mapping of a granodiorite near Flin Flon, detailed mapping and sampling of a talc occurrence at Iskwasum Lake, stripping and sampling a previously described marble occurrence at the Manasan Quarry, detailed mapping and sampling of an aplite-bearing pegmatite near the Manasan Quarry, and detailed mapping and sampling of a petalite-bearing leucogranite at Red Sucker Lake.

BISSETT

Recent fires in the Bissett district have added greatly to the amount of outcrop available for documentation. Detailed remapping of the metavolcanic and metasedimentary units appears warranted in the region between Wallace and Gem lakes.

The inventory of potential building stone in southeast Manitoba was extended to include granitic rocks close to Lake Winnipeg in the Berens and Pigeon rivers region. No new prospects were found, most of the outcrops being closely fractured and intruded by younger dykes.

The initial inventory of sphagnum bogs in the Interlake resulted in publication of a report by the Manitoba Remote Sensing Centre based on the Landsat V Thematic Mapper. The technique has promising applications for more widespread use.

As an adjunct to the field program industrial minerals staff also facilitated and acted as advisors to Sector C activities, a key component of which resulted in installation of granite curbing, cobblestones, and bollards in downtown Winnipeg.

Vegetation geochemical studies continued in the general vicinity of Bissett.

Anomalously high levels of Pd and Au were detected in one of four samples obtained from the Mirage property.

THOMPSON

U-Pb studies in the Thompson belt and northwest Superior Province, conducted in cooperation with the Royal Ontario Museum, have defined two ages of Archean terrains in the Nickel Belt as well as clearly defined Hudsonian reworking at 1809 Ma, and intrusion by younger granites at 1726 Ma.

Detailed mapping of the Pipe Pit generated a highly refined supracrustal stratigraphy for the Ospwagan Group permitting correlation of this sequence with those at Ospwagan Lake, the Manasan Quarry, and Thompson Open Pit, as well as reinterpretation of the structures and structural sequence in this complexly deformed terrain.

As part of a cooperative program with the Department of Geological Sciences, University of Manitoba, new major and trace element analyses of metavolcanic rocks from Moak and Assean lakes were compared with previous data from Ospwagan Lake and Fox River. The Moak and Assean lavas show some similarities, both being consistent with basin-margin settings, and with derivation from a relatively primitive mantle. Relatively high K and Rb values are explained as a result of sea-floor alteration. Assean and Ospwagan rocks tend to straddle the boundary between calc-alkali basalts and island-arc tholeiites whereas those from the Fox River belt and Moak Lake appear restricted to the island-arc tholeiite field.

In the central Cross Lake area a limited program of site checks, and correlation studies completed the 1:20 000 mapping of supracrustals. A pilot study of the thermotectonic evolution of the Cross Lake area was initiated by the Free University of Amsterdam. Two granitoid units were sampled for geochronological studies at the Royal Ontario Museum.

NORTHWEST SUPERIOR PROVINCE

Detailed sampling of the late Archean Magill Granite and associated pegmatites continued, and several new lepidolite-bearing pegmatites were identified east of McLaughlin Lake.

Petalite occurrences on Red Sucker Lake were remapped in detail and sampled to determine their suitability as a raw material for ceramics.

PHANEROZOIC

In the Phanerozoic sector of the province five separate projects entailed, detailed drilling of the Winnipegosis reef at The Bluff on Dawson Bay, a regional Silurian correlation project, regional outcrop mapping in the Moose Lake area, drilling to basement near North Moose Lake, drilling and mapping north of Grand Rapids, and drilling for the Water Resources Branch in the City of Winnipeg to provide additional information on the Upper Red River aquifer. Fourteen core holes were drilled for a total of 1260 m.

The ongoing documentation of Karst features in the Grand Rapids Uplands resulted in the discovery of several new caves bringing the overall total to 45. At least 20 others are known or reported from the southern Interlake.

Examination of Silurian outcrop and drill core data in the Interlake confirmed the usefulness of sand and clay zones in correlating between the Hodgson and Grand Rapids areas. The new information may resolve the "Inwood problem" in that more definite correlations now appear possible equating the Lower Inwood of the southern area with part of the Fisher Branch, and the Upper Inwood to the upper part of the Moose Lake Formation of the northern area. Although numerous new fossil localities have been discovered and sampled it is too early at this time to comment on their potential as unique stratigraphic markers.

GENERAL

Work continues on several maps in the 1:250 000 scale bedrock compilation series. NTS sheets 63N-Kississing Lake, 64H-Northern Indian Lake, and 54E-Herchmer are scheduled for release in November; 63 O-Nelson House is to be displayed in draft form.

Throughout the summer Branch staff also led numerous field tours in the northern mining districts for the benefit of industry and other government geologists.

Displays and field tours of Manitoba Paleozoic formations were provided in support of the American Association of Petroleum Geologists regional meeting in Bismarck, North Dakota, and an outline of the Province's basal till programs was presented at the September 29 Minnesota Geological Survey Open House in Hibbing, Minnesota.

Following the format developed in 1987, this year's Report of Field Activities contains abstracts and summaries of the work undertaken in Manitoba by the Geological Survey of Canada as the federal contribution to the Canada-Manitoba Mineral Development Agreement.

Agencies across Canada appear well disposed to the Mineral Development Agreements as a mechanism for focussing the combined technical resources and expertise of the Federal and Provincial Surveys in support of the mineral exploration sector. Over the last 12 months a concerted effort has been mounted to develop a comprehensive program of exploration supportive surveys and mineral investigations that could be mounted over the next five year period. Modelled in large part on the initiatives delivered during the 1984-89 period, this five year Workplan also incorporates numerous suggestions tabled by industry geologists.

Implementation of the initiatives would begin April 1, 1989, subject to receiving the appropriate approvals from the Federal and Provincial governments.

W.D. McRitchie
September 28, 1988

GS-1 ALKALINE INTRUSIONS OF THE CHURCHILL PROVINCE EDEN LAKE (64C/9) AND BREZDEN LAKE (64C/4)

by W.D. McRitchie

INTRODUCTION

After the initial study of the Burntwood Lake syenite (McRitchie, 1987), investigations into alkaline intrusions of the Churchill Province were extended this year to encompass all likely felsic intrusions in the Lynn Lake-Leaf Rapids-Kisseynew region.

Previously published reports were used as the principal guide in conducting the initial search. Thin sections, stained slabs and hand specimens were checked to confirm/reject bodies selected from the literature review. In this way, eight intrusions in the Nelson House, Osis Lake region that initially appeared to have alkaline attributes were rejected. Each of the three intrusions investigated to date displays multiphase assemblages recording a complex and extended intrusive history; however, only the earliest phase is conclusively alkaline. Accordingly, the selection process outlined above may inadvertently have excluded some alkaline intrusions if the available hand specimens represented only the younger silica-saturated granitic phases.

Two syenitic bodies were selected for field investigations in 1988 (Fig. GS-1-1), an aegirine-augite bearing monzonite to quartz monzonite on Eden Lake (Cameron, 1988), and a hornblende-alkali feldspar syenite east of Brezden Lake (Lenton, 1981). An occurrence of syenitic rocks recorded by Bateman (1945) south of McVeigh Lake was not field checked this year.

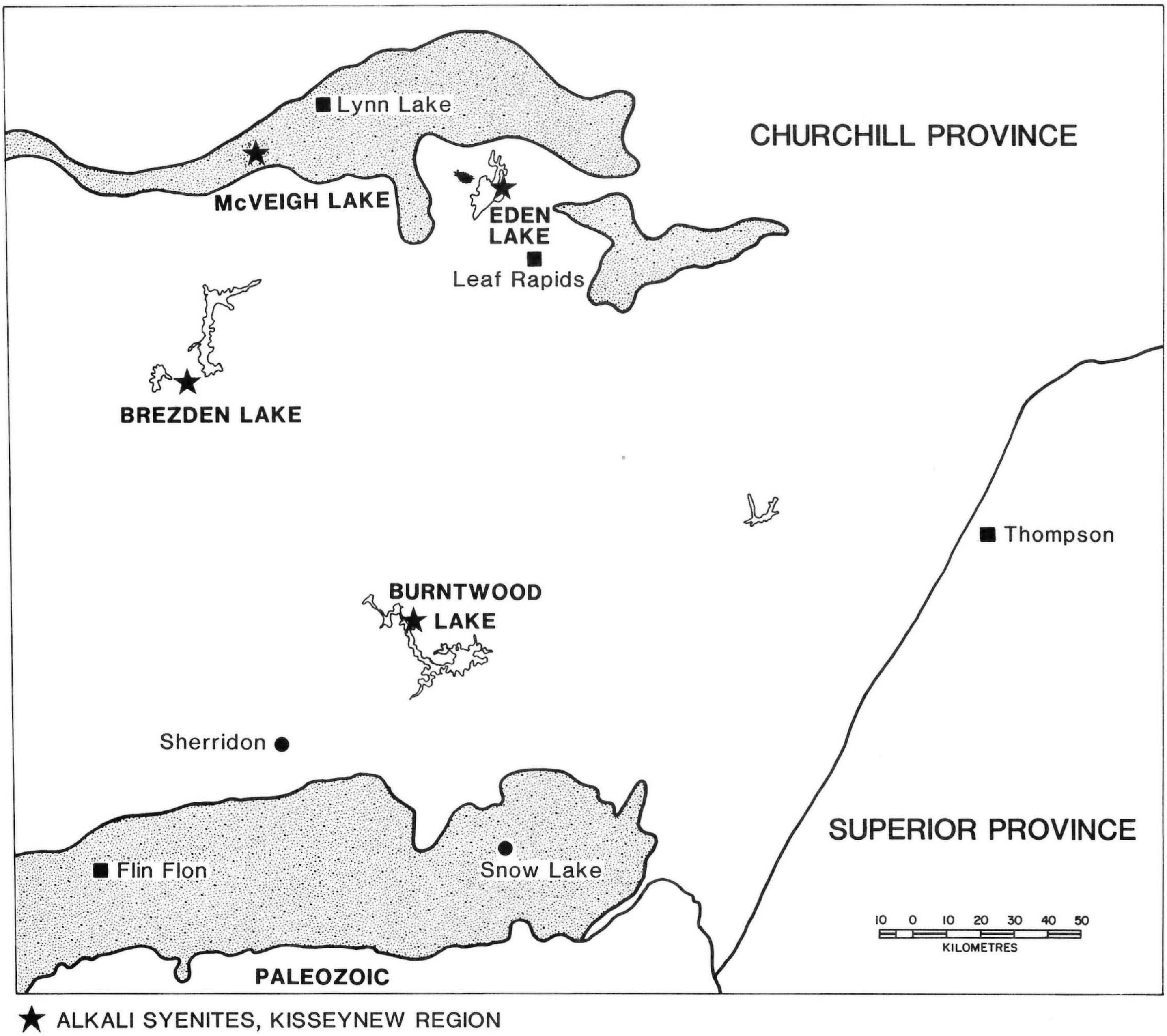

Figure GS-1-1: Alkali syenites of the Kisseynew region.

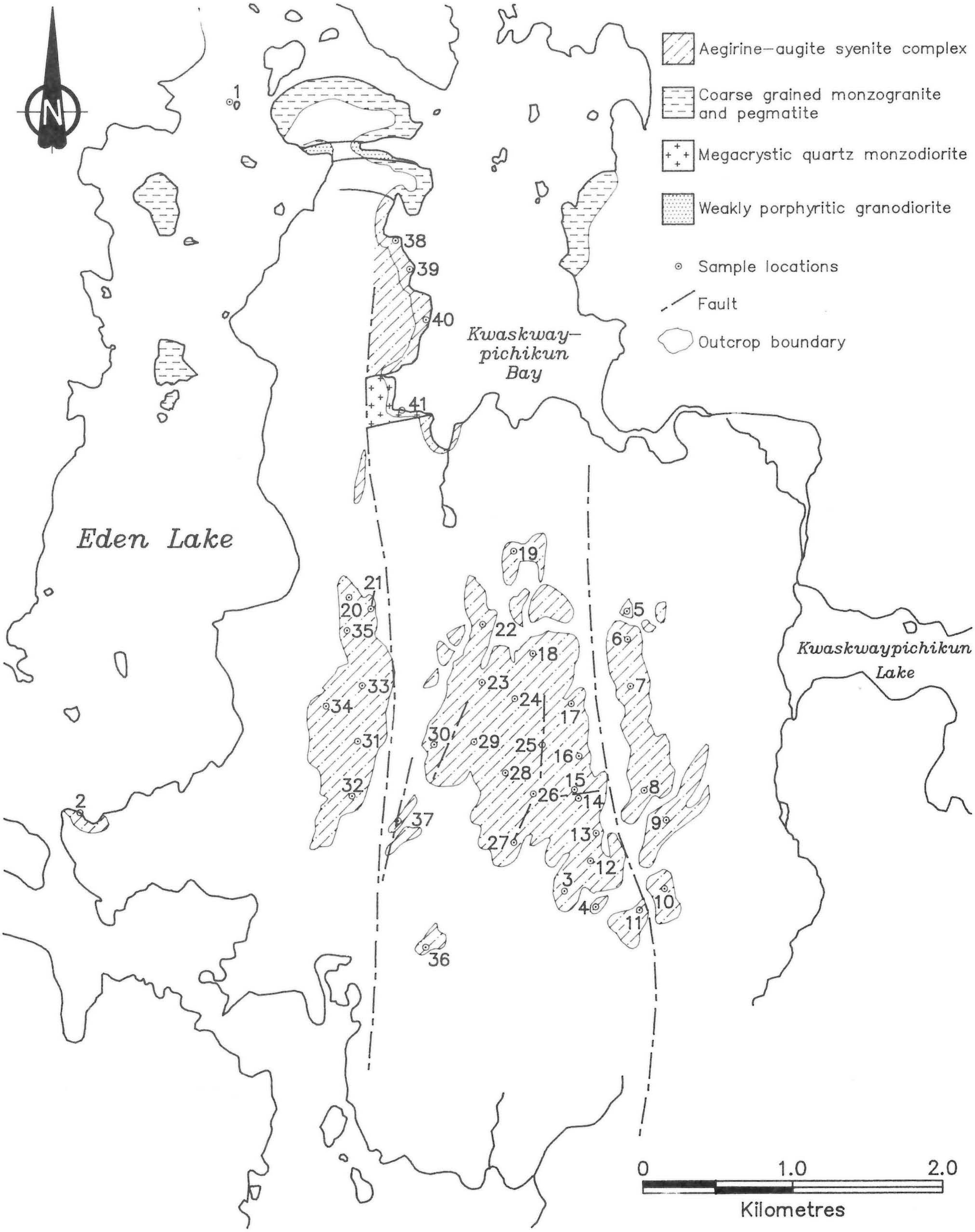

Figure GS-1-2: Outline geology and station locations, Eden Lake syenite. (Geology modified after Cameron, 1988).

EDEN LAKE AEGIRINE-AUGITE SYENITE

This 15 km^2 intrusion occurs on the east shore of Eden Lake, 60 km east-southeast of Lynn Lake (Fig. GS-1-2). Syenitic and associated granitic rocks form three high north-trending ridges (rising over 90 m above lake level) dissected by steep sided gullies that are probably fault controlled. Contacts with country rocks were not observed.

The body has a low to moderate aeromagnetic response (2600-2700 gammas) extending to 2980 gammas over the southeast corner, which is also the site of a URP uranium anomaly.

Forty-one stations were spaced evenly over the available exposures and more than 120 specimens of the various phases taken for follow-up analysis and study.

Most outcrops display several granitoid phases. An older, pink to pale cream, more monzosyenitic phase contains 15-30% ferromagnesian minerals. It is typically intruded by fine grained, pink aplitic leucosyenite, which in turn is cut by younger pink and white granite and pegmatitic granite dykes and stockworks. These are intruded by parallel sided pink pegmatites (002° and 280° azimuth) with purple interstitial fluorite, graphically intergrown quartz and potassium feldspar, plagioclase, and local, centrally concentrated, pods and lenses of white bull quartz.

Several narrow (1 mm-20 cm) vertical, north-trending cataclastic zones were observed containing finely ground quartz and cryptocrystalline crushed granite. One near-vertical 020° trending fault zone manifested as a curvilinear 20-40 cm wide recessively weathered trench, contains clotted ferromagnesian minerals in a carbonate matrix with smeared purple fluorite segregations in a finely ground granitic host.

An extensive, subhorizontal, 20 cm thick recessively weathered fault zone containing intensely microbrecciated granite, (exposed for 50 m in a 15 m vertical face) suggests that the intrusion may in large part be structurally bounded, and allochthonous.

The older syenite and monzosyenite is typically medium grained, homogeneous, weakly to non-foliated and equigranular with pink to pale orange potassium feldspar, deep green-olive brown pleochroic and locally twinned aegirine/augite, blue-green hornblende, abundant sphene, minor apatite and trace zircon. Centimetre layering is rare; however, layered segregations of clotted ferromagnesian minerals are fairly common as are rectilinear networks of centimetre and millimetre thick pyroxene-rich veinlets with feldspar/apatite-rich cores enclosed by pyroxene envelopes with "ingrowing" subhedral tabular crystals. More massive phases contain 0.3-0.8 cm poikilitic feldspars containing seed-like inclusions of 1.3 mm ferromagnesian minerals. In some coarser grained leucogranitic syenitic phases pyroxene megacrysts can are 2-3 cm long. Fine grained, dioritic or amphibolitic rafts and schlieren are uncommon but locally occur in abundance, forming hybridized contamination zones (southern end of western ridge).

The "older" coarser phases, are cut by extensive dykes and stockworks of more leucocratic, equigranular, homogeneous and unfoliated, pink to pale purple, fine grained aegirine-augite syenite with a sugary texture and average grain size less than 1 mm. At most locations quartz content is less than 4%.

Both syenitic phases are cut by locally dominant, pink, quartz-rich dykes and stockworks of aplite and granite, the latter commonly ranging in grain size from medium to very coarse grained or pegmatitic.

The youngest intrusive unit comprises pegmatite dykes ranging in thickness from 2 cm to 2 m. Most strike 280° or 0-20° and dip 40° to vertical. Quartz-rich cores occur in the larger bodies. Typically the dykes contain abundant pink or orange potassium feldspar with graphic intergrowths of quartz, almost ubiquitous interstitial purple fluorite (up to 1.5 cm), and less common andradite.

BREZDEN LAKE HORNBLENDE-ALKALI FELDSPAR SYENITE

This 3 km^2 intrusion has no aeromagnetic expression and occupies high ground east and southeast of Brezden Lake, a narrow north-trending topographic feature 5 km east of McCallum Lake (NTS 64C/4). Lenton (1981) describes the body as an indistinct area in a magnetite-bearing syenogranite (unit 14) with hornblende pseudomorphous after clinopyroxene, and with clinopyroxene remnants in crystal cores.

Country rocks comprise migmatitic metagreywacke-derived paragneiss metatexite and diatexite with locally dominant white granitic/pegmatitic mobilizate.

During the current investigation particular attention was given to mapping and tracing the contacts of the body (Fig. GS-1-3), to define the range and distribution of compositional variations. Forty-one stations and over 100 samples were collected from the northern two-thirds of the intrusion.

The body is banana-shaped, 4 km long in its northern dimension and with an average width of 0.8 km. Typically, it has eastward-dipping (30-50°) foliation, with oxidized and heterogeneous multiphase contact zones up to 40 m wide, and slightly less foliated, more massive syenitic core. All outcrops contain numerous crosscutting granitoid rocks, the older phases being syenitic, the younger, quartz-bearing and granitic or pegmatitic.

Fresh, less metamorphosed phases contain equant to stubby tabular pale green augite, with local twinning, as discrete and aggregated crystals in a hypidiomorphic-granular matrix of plagioclase (An_{18-25}), locally perthitic to mesoperthitic twinned microcline (up to 0.8 cm) and sporadic minor quartz. Accessory apatite is clouded with minute inclusions. Sphene is euhedral and fairly common as an accessory mineral, as is metamict allanite. Secondary minerals include blue-green hornblende as overgrowths on the augite, biotite and scattered carbonate.

CONCLUSION

The principal features of the three alkaline intrusions investigated thus far are compared in Table GS-1-1, and modal and chemical analyses for the Eden and Brezden bodies in Tables GS-1-2 and GS-1-3, respectively. Mineralogically the three intrusions are very similar, differing only in the degree of metamorphic overprint. The Burntwood intrusion is chemically the most undersaturated of this otherwise miaskitic and possibly comagmatic suite. Although no economic concentrations have yet been identified, one sample from Eden Lake was recorded to contain 14% allanite; the sample will be analyzed for rare earth element content.

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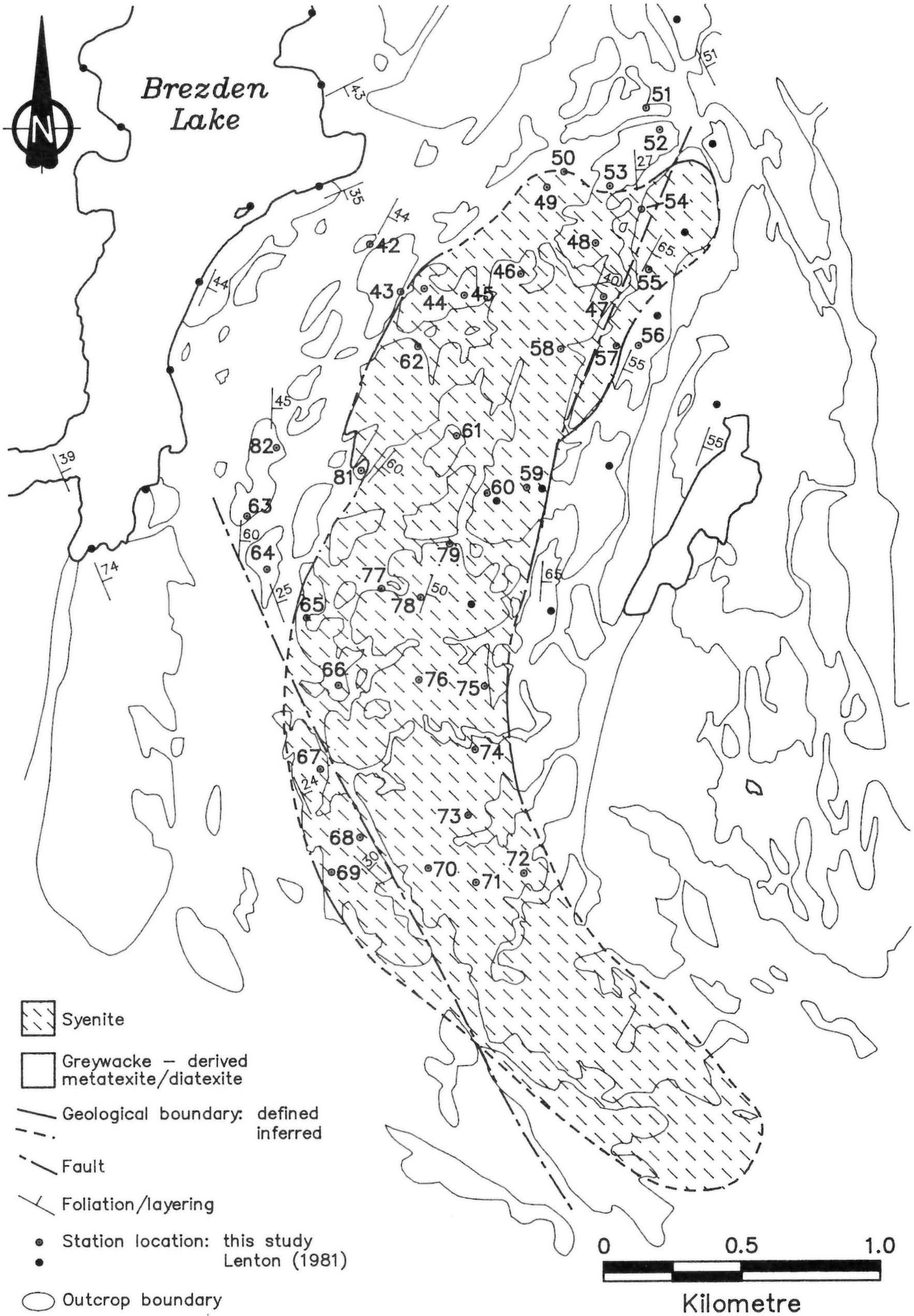

Figure GS-1-3: Outline geology and sample locations, Brezden Lake syenite.

TABLE GS-1-1
TYPICAL FEATURES OF ALKALI SYENITES IN THE CHURCHILL PROVINCE, MANITOBA

Features	LOCATION BURNTWOOD LAKE (63N/8, 9, 10)	EDEN LAKE (64C/9)	BREZDEN LAKE (64C/4)
Size of Intrusion	3 km^2	15 km^2	3 km^2
Shape of Intrusion	Folded sheets, phacolithic	Irregular elliptical outline; no contact observed	Folded sheet
Country rocks:			
a) Type	Greywacke-derived migmatite	Granite/greenstone	Greywacke-derived migmatite
b) Metamorphic Grade	Uppermost amphibolite	Lower/middle amphibolite	Uppermost amphibolite
Relationship to Country Rocks	Structurally conformable; local contact metasomatism - peripheral oxidized zone (3.5 m)	Unknown	Structurally conformable; local contact metasomatism - Peripheral oxidized zone (20-40 m)
Associated Phases	Granite, aplite, pegmatite (mafic rafts and schlieren)	Microsyenite, granite, aplite, fluorite-bearing pegmatite (mafic rafts and schlieren)	Granite, aplite (mafic rafts and schlieren)
Homogeneity	Heterogeneous	Heterogeneous	Heterogeneous
Range of Compositions	Syenite to syenodiorite	Syenite; separate syenodiorite?	Syenite to monzogranite
Colour	Salmon pink to cream	Salmon pink to cream	Pale orange or pink
Igneous Features			
a) Structures	Modal, textural, grain size and inclusion layering: vein networks of ferromagnesian minerals	Local textural, minor modal, and inclusion layering: vein networks of ferromagnesian minerals: oikocrystic microcline	Minor modal and contamination layering
b) Textures	Cumulitic pyroxene; oikocrystic microcline		
Grain Size	Coarse to medium	Medium to fine	Medium
Metamorphic/Tectonic Overprint	Strong marginal foliation; weak to moderate internal foliation and folding of igneous layering. Fresh textures and mineralogy near core. Local scapolite-rich phases.	Strong marginal foliation; weak internal foliation in older phases. Local scapolite-rich phases ± carbonate	Rare phaneritic phases. Moderate foliation present throughout. Minor blue-green hornblende, biotite and secondary carbonate.
Chemistry			
a) Silica Content	49.5 - 69.5%	56.5 - 72.1	61.0 - 71.5
b) K + Na : Al	K+Na $<$ Al	K+Na $<$ Al	K+Na $<$ Al
c) K + Na : 1/6 Si	K+Na $>$ 1/6Si	K+Na $\approx$ 1/6 Si	K+Na $\approx$6 Si
d) Na : K	Na $<<$ K	Na $\geq$K	Na $<$ K
e) Trace elements	Ba up to 5600 ppm Sr up to 2574 ppm	Ba 1300-3310 ppm Sr 1400-2200 ppm Local high REE, Y, etc.	Ba 1100-3500 ppm Sr 600-2400 ppm
Mineralogy			
a) Felsic Minerals	Microcline meso- and micro-perthite; plag. An_{8-14}; minor quartz	Microcline mesoperthite and plagioclase An_{7-13}; minor quartz	Microcline locally mesoperthitic plagioclase An_{18-25}; minor quartz
b) Ferromagnesian Minerals	Aeg./augite, augite, hornblende	Aeg/augite, minor augite	Augite or hornblende
c) Accessory Minerals	Sphene, apatite, (clouded) magnetite, zircon. Common myrmekite and albitization	Sphene, sparse apatite, allanite and zircon	Sphene, apatite (clouded), trace allanite Rare myrmekite and albitization

TABLE GS-1-2
EDEN AND BREZDEN LAKES: MINERALOGICAL SUMMARY

Mineral	EDEN LAKE 04-88-03-1	EDEN LAKE 04-88-6-5	EDEN LAKE 04-88-33-4	EDEN LAKE 04-88-33-2	EDEN LAKE 04-88-35-2	BREZDEN LAKE 04-88-50-1	BREZDEN LAKE 04-88-65-1	BREZDEN LAKE 04-88-70-3
Clinopyroxene	15 (aegirine-augite)	20 (aegirine-augite)	30 (aegirine-augite)	40 (aegirine-augite)	10 (aegirine-augite)	46 (augite)	40 (augite)	35 (augite)
Plagioclase	35 (An_8)	25 (An_6)	20 (An_5)	25 (An_9)	10 (An_{12})	10 (An_{37})	24 (An_{29})	20 (An_{27})
K-feldspar	20	30	15	20	60	21	20	25
Clinoamphibole	-	-	-	-	-	3	10	-
Quartz	22	5	<1	-	<1	5	<1	5
Apatite	2	3	13	5	-	7	3	10
Sphene (Titanite)	1	2	2	10	5	2	3	3
Allanite	1	14	<1	-	<1	3	-	-
Oxides	<1	-	-	-	<1	-	<1	-
Carbonates	3	-	20	<1	10	3	-	2
Zircon	1	-	-	-	-	<1	-	-
Fluorite	-	1	pr.	-	-	-	-	-
Chlorite	-	-	-	-	<1	-	<1	<1
Garnet	-	-	-	-	5	-	-	-

TABLE GS-1-3
EDEN AND BREZDEN LAKES SYENITES: CHEMICAL ANALYSES

Sample #	EDEN LAKE 04-88-03-1	04-88-03-4	04-88-05-1	04-88-06-5	04-88-15-2	04-88-19-1	04-88-20-3	04-88-33-2	04-88-34-2	04-88-36-1	04-88-36-2	04-88-40-2
SiO_2%	67.2	63.8	60.9	59.1	61.9	62.4	62.8	60.6	72.1	60.0	56.5	70.2
Al_2O_3	15.74	17.10	13.43	12.20	14.45	15.31	16.80	14.39	14.49	13.52	10.96	15.08
FeO	0.72	1.06	3.16	2.16	2.46	2.12	1.54	2.24	0.56	2.60	3.62	0.91
Fe_2O_3	1.27	1.24	2.49	2.64	2.03	2.03	1.86	2.20	0.41	2.66	3.75	0.87
CaO	1.78	2.51	6.28	6.69	5.56	3.90	3.12	5.47	1.21	6.59	9.58	1.82
MgO	0.52	0.61	2.21	1.26	1.75	1.15	0.75	1.42	0.34	1.85	2.33	0.56
Na_2O	5.71	6.11	5.23	4.18	6.39	5.05	6.51	5.76	6.70	5.65	4.96	5.44
K_2O	6.04	6.50	4.81	3.91	3.67	6.67	4.53	4.72	3.09	4.55	4.02	3.88
TiO_2	0.24	0.30	0.38	0.38	0.39	0.38	0.51	0.57	0.17	0.36	0.24	0.31
P_2O_5	0.10	0.21	0.15	1.56	0.17	0.26	0.25	0.54	0.05	0.59	1.16	0.10
MnO	0.06	0.07	0.20	0.26	0.17	0.16	0.12	0.14	0.02	0.19	0.28	0.05
H_2O	0.37	0.33	0.35	0.95	0.42	0.32	0.42	0.27	0.20	0.21	0.29	0.23
S	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.02	0.00	0.01	0.02	0.01
CO_2	0.35	0.42	0.14	0.28	0.61	0.12	0.3	0.42	0.12	0.64	1.14	0.12
Other	0.20	0.46	0.47	0.40	0.35	0.45	0.59	0.62	0.16	0.39	0.35	0.23
LOI												
O=S,F	-0.02	-0.02	-0.02	-0.12	-0.02	-0.02	-0.03	-0.04	-0.07	-0.04	-0.08	-0.05
TOTAL	100.33	100.75	100.02	96.16	100.35	100.36	100.14	99.42	99.72	99.87	99.29	99.87
FeO(T)	1.86	2.18	5.40	4.54	4.29	3.95	3.21	4.22	0.93	4.99	6.99	1.69
*Rb ppm	125	113	108	87	65	174	115	82	101	79	60	131
Sr	334	1430	1520	1470	1390	1130	1750	2270	464	1580	1430	638
Ba	1290	2458	2482	1951	1611	2688	3310	3052	867	1762	1558	1300
F	390	455	408	2910	479	504	564	774	1665	1010	1680	1100
Y	13	13	18	1152	30	18	27	44	3	36	62	4
Zr	398	319	200	162	388	313	771	286	121	263	230	153
Nb	11	15	17	43	26	28	44	21	5	17	10	4

TABLE GS-1-3 (CONT'D.)

Sample #	04-88-62-2	BREZDEN LAKE 04-88-69-1	04-88-73	04-88-75-1	04-88-77-2	04-88-78-1
SiO_2%	62.2	63.0	61.0	65.3	71.5	61.8
Al_2O_3	15.13	15.33	16.89	14.89	14.96	15.36
FeO	2.72	1.86	1.72	2.40	1.06	2.52
Fe_2O_3	0.90	1.02	1.88	0.99	0.47	0.98
CaO	4.57	4.45	3.43	3.70	1.85	5.02
MgO	1.49	1.77	1.38	1.32	0.53	1.88
Na_2O	3.38	4.49	4.61	3.77	5.33	4.15
K_2O	8.03	6.17	6.66	5.80	3.34	6.67
TiO_2	0.39	0.43	0.53	0.35	0.19	0.44
P_2O_5	0.38	0.39	0.33	0.39	0.06	0.43
MnO	0.11	0.08	0.08	0.08	0.02	0.12
H_2O	0.42	0.45	0.47	0.46	0.42	0.43
S	0.00	0.04	0.05	0.01	0.01	0.00
CO_2	0.09	0.25	0.12	0.12	0.1	0.19
Other	0.65	0.68	0.52	0.53	0.21	0.61
LOI						
O=S,F	-0.02	-0.04	-0.05	-0.04	-0.02	-0.02
TOTAL	100.49	100.42	99.69	100.16	100.07	100.64
FeO(T)	3.53	2.78	3.41	3.29	1.48	3.40
*Rb ppm	133	134	131	102	52	112
Sr	2100	2370	1830	1720	628	2190
Ba	3490	3460	2585	2790	1127	3032
F	461	532	743	895	411	584
Y	24	22	38	24	4	24
Zr	224	290	485	206	99	106
Nb	19	15	29	14	<2	14

*Rare element analyses by N. Halden, Department of Geological Sciences, University of Manitoba

ACKNOWLEDGEMENTS:

1) Table GS-1-2: Mineral identifications by C. McGregor.
2) Table GS-1-3: Major element analyses by Geological Services Analytical Laboratory.

GS-2 INVESTIGATION OF VOLCANIC STRATIGRAPHY AND IRON FORMATION OCCURRENCES, LYNN LAKE AREA

by D.T. Parbery

INTRODUCTION

This project was a continuation of the investigation of volcanic stratigraphy associated with the Agassiz Metallotect and iron formation occurrences initiated in 1987 (Parbery and Fedikow, 1987).

The Agassiz Metallotect is characterized by a distinctive geophysical signature (Questor, 1976; Fedikow, 1986a), a specific lithologic association that consists of high MgO-Ni-Cr basaltic rocks, clastic sedimentary rocks, and iron formation (Fedikow and Gale, 1982). This rock association has a known strike length of 70 km and extends from the Sheila Lake-Margaret Lake area (Ferreira, 1986) eastwards to Spider Lake (Fedikow, 1986b), and is the setting for several base/precious metal occurrences (Fedikow et al., 1986). Outcrops coincident with Questor anomalies in the Barrington Lake, Arbour Lake, and White Owl Lake areas were examined (Fig. GS-2-1). In addition banded iron formation was mapped and sampled at Jim Lake and Muskeg Lake and three volcano-sedimentary hosted mineral occurrences at Arbour Lake were examined.

VOLCANIC STRATIGRAPHY ASSOCIATED WITH THE AGASSIZ METALLOTECT

Barrington Lake Area

Barrington Lake is located 56 km east of the town of Lynn Lake. Rocks that are part of the Agassiz Metallotect occur south of Barrington Lake between Nickel Lake and Spider Lake (Fig. GS-2-2). Figure GS-2-3 is a sketch of an idealized stratigraphic section in the Barrington Lake area. The lithologies noted in Figure GS-2-3 are described below.

I. Fragmental Mafic Volcanic Rocks

These rocks are exposed on a peninsula on the south shore of Barrington Lake (Janet occurrence — Baldwin et al., 1985) and south of Webb Lake (to east of Barrington Lake). They consist of mafic to intermediate flow breccias, crystal tuffs, tuffs and minor heterolithic breccia. The units are 0.10-3.0 m thick and are weakly foliated. They occur to the north of the high-Mg volcanic rocks.

II. Felsic Volcanic Rock

The felsic volcanic rocks contain quartz megacrysts and have an aphanitic groundmass. The megacrysts are augen-shaped, blue to blue-grey, 0.1-0.6 cm in length and make up 10-30% of the rock. Minor, 10-20 cm thick, aphyric felsic layers are found within the quartz-eye felsic volcanic rocks; they are considered to be felsic dykes.

III. Siliceous Tuff/Sediments

These rocks are very fine grained to aphanitic, weather white to brown-grey and contain (less than 1%, less than 1 mm, subhedral) magnetite. Rare (less than 1%) anhedral, (less than 1 mm) plagioclase crystals are found in some outcrops. Prominent features of the rock include amphibole-rich layers and are recessively weathered layers. Amphibole-rich layers are 0.5-2.0 cm thick, are composed of 5-20% amphibole, 0.5-2.0 mm in length. The layers are commonly centred around 1 mm thick, grey, discontinuous, quartz veinlets that parallel the foliation. The amphibolite layers commonly contain 0.5-3.0 mm pink-orange garnets. Recessive weathering imparts a subparallel parting in the rock identifed by bands with negative relief that are 1 cm wide and 2-10 cm apart.

IV. High-Mg Volcanic Rocks

The high-Mg volcanic rocks weather a distinctive dark green to blue-green and occur south of the felsic volcanic and tuffaceous rocks described above. Most of the high-Mg rocks are fragmental and comprise heterolithic breccia, flow breccias, flow-top breccias, crystal tuff, and tuffs. The units are moderately to strongly foliated (Az 270°/80°S) and are 0.05-4.0 m thick.

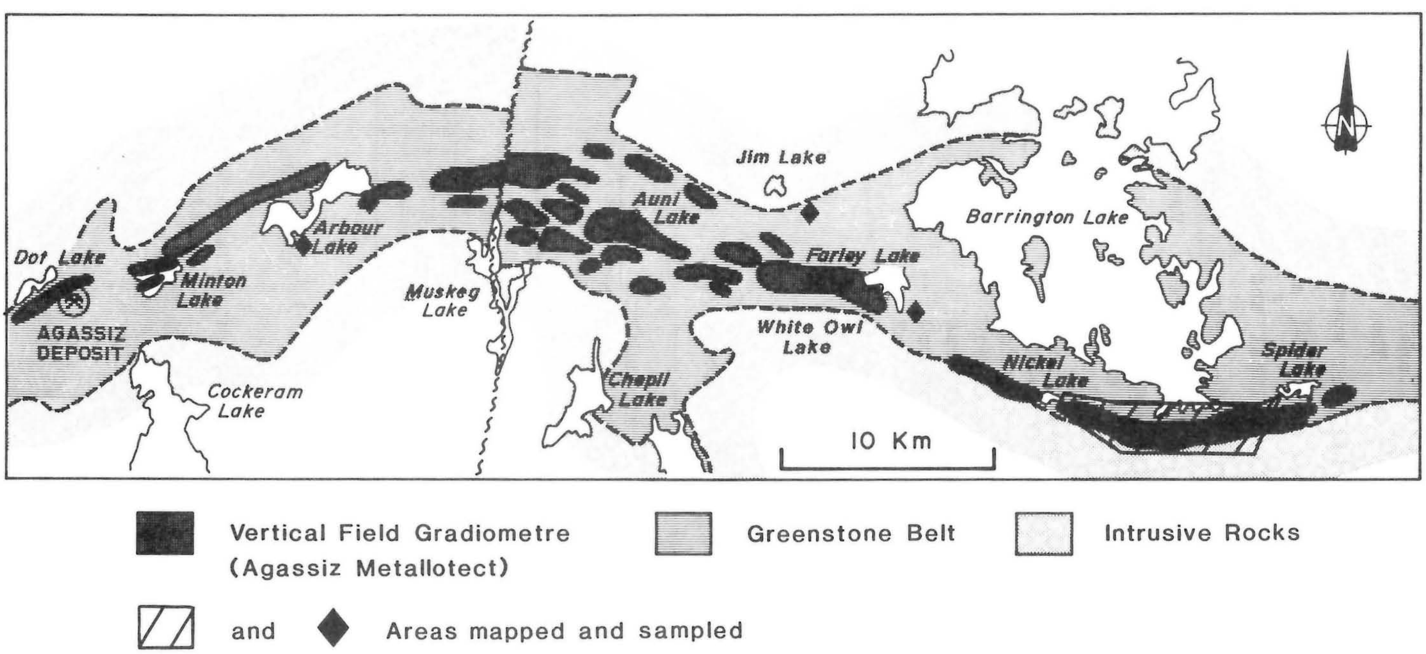

Figure GS-2-1: Location map showing areas mapped and sampled within the Agassiz Metallotect.

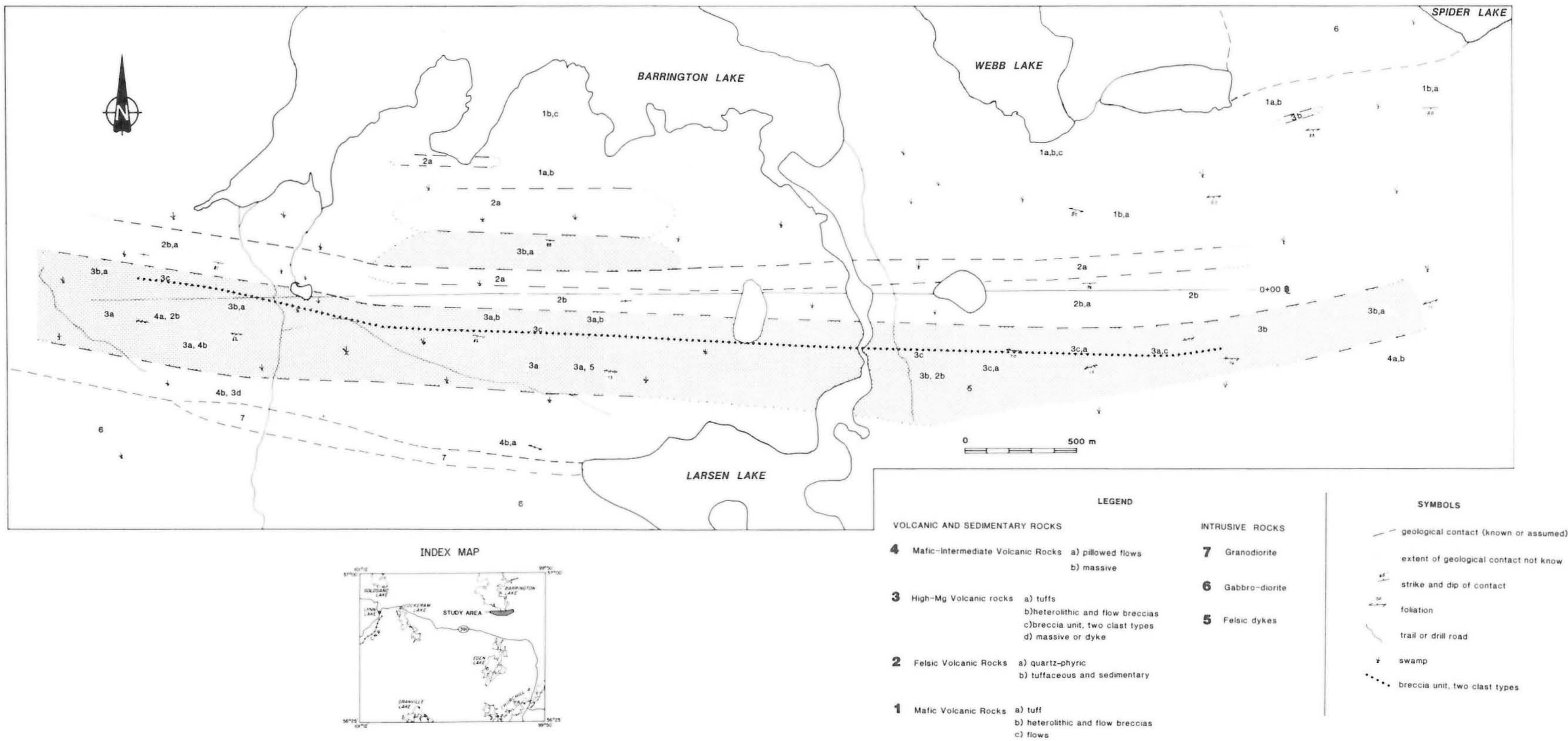

Figure GS-2-2: Geological map of the Barrington Lake area (after Milligan, 1960 and Gilbert, 1987).

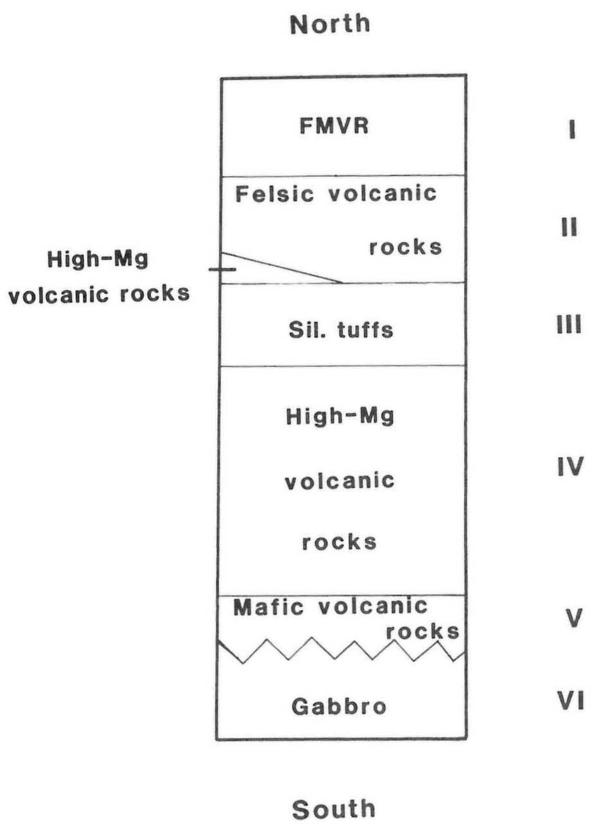

Figure GS-2-3: Diagrammatic stratigraphic section of the Barrington Lake area. Stratigraphic thickness is 1.5 km. FMVR = fragmental mafic volcanic rocks; Sil. tuff = siliceous tuffs/sedimentary rocks.

The most common unit of high-Mg rocks is a breccia that contains two clast types supported in a dark green, very fine grained to aphanitic matrix. The major clast type, which constitutes 40% of the rock, is very fine grained to aphanitic, intermediate and contains 20-25%, 0.2-0.5 cm, pyroxene phenocrysts and 10%, 0.5-1.0 mm, plagioclase amygdules. The second clast type is plagioclase-phyric, quartz-amygdaloidal, and intermediate in composition; it makes up 20% of the rock. Plagioclase phenocrysts are 1 mm across and make up 5% of the clast volume. Amygdules are oval, 1-3 mm long and make up 5-10% of the clast volume. Clasts range from 1.5 x 12 cm to 0.5 x 5.0 cm and are elongate parallel to the rock foliation. The breccia unit has a known strike length of 4.5 km.

Heterolithic breccias have two to five clast types that, in total, compose 40-80% of the rock. Clasts are commonly amygdaloidal and may be aphyric or phyric. They range in size from 15 x 30 cm to 0.5 x 1 cm, and are elongate parallel to rock foliation.

In outcrops of fragmental rocks that have been strongly foliated amphibole porphyroblasts occur within the matrix and the clasts. These porphyroblasts are probably pseudomorphs of pyroxene.

The high-Mg volcanic rocks contain a minor amount of interlayered thin intermediate sedimentary rocks that are very similar in appearance to unit III. They are also intruded by many thin, aphanitic felsic to intermediate dykes that are parallel to the foliation and bedding directions.

V. Mafic Volcanic rocks

The mafic volcanic rocks that occur to the south of the high-Mg rocks are massive to weakly foliated tuffs with a minor amount of pillowed flows. Pillows are 30 x 10 to 20 x 5 cm and have chloritized rims. The rocks are crosscut by medium grained felsic dykes that are most likely related to the small granodioritic intrusion to the south.

VI. Intrusive Rocks

A fine grained to medium grained gabbroic intrusion occurs to the south of the volcanic rocks and extends from Larsen Lake to Nickel Lake. A small, medium grained intermediate intrusion is situated between the gabbro and the mafic volcanic rocks described above.

STRUCTURE

Most layers trend east-west and dip steeply to the south. They are moderately to strongly foliated parallel to subparallel to strike. Layer contacts and foliation planes are gently folded in places.

Within the high-Mg volcanic rock layers, tops are to the south as indicated by pillow tops, pillow breccia and graded bedding. Also, within these rocks a crenulation cleavage at 244°/78°W, occurs over a length of 5 km.

The stratigraphy at Barrington Lake has broad similarities to that at Eagle Lake (Fig. GS-2-1, Parbery and Fedikow, 1987).

Arbour Lake area

Arbour Lake is located 21 km northeast of the town of Lynn Lake (Fig. GS-2-1). The high-Mg rock units at the southeast end of the lake are massive, 0.1-5.0 m thick, poorly exposed and trend southwest. Some units are of possible fragmental origin. Interlayered with the high-Mg volcanic rocks are mafic grey-black plagioclase- ± hornblende-pyhric basalts, and minor amounts of breccia and tuff.

The high-Mg volcanic rocks at the northeast end of Arbour Lake occur 300-600 m east of the lake and consist of heterolithic breccia, flow breccia, pillowed flows and pillow breccia. The units trend southwest, have a steep to vertical dip, are 0.5-3 m thick and are discontinuously exposed along strike. Areas of outcrop are usually 10-20 m wide and approximately 300 m long.

High-Mg, matrix-supported, heterolithic breccias typically contain clasts of several distinct lithologic types. Many of the larger fragments (20 x 12, 9 x 3 cm) are plagioclase amygdular, mafic and subrounded to elongate; the smaller clasts (8 x 7, 1 x 0.5 cm) are more numerous, similar in composition and colour to the matrix, generally subangular, and may be vesicular, amygdaloidal, aphyric or pyroxene-phyric. The matrix is very fine grained and dark green.

Heterolithic breccias make up approximately 40% of the high-Mg volcancic rocks that are exposed in the Arbour Lake area. The breccias probably represent debris flows. Primary features in pillowed flows and pillow breccias indicate stratigraphic top is to the southeast. Pillows are small, 30 x 10 to 10 x 10 cm, and most selvages are indistinct. The high-Mg volcanic rocks are in contact with a southwest-trending tonalite and occur in low swampy ground at the edge of the tonalite outcrops. High-Mg volcanic rock also occurs as fragments within the surrounding tonalite and as rubble throughout the area.

Three mineral occurrences were mapped and sampled in the area east of Arbour Lake:

Occurrence 1 — Located between Arbour Lake and the Hughes River, it consists of a 9 x 11 m outcrop of 0.5-3 m thick, interlayered, very fine grained, massive, mafic to amphibolitic rock and intensely rusty weathered, fine grained, green mafic rock. There are several repetitions of each rock layer in the outcrop. Contacts between layers are sharp and strike west-southwest and dip steeply to the north. The repetition of the two units is probably the result of tight folding of a mafic volcanic rock and a sulphide-bearing mafic volcanic layer. Quartz veinlets parallel the contacts.

Occurrence 2 — Several outcrops of a high-Mg heterolithic breccia and a pillowed flow contain approximately 5% disseminated, 1-2 mm, anhedral to subhedral magnetite. A large outcrop of heterolithic breccia that contains abundant magnetite (5-10%) is stained black. The staining appears to be fracture controlled and thus the magnetite is considered to be of secondary origin. The magnetite is found in both the matrix and clasts of the breccia.

Occurrence 3 — A sulphide-bearing siliceous unit on the east shore of Arbour Lake, noted by Gilbert et al. (1980) extends over 600 m southwards and parallels the lake shore. A 5 x 1.5 m trench exposes a strongly foliated, banded siliceous rock that contains three subparallel rusty weathered zones. The siliceous bands are 0.5-20 cm thick, aphanitic to very fine grained, and contains approximately 3%, 1 mm anhedral plagioclase grains. This unit is probably a felsic-intermediate, silicified, tuff/sedimentary rock. The rusty weathered zones are 0.3-2 m thick. Two of the zones contain 5-10% disseminated pyrrhotite ± pyrite and the other is composed of near-solid pyrrhotite ± pyrite. Rocks on strike and to the northeast of the silicic rock are rusty weathered, mafic to intermediate siltstones/greywackes.

Outcrop to the south and east of the trench consists of an interlayered sequence comprising medium grained, salt and pepper textured, grey basalt, and high-Mg fragmental volcanic rocks. Clasts in the latter rocks are very fine grained, dark green, subrounded to subangular 3-6 x 2-4 cm, and make up 10% of the rock. The matrix is light green and aphanitic. Rare, larger clasts of a pyroxene-phyric mafic rock and a quartz-amygdaloidal intermediate rock occur in the fragmental rock at the south end of a small outcrop, about 80 m south-southwest of the trench. Units trend south-southwest.

White Owl Lake area

High-Mg volcanic rocks occur southeast of White Owl Lake and south of Leo Lake (Fig. GS-2-1). They comprise very fine grained tuff and very fine grained to aphanitic massive flows containing 10-15%, 1-4 mm, oval, quartz amygdules. Rock units trend northwest and dip steeply to the south. The high-Mg rocks outcrop sparsely over a 600 m wide zone. They are interlayered with mafic pyroxene- and plagioclase-crystal tuffs.

BANDED IRON FORMATION OCCURRENCES

Muskeg Lake area

Muskeg Lake is located 25 km northeast of the town of Lynn Lake (Fig. GS-2-1). Banded iron formation occurs northeast of the lake. The iron formation is bounded on the north by felsic layered sedimentary rocks, and to the south by massive mafic to intermediate rocks. Granodiorite occurs to the north of the sedimentary rocks and gabbro occurs to the south of the mafic rocks.

The felsic layered sedimentary rocks are very fine grained to aphanitic and weather white to beige; (they strike 090°/75°N). The layers are 0.1-2 cm thick. Cherty, 1-4 cm thick layers occur within these rocks.

The banded iron formation comprises interlayered magnetite-rich, quartz-chlorite-rich, and siliceous laminae. Magnetite-rich layers are 0.1-1 cm thick and the quartz-chlorite layers and the siliceous layers are 0.1-0.5 cm thick. Rare hematite layers, less than 1 mm thick, also occur within the rock.

The mafic to intermediate rocks trend east, have a vertical dip and are massive to weakly foliated. They may be high-Mg basaltic tuffs. Gilbert et al., (1980) sampled high-Mg pillowed basalt 1 km east of Bob Lake that is located just north of Muskeg Lake.

Jim Lake area

Jim Lake is located 38 km northeast of the town of Lynn Lake (Fig. GS-2-1). Banded iron formation occurs 1.2 km southeast of Jim Lake and 2.5 km north of the Farley Lake gold deposit. The quartz magnetite iron formation trends west-northwest for a distance of 300 m, dips steeply to the south, and has an exposed width of 90 m. The rock consists of alternating, less than 5 mm thick, quartz-rich layers, 5 mm thick, green, mafic silicate layers and 1-5 mm thick magnetite layers. Magnetite layers make up 30% of the iron formation at the south end of the exposure and decrease in abundance to the north where they make up approximately 5% of the rock. The silicate layers are green-brown and recessively weathered in the northern outcrops.

North of the banded iron formation, plagioclase-phyric mafic to intermediate volcanic rocks occur. South of the banded iron formation the rocks consist of felsic to intermediate siltstone, quartz crystal tuff, laminated siltstone with approximately 1% disseminated magnetite, and massive, intermediate plagioclase crystal tuffs. The felsic sedimentary rocks and tuff are exposed over a 4 m width of outcrop. The intermediate crystal tuffs occur in scattered outcrops from 4 to 10 m south of the banded iron formation.

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GS-3 PRELIMINARY OBSERVATIONS OF A DETAILED GEOLOGICAL INVESTIGATION OF THE GEMMELL LAKE AREA, LYNN LAKE

by G.R. Sherman, I.M. Samson and P.E. Holm[1]

INTRODUCTION

The Lynn Lake greenstone belt comprises two metamorphosed Aphebian volcano-sedimentary sequences that are separated by granitic plutons (Gilbert et al., 1980; Syme, 1985). The southern belt contains numerous vein-type gold occurrences associated with a regional lineament known as the Johnson shear zone. The Johnson shear zone is an ill-defined zone of structural disruption that crosscuts volcanic, sedimentary and intrusive rocks (Fedikow et al., 1986).

Baldwin (1987) concluded that the Johnson shear zone extends west from its previously mapped termination, at Franklin Lake, through the Gemmell Lake area, located in the western end of the southern portion of the greenstone belt. Other reports on the Johnson shear zone include Bateman (1945), Milligan (1960), Gilbert et al. (1980), Peck (1984, 1985), Ferreira (1986) and Fedikow et al. (1986).

This study was initiated to investigate the relationship of gold mineralization in the Gemmell Lake area to igneous intrusion, deformation, metamorphism, and veining. Geological mapping at a scale of 1:2400 was carried out on the Shoe-Lace claim block (CB 7811), located 14 km southwest of Lynn Lake (Fig. GS-3-1). Detailed mapping of the Finlay McKinlay gold showing and the Prospector vein occurrence, both of which are located in the claim block, was completed at scales of 1:300 and 1:30 respectively. Future work will include petrographic and geochemical studies. The results of this study will be contained in an M.Sc. thesis presently being undertaken at the University of Windsor.

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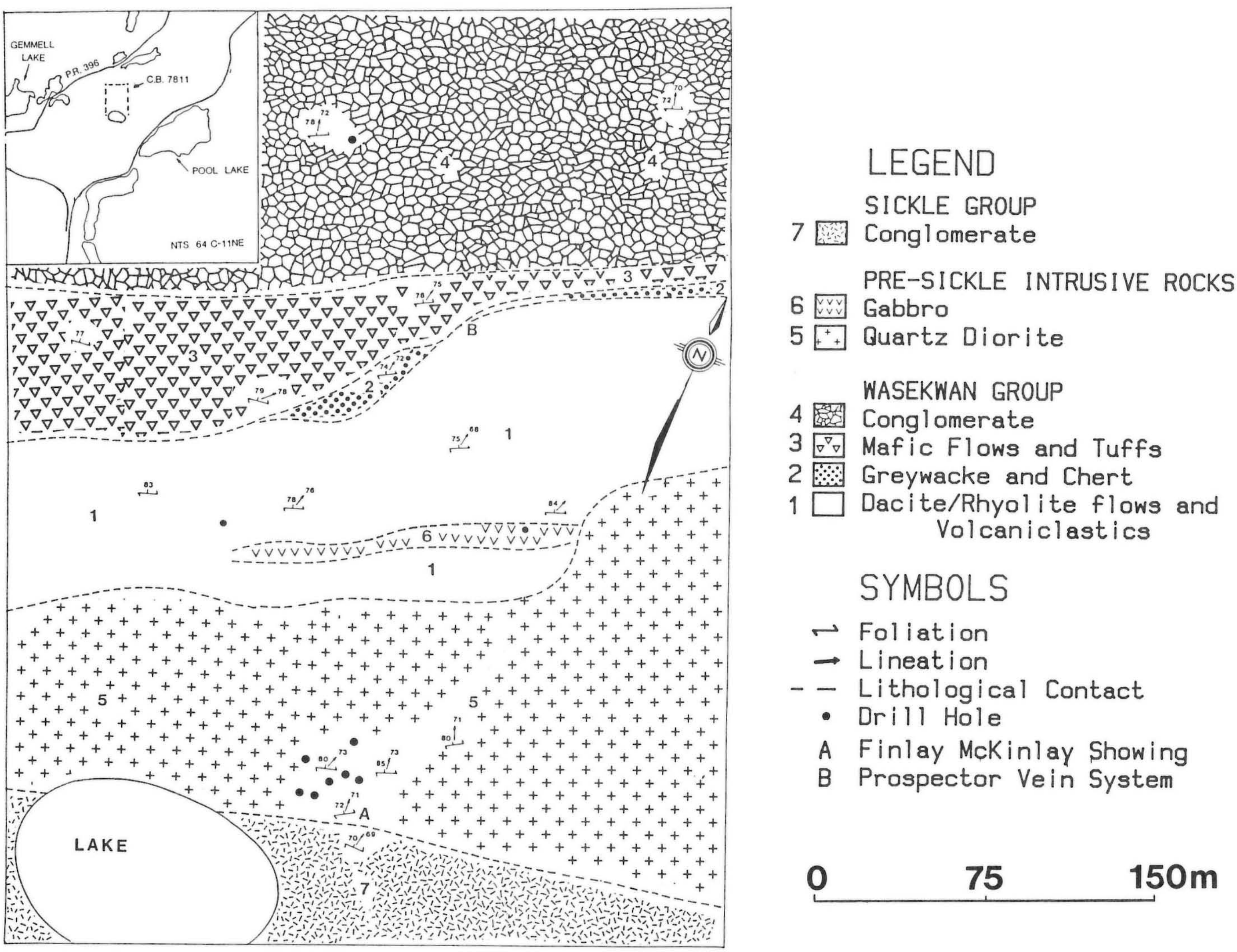

Figure GS-3-1: Geology of the Shoe-Lace claim block (CB 7811), east of Gemmell Lake.

EXPLORATION HISTORY

Prior to 1980, activity on the Shoe-Lace claim group consisted of base-metal exploration by Sherritt Gordon Mines. In 1985, Granges Exploration AB announced a gold discovery on its adjacent Gemmell Lake claim group. The Shoe-Lace claim was subsequently reevaluated through geological and geophysical surveys that resulted in the discovery of the Finlay McKinlay gold showing. During 1986 and 1987, a diamond drilling program was carried out on the Finlay McKinlay showing and other areas that were targeted with magnetometer and VLF techniques. The property is currently a joint venture between Lynngold Resources Inc. and Manitoba Mineral Resources Ltd.

LOCAL GEOLOGY

The geology of the Gemmell Lake area (Fig. GS-3-1) consists of a sequence of Wasekwan Group volcanic, volcaniclastic and sedimentary rocks, Pre-Sickle intrusive rocks and Sickle Group sedimentary rocks, that have undergone amphibolite grade metamorphism (Gilbert et al., 1980). The local stratigraphy of the supracrustal rocks was established by Baldwin (1987) (Fig. GS-3-2).

CONGLOMERATE ——U————U——	SICKLE GROUP
CONGLOMERATE	WASEKWAN/SICKLE ?
MAFIC FLOWS AND TUFFS GREYWACKE AND CHERT RHYOLITE FLOWS AND TUFFS CRYSTAL TUFF PORPHYRITIC DACITE FLOWS AND BRECCIA	WASEKWAN GROUP

Figure GS-3-2: Stratigraphy of the supracrustal rocks, Gemmell Lake.

Individual rock units strike east-west and dip steeply to the north. The Wasekwan and Sickle Group rocks exhibit a regional, penetrative, northeast-striking schistosity and slaty cleavage that dips steeply to the northwest. The foliation is well developed within the mafic volcanic rocks, moderately developed within the sedimentary rocks and poorly developed within the felsic volcanic and plutonic rocks. Associated with the foliation is a north-plunging stretching lineation (Fig. GS-3-1) defined by either the elongation of sedimentary clasts, aggregates or grains, or the alignment of chlorite, biotite and sericite.

WASEKWAN GROUP

FELSIC VOLCANIC ROCKS

Felsic volcanic rocks in the study area (Unit 1, Fig. GS-3-1) comprise massive dacite to rhyolite flows, volcanic breccia, crystal tuff, and other volcaniclastic rocks.

The northern portion of this sequence consists of massive aphanitic rhyolitic flows (up to 5 m thick) and fine grained tuffaceous rocks, with rare quartz- and plagioclase-rich phaneritic units.

The southern portion of the sequence consists of massive, grey-green quartz-porphyritic flows that are overlain by flow breccia and crystal tuff. The quartz phenocrysts (less than 15%) are grey, rounded and set in a fine grained quartz-feldspar-white mica matrix. The breccia is monolithic and consists of angular to subrounded, dacitic clasts ranging in size from 5 to 30 cm and set in a predominantly felsic matrix. Overlying the flows and breccia is a sequence of crystal tuffs that contain abundant quartz phenocrysts. In addition, the crystal tuff contains mafic fragments, which may be lapilli-sized bombs, that have been flattened in the plane of foliation. Fining sequences that contain pyroclastic rocks do not indicate younging directions.

MAFIC AND FELSIC SEDIMENTARY ROCKS

A thin sedimentary unit (less than 30 m thick) is localized between the felsic and mafic volcanic sequences. Individual beds that range in thickness from less than 1 cm to 1 m consist of garnetiferous metagreywacke with lesser tuffaceous rocks and chert. The metagreywacke contains pink, coarse grained garnet poprhyroblasts (10-15%) set in a fine grained amphibole-chlorite-biotite-rich matrix. The chert is massive to laminated and ranges from dark to light brown. This unit also contains rare beds of magnetite-rich iron formation that are less than 3 cm in thickness.

MAFIC VOLCANIC ROCKS

Mafic volcanic rocks (amphibole-chlorite-biotite schists) consist of porphyritic flows, aphanitic flows and tuffs intercalated with fine grained mafic sedimentary rocks. Individual units range in thickness from 3 to 20 m. The porphyritic flows are characterized by the presence of elongate, medium- to coarse-grained hornblende phenocrysts set in a fine grained plagioclase-biotite-rich matrix. The mafic tuff is a fine grained, banded schist. The mafic sedimentary rock is predominantly fine grained, finely laminated and is strongly magnetic, although some beds contain coarser detrital quartz and lithic clasts. This sequence also contains minor volcanic breccia and pillowed flows. The volcanic breccia consists of rounded clasts, which range in diameter from 2 to 15 cm, set in a fine grained, amphibole-rich matrix. The pillows have 2-3 cm wide, amphibole-rich selvages and range in size from 12 to 30 cm. Pillow interiors contain 1-2 mm, white, quartz and calcite amygdules. The distribution of these amygdules (concentrated in pillow tops) together with pillow shape suggests that the sequence youngs to the northwest.

WASKEWAN OR SICKLE CONGLOMERATE

The conglomerate exposed in the northern part of the study area (unit 4, Fig. GS-3-1) was classified by Gilbert et al. (1980) as a Sickle Group conglomerate that rests on the Wasekwan Group rocks with a slight angular unconformity. However, McRitchie (1974, p. 19) suggests that the name Wasekwan Group be restricted to rocks that occur to the north of the northern contact of the Sickle Group.

This unit comprises polymictic conglomerate composed of pebble- to cobble-sized clasts, interbedded with fine grained biotite-quartz greywacke. Individual conglomerate units are moderately to poorly sorted and range from a muddy conglomerate to a pebbly mudstone. Clasts are of dominantly felsic and intermediate volcanic lithologies. Granitic clasts, which are rare in the Wasekwan Group conglomerates, are common, particularly in the muddy conglomerate units. In contrast to granitic clasts, which are relatively undeformed, felsic and intermediate volcanic clasts are strongly flattened.

SICKLE GROUP CONGLOMERATE

The Sickle Conglomerate is a poorly sorted, matrix-supported polymictic conglomerate. Clasts are well rounded to subrounded, range in size from boulders (30 x 20 cm) to pebbles, and include: felsic, intermediate and mafic volcanic rocks; granite; syenite; tonalite; quartz diorite; quartz vein material; and magnetite-rich chert. Interbedded with the conglomerate are thin beds (less than 30 cm thick) of biotite-quartz greywacke. The greywacke matrix is mineralogically variable and contains quartz + feldspar ± biotite ± muscovite ± magnetite. Adjacent to the contact with the greywacke there is an increase in the abundance of characteristic blue quartz-eye grains in the matrix of the quartz diorite (see below). The contact between the quartz diorite and the conglomerate dips to the north (255°/74°). The presence of quartz diorite material in the conglomerate indicates that the quartz diorite predates the deposition of the conglomerate.

PRE-SICKLE INTRUSIVE ROCKS

FELSIC PLUTONIC ROCKS

The Wasekwan Group rocks have been intruded by a quartz diorite pluton (unit 5, Fig. GS-3-1) that marks the southern boundary of the Lynn Lake greenstone belt. The intrusive rock grades from a coarse grained, inequigranular quartz diorite phase to a subequigranular coarse grained granodiorite phase towards its northern contact. In outcrop, the intrusive rock is characterized by porphyritic, blue quartz eyes set in a fine grained hornblende-biotite matrix. The diorite contains discontinuous lozenge-shaped zones that are generally less than 2 cm wide and display a weak foliation. The quartz diorite contains amphibolite xenoliths but apparently no felsic volcanic xenoliths.

MAFIC INTRUSIVE ROCKS

A 10-20 m thick grabbroic sill intrudes the felsic volcanic rocks in the central part of the map area (Fig. GS-3-1). The intrusive is massive to weakly foliated, fine grained and equigranular. The sill contains abundant 1-3 cm wide epidote-carbonate veinlets and locally contains minor disseminated pyrite and chalcopyrite.

FINLAY McKINLAY GOLD SHOWING

Anomalous gold values were obtained by Sherritt Gordon Mines Ltd. from quartz veins that occupy a shear zone within the quartz diorite close to the contact between the Sickle Group conglomerate and the quartz diorite (Fig. GS-3-1).

The mineralized veins contain grey-white, coarse grained, highly fractured quartz and minor carbonate, biotite, chlorite and tourmaline. Mineralization is localized within the directly adjacent wall rock or along fractures within the quartz veins and includes free gold (Baldwin, 1987), pyrite, chalcopyrite, pyrrhotite, arsenopyrite and magnetite. Alteration halos, which range in width from less than 2 to 6 cm, contain biotite + tourmaline + chlorite ± carbonate ± potassium feldspar ± pyrite.

Deformation associated with the Finlay McKinlay gold showing is characteristic of a relatively discrete shear zone. It is a planar zone that exhibits protomylonitic to mylonitic textures with locally developed ultramylonitic fabrics and is the host to the gold-bearing veins. The orientation of the mylonitized zones is subparallel to the regional foliation. The transition from undeformed to most deformed is marked by an intensification of foliation and grain size reduction.

Four degrees of deformation have been identified:

1. The host rock quartz diorite as described above is relatively undeformed.
2. Protomylonite is recognized by a readily visible foliation and the replacement of hornblende by biotite and chlorite. The primary quartz grains display a slight augen shape that defines a weak stretching lineation.
3. The transition to mylonite is abrupt, beginning with discrete bands anastomosing around and confining zones of less deformed protomylonite. In addition, biotite becomes the predominant mafic mineral and a pervasive, penetrative foliation develops with a strong stretching lineation defined by the elongation of quartz grains into ribbons and the alignment of biotite, chlorite and pyrite blebs.
4. The ultramylonite is localized in narrow, discrete bands composed of fine grained quartz, biotite and white mica. The bands display a distinct laminated appearance and anastomose around less deformed mylonitic rocks.

The shear zone has a maximum width of 30-40 m and appears to terminate to the west at the contact with the Sickle conglomerate. To the east, the zone can be followed for 100 m then curves towards the northeast before it is lost beneath overburden.

Four vein sets have been recognized on the basis of crosscutting relationships and orientation. Two of these are mineralized and all terminate at or before the contact between the Sickle Group and the quartz diorite.

1. Non-mineralized, north- to northwest-trending quartz veins and pods.
2. Non-mineralized, thin, planar quartz veins that are subparallel to the regional foliation.
3. Mineralized, north- to northeast-trending, sigmoidal quartz-filled extension veins that exhibit composite crack and seal textures. These veins are typical of those that develop within a brittle-ductile shear zone and indicate sinistral sense of shear (Ramsay and Huber, 1983).
4. Mineralized, gold-bearing, boudinaged quartz veins that lie within, and parallel to, the mylonitized zone and display complex crack and seal textures. These veins decrease in width towards the east. Sulphides in the vein set occur in fractures suggesting that mineralization was introduced after, or towards, the end stages of mylonitization.

Localized along the northern edge of vein set 4 is a 1-2 m zone of fracturing, faulting, and brecciation. The breccia consists of angular to subrounded clasts of quartz and variably altered quartz diorite in a fine grained matrix of pseudotachylyte. This zone is the result of a brittle deformation event that postdates mylonitization and the formation of the main gold-bearing vein.

PROSPECTOR VEIN OCCURRENCE

The Prospector vein occurrence located approximately 200 m north-northwest of the Finlay McKinlay showing (Fig. GS-3-1) consists of a number of milky white quartz veins and lenses localized within the felsic to mafic sedimentary rocks (unit 2).

The veins consists of white, coarse grained, highly fractured quartz and minor carbonate, biotite, tourmaline, chlorite, sericite, potassium feldspar, and garnet. Alteration halos associated with the veins range in width from less than 1 cm to 4 cm and contain carbonate, biotite, tourmaline, chlorite, and garnet. The veins contain no sulphides, although minor pyrite, pyrrhotite, arsenopyrite and magnetite are disseminated in the directly adjacent wall rocks. Assay results performed by Lynngold have provided only minor gold values for the veins in the Prospector vein outcrop.

Ductile deformation associated with the Prospector Vein outcrop consists of tight folds, small-scale asymmetric folds and folded and boudinaged quartz veins. At least some of this folding is thought to be related to the regional deformation. Mylonitic textures were not observed at this locality.

Brittle deformation consists of fracturing, brecciation, pseudotachylyte development, and faulting localized in narrow zones. Crosscutting relationships indicate that brittle deformation postdates the ductile deformation.

Brittle deformation such as that seen in the Prospector Vein outcrop can be found across the central part of the study area and defines a north-northeast-trending zone that is up to 50 m wide. This type of deformation is similar to that described for the Johnson Shear Zone by Gilbert et al. (1980), Peck (1984), Ferreira (1986) and Fedikow et al. (1986).

SUMMARY

A brittle ductile shear zone with mylonite development exists in the study area, and contains gold mineralization. However, it is limited in extent and is restricted to the quartz-diorite intrusive. A brittle deformation event, associated with the development of pseudotachylyte, also exists and postdates ductile deformation, including mylonitization.

Brittle deformation, not associated with mylonitization, is more extensive and includes the development of a brittle deformation zone that crosscuts the central part of the study area.

Although it is clear that the 'Johnson Shear Zone' extends through the Gemmell Lake area, many aspects of the deformation are not related to shearing. There is a large variation in the intensity of the regional foliation due to lithology-controlled ductility contrasts. Most of the highly foliated rocks are therefore not related to shearing.

Several generations of mineralized and non-mineralized quartz veins exist and have a complex relationship to the above deformational features.

Future work will include a more detailed analysis of the relationship between deformation, veining, fluid evolution (fluid inclusion studies) and mineralization.

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GS-4 ATHAPAPUSKOW LAKE PROJECT

by E.C. Syme

INTRODUCTION

The Athapapuskow Lake project entails detailed, 1:15 840 mapping of Early Proterozoic metavolcanic, metasedimentary and intrusive rocks in the southwestern portion of the Flin Flon metavolcanic belt. Field work in 1988 completed a three-year study of the area (Fig. GS-4-1); previous work is described by Syme (1985, 1986, 1987). This mapping, together with similar projects completed (Bailes and Syme, 1987) and in progress (Gilbert, this volume) will provide an improved undertstanding of the complex stratigraphic and structural relationships in this part of the Flin Flon belt. Within the area encompassed by these three projects there are 11 Cu-Zn deposits that have been or are being mined, one Au deposit now in production, and several base metal and gold occurrences currently being explored. The purpose of the regional mapping is to place known deposits in geological context and to provide a sound base for further exploration.

GEOLOGICAL SETTING

The Flin Flon belt is composed of an assemblage of metamorphosed subaqueous and subordinate subaerial volcanic rocks and associated sediments (Amisk Group), an unconformably overlying alluvial sequence of metamorphosed sandstones and conglomerates (Missi Group), and a complex array of intrusive rocks ranging in age from syn-Amisk to post-Missi. The Flin Flon belt is bounded to the north by the Kisseynew gneiss belt and is overlain to the south by flat-lying Ordovician dolomitic limestone (Fig. GS-4-2). U-Pb zircon ages from the belt (summarized in Gordon et al., in press) indicate that the Amisk Group rocks were emplaced at 1886 Ma, Missi Group rocks at 1832 Ma and plutons from 1889 Ma (Bailes, this volume) to 1830 Ma.

Structure in the western Flin Flon belt is dominated by a system of NNW to NNE and NE faults, some of which separate distinct domains. Each domain or fault-bounded block has a characteristic stratigraphic sequence, style of internal deformation, metamorphic grade, and suite of contained intrusions. In the Athapapuskow Lake area, folds predate an 1847 Ma pluton whereas faults postdate the pluton.

RESULTS OF 1988 MAPPING

In 1988 mapping in the 400 km^2 Athapapuskow project area was completed, with field work concentrated in the Neso Lake-Payuk Lake-southern Athapapuskow Lake region (Syme, 1988a, b, c, d). A structurally complex and very well exposed sequence of mafic pyroclastic rocks was remapped on the peninsula between Northwest Arm and Inlet Arm of Schist Lake (Fig. GS-4-1), and key outcrops in the strongly deformed zone in Northeast Arm of Schist Lake were revisited. Some of the progress made in 1988 includes:

(1) Recognition of a system of dextral, NE-trending faults and shear zones in the eastern half of the area. These structures range from sharp breaks (e.g. Neso Lake fault) to wide shear zones (e.g. Mistik Creek shear, up to 420 m wide) to very wide zones of brittle deformation (e.g. Payuk Lake zone, up to 820 m wide). Kinematic indicators consistently show that movement in this entire system was dominantly right-lateral; lineations in the shear zones plunge steeply (50-70°) east, indicating a large component of vertical movement.

(2) Identification of a very wide, ENE-trending zone of intense deformation in southern Athapapuskow Lake (Fig. GS-4-1). Only partially exposed, the zone is approximately 1 km wide and is characterized by extreme attentuation of pillow basalt, development of mafic phyllonite (schist) and subsequent folding and crenulation of the schist. Parallel, narrower shear zones are exposed to the north, on islands in the lake near the east border of the map area (Fig. GS-4-1). These strucutres can be traced on 1:50 000 gradiometer maps northeast through the Cranberry Lakes to Elbow Lake, where Galley et al. (1987) describes a 2 km wide system of dextral faults and shear zones.

(3) Geological mapping has resolved nearly all major faults in the area into a single master structure in south central Athapapuskow Lake (Fig. GS-4-1). This master structure corresponds precisely with a southwest-trending magnetic linear in the sub-Paleozoic (Blair et al., 1988) that is defined by the truncation of large magnetic domains. The entire system can be interpreted as a large-scale crustal structure that splays northward through the Flin Flon belt.

(4) Definition of suparacrustal rocks in the Neso Lake area. Heavy lichen cover, higher metamorphic grade and preponderance of high level intrusive rocks precludes the development of volcanic stratigraphy; indeed, not a single top determination could be made. The only Amisk Group extrusive rocks observed are strongly deformed mafic flows; other supracrustal rocks are subdivided on the basis of dominant intrusive type (i.e. rhyolite dyke complex, plagioclase-pyroxene porphyry).

(5) Mapping of supracrustal rocks in the West Arm (Athapapuskow Lake) area indicates that the area south of the Kaminis Lake pluton and west of the Ross Lake fault (Fig. GS-4-1) is composed of very strongly deformed mafic rocks derived from diabase, mafic flows and mafic tuff. On West Arm, south of a large ultramafic intrusion (Fig. GS-4-1), supracrustal rocks are a similarly strongly deformed, tectonically layered assemblage of hypabyssal rhyolite, diabase, quartz diorite and pegmatite.

(6) Geological mapping in conjunction with interpretation of vertical gradient aeromagnetic maps indicates that a pyroxenite-peridotite ultramafic intrusion sporadically exposed in the West Arm area forms a continuous though largely lake-covered body 6.4 km long and up to 900 m thick (Fig. GS-4-1). This intrusion must have been emplaced late in the tectonic evolution of the area as it is unfoliated, emplaced in very strongly deformed supracrustal rocks, and appears to cross some NNE-trending faults with little or no offset.

(7) documentation of a thick, heterogeneous mafic pyroclastic sequence in the Hook Lake block (between Ross Lake and Inlet Arm faults; Fig. GS-4-1) has identified almost 3 km of scoria-rich redeposited breccia, tuff and crystal-lapilli tuff. The pyroclastic rocks are significant in that they record the subaqueous deposition of a huge volume of shallow water to subaerial mafic pyroclastic material, high in the Hook Lake block stratigraphic section.

SUPRACRUSTAL ROCKS

NESO LAKE-PAYUK LAKE

Mapping in the Neso Lake-Payuk Lake area was hampered by heavy lichen cover, a preponderance of high level intrusive rocks, a metamorphic grade higher than elsewhere in the Bakers Narrows block, and the presence of dextral fault and shear systems with a strong penetrative fabric.

The oldest rocks are epidotized aphyric to sparsely plagioclase-phyric mafic flows north and west of Neso Lake. These rocks weather a mottled grey-black, green and yellow-green due to pervasive alteration to epidote-rich assemblages; pillow selvages and amygdales are only locally preserved. The flows are intruded by abundant (to 60% of outcrops) plagioclase-porphyry mafic dykes 30 cm-3 m wide, trending approximately parallel to foliation. No unambiguous flow orientations or tops were observed. South of Mistik Creek, at the north end of Neso Lake, plagioclase and plagioclase-pyroxene (pseudomorph) porphyry dykes are so abundant that the host mafic flows are rarely observed. Both the flows and the porphyry dykes are cut locally by rhyolite dykes trending 055°.

Most of Neso Lake and the area to the east is underlain by a rhyolite dyke complex; this complex forms a readily defined unit 1100 m thick east of Neso Lake. Generally the host rock for the rhyolite is not observed, and contacts between various textural varieties of rhyolite are intrusive. Where best observed on the shore of Neso Lake, rhyolite dykes are 0.3-3 m wide, and are distinguished mainly by texture with aphyric, porphyritic, and spherulitic types. In the southwest part of Neso Lake the rhyolites intrude plagioclase-pyroxene porphyritic mafic rocks and porphyritic intermediate (andesitic) rocks. Contact relationships between the rhyolite dyke complex and older rocks east of Neso Lake are sharply gradational through an abrupt decrease in abundance of dykes; south of Neso Lake there is a sharp, sheared contact between rhyolite and mafic schists (derived from pillow basalts) within the Mistik Creek shear zone.

South of the Mistik Creek shear, north of Payuk Lake, there is a similar group of mafic flows, rhyolite dykes and a variety of mafic intrusions. The largest unit is composed of abundant diabase dykes emplaced in an older rhyolite dyke complex; the diabase and rhyolite are in turn intruded by weakly plagioclase-phyric dykes, plagioclase porphyry dykes and plagioclase-pyroxene porphyry dykes. The rocks are only weakly foliated or unfoliated, and are in sharp, sheared contact to the north with mafic schists within the Mistik Creek shear zone. The southern contact of the diabase unit is defined by an abrupt decrease in diabase dyke abundance; mafic flows on the north shore of Payuk Lake are intruded by both rhyolite and diabase dykes.

The western part of Payuk Lake is underlain by a rhyolite dyke complex, similar to that on Neso Lake, which is cut by diabase dykes. These rocks are in sharp tectonic contact with strongly deformed mafic rocks within the Payuk Lake shear zone.

EAST ATHAPAPUSKOW LAKE

Supracrustal rocks in the area southeast of Lynx Lake pluton (Fig. GS-4-1), on the north shore of Athapapuskow Lake, are Amisk Group basalt flows intruded by diabase, related oikocrystic gabbro, and fine grained equigranular diorite. The basalts are the same unit as the "Athapapuskow basalts" (Syme, 1987) exposed southeast of Millwater. Three flow types are exhibited:

(1) thin (1.5-6 m) massive flows characterized by: chilled fine grained bases with few or no amygdales; strongly amygdaloidal, heavily epidotized flow tops comprising 30-50% of the total flow thickness; and, in the thicker flows, coarse grained (1 mm) non-amygdaloidal flow centres.

(2) very thick (to more than 30 m) massive flows, fine grained throughout with sporadic 2-8 mm amygdales and strongly amygdaloidal flow tops; because of the thickness of these flows there are many large, clean outcrops of homogeneous fine grained basalt, but flow contacts are not exposed.

(3) rare pillowed flows.

The composition, flow orrganization, and magnetic signature of Athapapuskow basalt are distinct from Millwater basalt, the other major basalt unit on northern Athapapuskow Lake (Table GS-4-1). The contact between these two units is faulted, and in the contact area the two are structurally discordant (Fig. GS-4-3).

WEST ARM

Supracrustal rocks in and north of the West Arm of Athapapuskow Lake are geologically and geographically separate from Amisk Group rocks elsewhere in the area. A wide zone of extensive drift cover, through which pass the Ross Lake, Inlet Arm and Centennial faults, separates West Arm rocks from very different rocks in the Limestone Narrows area. To the north, West Arm supracrustal rocks are in contact with Kaminis granodiorite, and to the south they are covered by Paleozoic carbonates.

Rocks bordering the Kaminis pluton, north of the West Arm ultramafic intrusion, are strongly foliated, mafic in composition, and appear to have undergone amphibolite facies metamorphism. They include: (a) foliated fine grained amphibolite with subtle tectonic/metamorphic mineralogic banding, derived from fine grained diabase, (b) layered and laminated mafic rock possibly derived from mafic tuff and subordinate flows, and (c) pseudo-layered mafic rocks in which the "layering" is produced by abundant parallel stringers and veins of quartz, feldspar and epidote.

TABLE GS-4-1: CHARACTERISTICS OF ATHAPAPUSKOW AND MILLWATER BASALTS

	Millwater basalt	Athapapuskow basalt
Weathering colour	Buff	Dark green
Flow thickness	Unknown; several m to tens of m	1) 1.5 - 6 m 2) more than 20 m
Flow types	Pillowed only	1) thin massive 2) thick massive 3) rare pillowed
Alteration assemblage	Carbonate	Epidote
Aeromagnetic signature	Low	High
Composition:		
MgO%	6.31-8.20, avg. 6.99	5.75-10.99, avg. 7.99
TiO_2%	0.91-1.82, avg. 1.18	0.73-1.64, avg. 1.08
Ni ppm	72-120, avg. 85	62-326, avg. 159
Zr ppm	51-94, avg. 60	24-91, avg. 46
Cr ppm	94-324, avg. 158	89-999, avg. 378

South of the West Arm ultramafic intrusion (Fig. GS-4-1) the supracrustal assemblage is similarly strongly deformed but composed of different members than to the north. In exceptional outcrops where the effects of deformation are least the primary rock types include (from oldest to youngest):

(1) very fine grained, aphyric, greenish buff rhyolite

(2) fine grained (0.5-1 mm) leucotonalite/rhyolite similar in composition to the rhyolite above

(3) fine grained aphyric and plagioclase-phyric mafic rocks, some with remnants of diabasic texture and chilled margins against the rhyolites

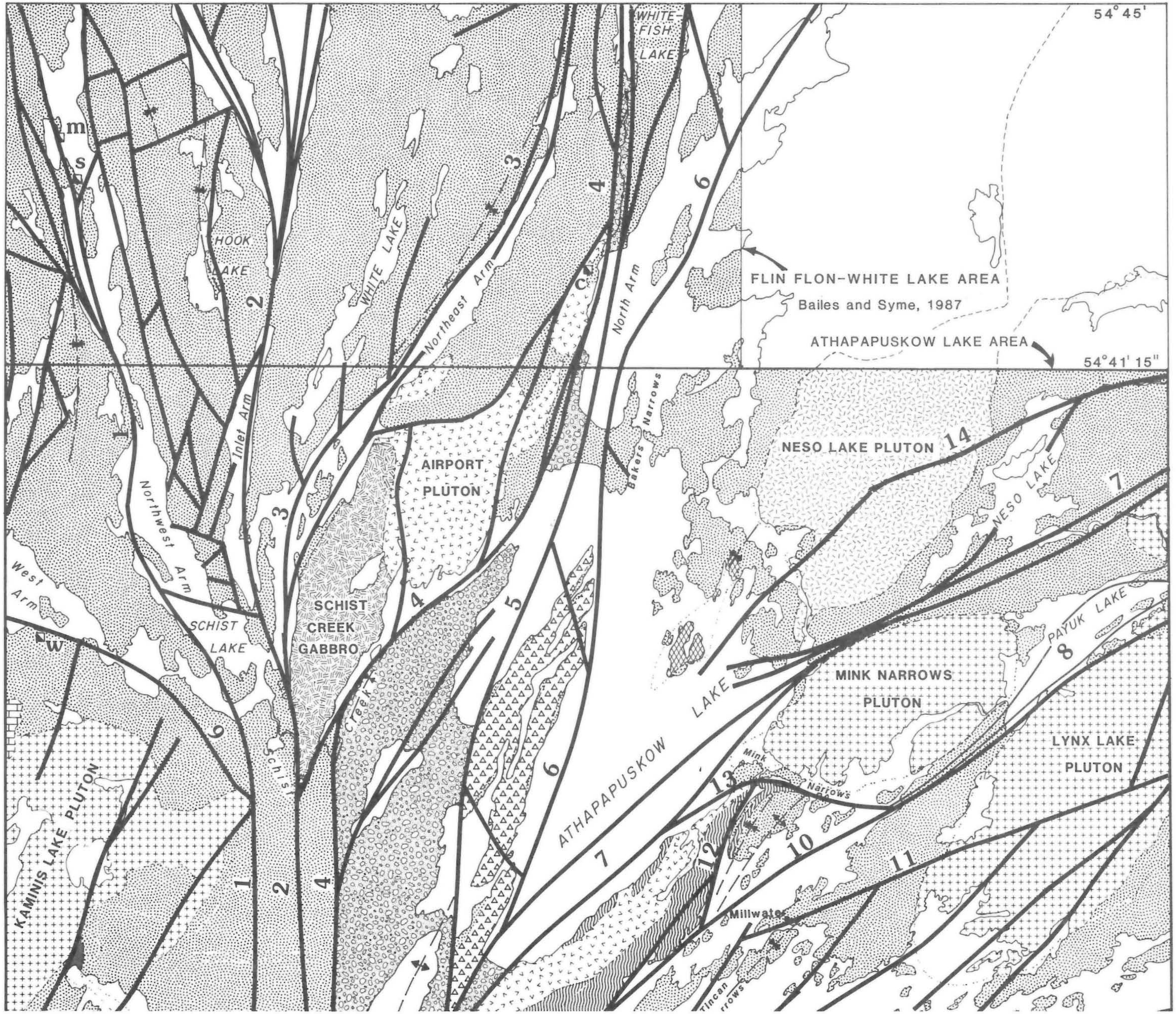
(4) buff leucocratic aplite dykes

(5) boudinaged orange weathering pegmatite dykes.

Generally this suite of intrusive rocks has been strongly flattened, transposed and foliated, resulting in a striking layered mafic and felsic sequence (Fig. GS-4-4). Individual "layers" range in thickness from 1 cm to 1 m, and individual mafic and rhyolite components commonly contain an internal, tectonic lamination. The flattening and transposition is locally so extreme that when first examined the rocks appear to be laminated tuff or greywacke; however, in detail the "layering" is discontinuous due to the intrusive nature of contacts. This zone of extreme deformation and absence of unambiguous volcanic rocks is about 1.5 km wide. It is intruded by larger bodies of strongly foliated quartz-megacrystic tonalite, poorly foliated gabbro-melagabbro, the West Arm ultramafic intrusion, and Kaminis granodiorite.

MAFIC PYROCLASTIC ROCKS, SCHIST LAKE

Mafic volcaniclastic rocks in the Hook Lake block form an enormous thickness of redeposited pyroclastic material, in a diverse assemblage of breccias, lapilli-tuff and tuff (Fig. GS-4-5). Metamorphic grade is within the subgreenschist (prehnite-pumpellyite) facies, penetrative deformation is generally not intense, and outcrops are large and free of lichen; consequently primary features of these rocks are well preserved. However, structure within the Hook Lake block is complex and as a result, a continuous, complete stratigraphic section is not present. The volcanic sequence was folded about north-trending axial planes, and subsequently block faulted in a conjugate system of NNE and NNW trending structures; many lithologic contacts are in fact faults (Fig. GS-4-5).


54° 45'
54° 41' 15"
WHITE-FISH LAKE
HOOK LAKE
WHITE LAKE
Northeast Arm
North Arm
FLIN FLON-WHITE LAKE AREA
Bailes and Syme, 1987
ATHAPAPUSKOW LAKE AREA
Inlet Arm
Northwest Arm
West Arm
SCHIST LAKE
AIRPORT PLUTON
SCHIST CREEK GABBRO
Schist Creek
Bakers Narrows
NESO LAKE PLUTON
NESO LAKE
PAYUK LAKE
MINK NARROWS PLUTON
LYNX LAKE PLUTON
ATHAPAPUSKOW LAKE
Mink Narrows
Millwater
Tincan Narrows
KAMINIS LAKE PLUTON

LEGEND

PALEOZOIC

- Ordovician dolomite

PROTEROZOIC

- Missi Group metasandstone, metaconglomerate
- Granodiorite
- Tonalite
- Diorite, quartz diorite
- Gabbro, quartz diorite
- Gabbro, leucogabbro
- Pyroxenite, peridotite
- Leucotonalite, rhyolite
- Fine grained diorite, quartz diorite
- Amisk Group metavolcanic and metasedimentary rocks, minor intrusions

SYMBOLS

- Syncline, anticline
- Fault

1 Ross Lake fault
2 Inlet Arm fault
3 Northeast Arm fault
4 Centennial fault
5 Scheiders Bay fault
6 North Arm fault
7 Mistik Creek shear zone
8 Payuk Lake zone
9 West Arm fault
10 Payuk Lake fault
11 Millwater fault
12 Limestone Channel fault
13 Mink Narrows fault
14 North Neso Lake fault
15 North Athapapuskow Lake fault
16 South Athapapuskow Lake shear zone
17 Namew Lake structure

m Mandy Mine
s Schist Lake Mine
c Centennial Mine
w West Arm Mine

Figure GS-4-1: Athapapuskow Lake project area with simplified geology.

Figure GS-4-2: Escarpment formed by flat-lying Ordovician dolomite; West Arm, Athapapuskow Lake.

Mafic pyroclastic rocks form the uppermost part of the Hook Lake block stratigraphic sequence. To the north, in the Flin Flon-White Lake area (Bailes and Syme, 1987), the sequence is composed of about 7.5 km of basalt and basaltic andesite flows and related breccias. This thick sequence of flows is overlain in the Athapapuskow map area by an aggregate thickness of almost 3 km of volcaniclastic rocks. The aggregate thickness includes the maximum observed thickness for each of the 5 or 6 major units; of this, 1.6 km occurs in a single continuous section unbroken by faults. The true thickness of the entire volcaniclastic sequence is unknown.

The sequence of mafic volcaniclastic rocks on Schist Lake is significant because it records the eruption of a very large amount of mafic pyroclastic material; in fact, more pyroclastic rocks are exposed here than anywhere else in the Flin Flon-Athapapuskow region. The abundance of highly vesiculated, scoriaceous blocks, lapilli and granules indicates that the material was erupted from very shallow water or subaerial sources, but bedforms and intercalated pillowed flows demonstrate that the pyroclastic debris accumulated in what must have been a flanking marine basin.

Major units in the volcaniclastic sequence (Fig. GS-4-5) are summarized below:

(1) redeposited mafic pyroclastic breccia. Scoria-rich breccia forms a unit more than 800 m thick, directly overlying plagioclase-phyric mafic flows in the northern part of the area. The breccias are composed of subrounded to rounded plagioclase-phyric scoria fragments (Fig. GS-4-6) and angular non-scoriaceous accessory fragments supported by a matrix of scoria granules, plagioclase crystal fragments and recrystallized ash. Accessory fragments, including amygdaloidal and non-amygdaloidal, plagioclase-phyric and aphyric types, typically compose 10-30% of the fragment population. Bedding is thick, defined by fragment size and abundance, grading, and rare tuffaceous interbeds (Fig. GS-4-7, 8). Many of the beds grade to matrix-rich tops; some have reverse grading at the base.

(2) heterolithologic breccia. Scoria-rich breccia (above) is overlain by a more varied sequence of heterolithologic breccia and intercalated flows, exposed for a total of 760 m; flows form units up to 100 m thick. Fragments in heterolithologic breccia include the same varied suite that occurs as accessory fragments in scoria breccia; some beds also contain rhyolite fragments. Scoria fragments are present but only in small amounts, or are concentrated in rare intercalated scoria-rich beds. Bedding is thick, massive, and the breccias are typically fragment-supported. These highly mixed breccias may represent avalanche deposits developed along synvolcanic scarps — one such paleoscarp between pillowed flows and breccia is exposed.

(3) interlayered scoria breccia and tuff. This unit occurs in three of the fault-bounded blocks or panels; in one it underlies plagioclase crystal-lapilli tuff (described below at (5)). Its stratigraphic relationship to other units is unknown. The unit consists of typical scoria-rich breccia beds interlayered with 50 cm-2 m thick tuff beds. The tuff interbeds are graded, locally contain scoria granules and lapilli, and have sharp contacts with the massive scoria breccia beds. The unit is interpreted as a more distal facies of the massive scoria breccia unit.

(4) bedded fine grained tuff. Three of the fault-bounded blocks are composed mainly of well bedded, sandy textured tuff, locally interlayered with scoria lapilli tuff and tuff breccia. Beds are 2-100 cm thick (Fig. GS-4-9), normally graded with respect to crystal and rock fragment size, with sedimentary structures such as flames, load structures, scours and parallel lamination. Most beds are Bouma A types, some of which contain white mudstone tops. All three fault-bounded occurrences of this facies of the pyroclastic sequence contain a unit of heterolithologic breccia dominated by rhyolite fragments, implying stratigraphic equivalence between blocks.

(5) plagioclase crystal-lapilli tuff. Bedded tuff characterized by the presence of very large (up to 13 mm) plagioclase crystals and crystal fragments (Fig. GS-4-10) occurs in six of the fault-bounded blocks. In one block it directly overlies pillowed mafic flows and thus is stratigraphically equivalent to scoria breccia; in another block it overlies interlayered scoria breccia and tuff. The tuff is well stratified, with beds 50 cm-5 m thick, including Bouma A and AB types. Beds contain angular plagioclase-phyric lapilli and blocks up to 20 cm. Beds are commonly normally graded with respect to size of plagioclase crystals and lapilli; reverse grading occurs in the base of the some beds. In some localities there are minor breccia beds interlayered with the tuff.

(6) plagioclase crystal-lapilli tuff, scoria breccia. This rather heterogeneous unit occurs within a fault-bounded panel, along the western shore of the peninsula adjacent to Northwest Arm. It is composed of bedded tuff, lapilli tuff and subordinate scoria-rich breccia; plagioclase crystal size is up to 10 mm but generally significantly smaller than the crystal tuff described above.

The complex structure mapped in the Hook Lake block allows some interpretation of the facies relationships in this thick pyroclastic sequence. Faulting has repeated the hinge zone of the north-trending anticlinal structure; as a result, the contact between underlying flows and overlying pyroclastics is repeated in three separate fault blocks. Different pyroclastic units form the base of the section in each of the blocks (Fig. GS-4-5), so that some of the units must be stratigraphically equivalent. Also, scoria breccia, interlayered scoria breccia and tuff and bedded tuff form a uniform fining succession that may represent a synchronous proximal to distal depositional sequence.

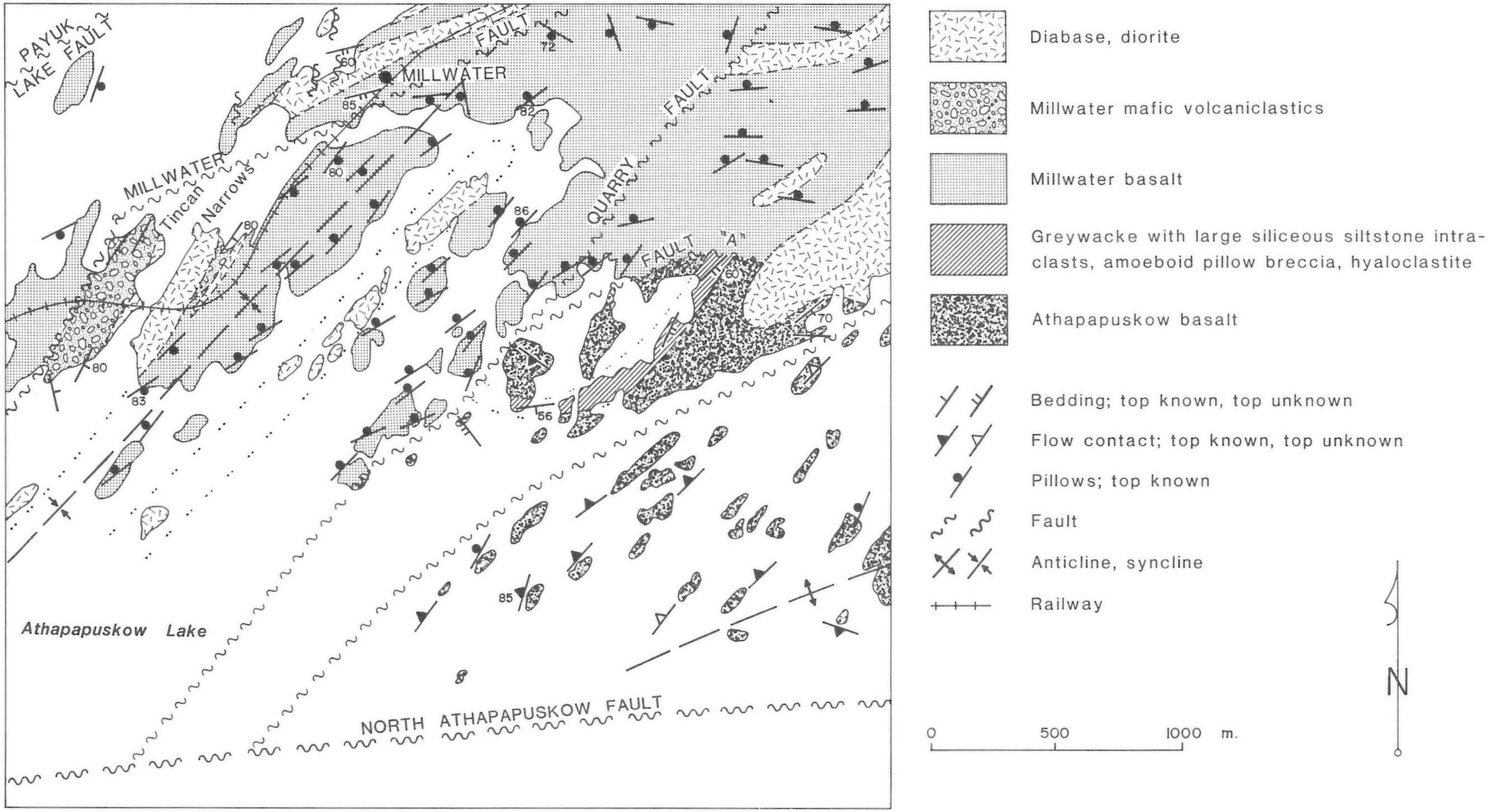


Figure GS-4-3: *Geology of the area around Millwater, showing structural relationships between Millwater and Athapapuskow basalts. Quarry fault is approximately the same age as Millwater and North Athapapuskow faults; fault "A" is probably much older, possibly synvolcanic. Athapapuskow basalts in the central fault panel are folded, topping south and east.*

Figure GS-4-4: *West Arm supracrustal rocks. Rhyolite (light) is intruded by fine grained diabase (dark); both contain a strong foliation and tectonic lamination.*

INTRUSIVE ROCKS

Most large mafic to felsic intrusions in the Athapapuskow project area (Schist Creek gabbro, Airport tonalite, Mink Narrows granodiorite, Lynx Lake granodiorite, Neso Lake pluton, Limetone Narrows layered mafic complex) have been briefly described in previous reports (Syme; 1986, 1987). Intrusions mapped in 1988 are described below.

KAMINIS GRANODIORITE

Only the eastern part of the granodiorite pluton described by Heywood (1966) occurs in Manitoba (Fig. GS-4-1). The pluton is emplaced in Amisk Group mafic volcanic and high level intrusive rocks; it is surrounded by a contact metamorphic aureole at least 1 km wide that attains amphibolite grade. Granodiorite contains a well defined foliation parallel to the strong foliation in adjacent supracrustal rocks.

The northern contact of the pluton is planar and, where exposed, consists of a narrow (20-150 cm) zone of mylonitized granodiorite adjacent to strongly deformed, veined, amphibolite. The northern margin of the pluton is locally bordered by a more mafic, intrusive, hybrid zone up to 600 m wide comprising melanocratic diorite and quartz diorite with rafts and screens of amphibolite. The southern contact of the pluton is sharp, irregular, and a hybrid zone is not developed.

The pluton and adjoining amphibolite grade country rocks are cut by a system of NNE-trending dextral faults which offset and truncate contacts, and juxtapose different zones within the pluton and different supracrustal domains outside the pluton (Syme, 1986). These faults are interpreted to have considerable vertical component of slip in addition to the generally small component of dextral slip observed on offset contacts.

The Kaminis pluton is compositionally zoned, with a mafic, granodiorite-quartz diorite margin and a more leucocratic granodiorite core. The contact between zones appears to be gradational, with content of mafic minerals increasing towards the outer margins of the intrusion. The margin phase is 0.5-1 km wide, and comprises the entire narrow, eastern termination of the pluton. Granodiorite in the margin weathers grey buff and contains 15-40% mafic minerals (subhedral hornblende and subordinate biotite), about 20% quartz, plagioclase, and poikilitic K-feldspar up to 1 cm across. Locally the outermost 50 m of the pluton grades to quartz diorite (10% quartz) with abundant mafic xenoliths. Granodiorite in the core of the pluton weathers light buff and contains a total of 5-10% hornblende and biotite, 25-30% quartz, plagioclase and poikilitic K-feldspar as in the margin; xenoliths generally comprise less than 1% of the rock.

Kaminis granodiorite contains a set of fractures along which the adjacent rock is moderately to strongly hematized. The alteration envelope associated with the fractures is 1-30 cm wide; some fractures are cored with epidote or quartz veinlets, and some display offsets. Fracture orientations are commonly parallel to regional faults in the area (several orientations may occur on any given outcrop), and they are interpreted as being the same age as the large structures. Similar fractures and alteration occur in every other felsic pluton in the Athapapuskow project area.

WEST ARM ULTRAMAFIC INTRUSION

The West Arm ultramafic intrusion is a 6.4 km long body of pyroxenite, peridotite and derived serpentinite that is only sporadically exposed in western Athapapuskow Lake (Fig. GS-4-1). Previous mapping (Tanton, 1941) showed only the southeast portion of the body, an island in the entrance to West Arm on which there are several asbestos showings. This year a number of outcrops of identical ultramafic material were located in the northwest part of West Arm. Vertical gradient aeromagnetic maps clearly indicate continuity of the intrusion between the two main areas of exposure.

The ultramafic intrusion is emplaced in strongly deformed, upper greenschist to amphibolite grade supracrustal rocks, but contains only a very weak penetrative fabric. The southeast end of the body is terminated against Ross Lake fault, and the northwest end is terminated against the dextral Athapapuskow West Arm fault. Aeromagnetic maps indicate that the intrusion crosses other NNE-trending faults in West Arm with little or no offset. This relationship, together with the excellent presentation of primary textures and absence of a well defined penetrative fabric, suggests that the West Arm ultramafic intrusion was emplaced after the supracrustal rocks were deformed, and is approximately synchronous with faulting.

Exposed portions of the intrusion are dominated by coarse grained pyroxenite, which varies in grain size and colour and is at least locally interlayered with olivine-bearing pyroxenite. Mappable subunits within the pyroxenitic sequence are finer grained and contain up to 50% serpentine, presumably after primary olivine; they are considered peridotites and olivine-bearing pyroxenites. Locally the peridotite is cut by narrow (up to 30 cm wide) veins of extremely coarse grained pyroxenite (crystals up to 17 cm long). Slip-fibre asbestos veins occur throughout the ultramafic complex.

FAULTS, SHEAR ZONES

NORTHEAST-TRENDING DEXTRAL SYSTEM

The eastern half of the map area is dominated by a set of northeast-trending faults and shear zones for which there is abundant direct evidence of dextral (right-hand) displacement. Major structures include the North Neso Lake fault, Mistik Creek shear zone, Payuk Lake zone of brittle defor-

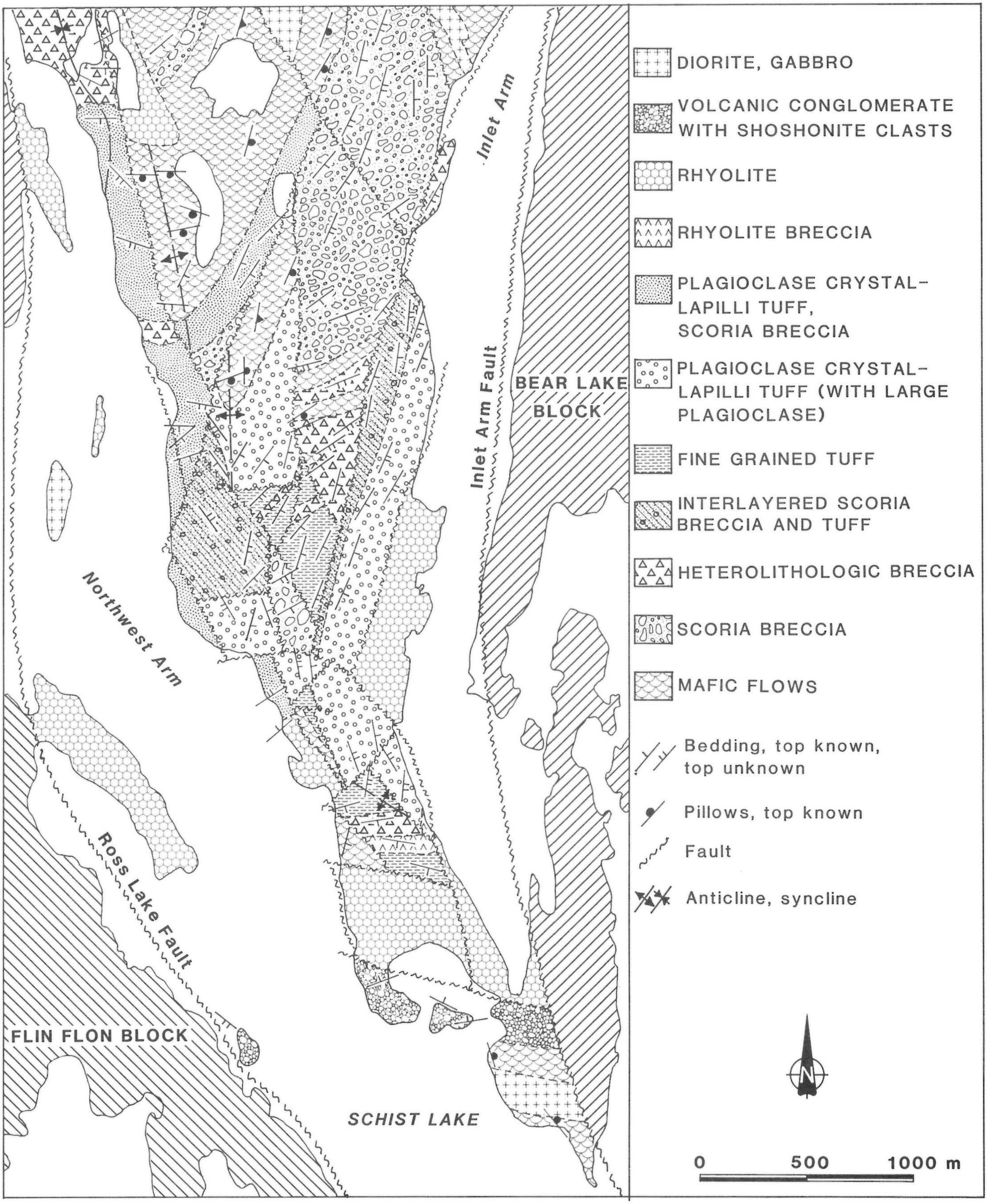


Figure GS-4-5: *Geology in the Hook Lake block, Schist Lake. Redeposited mafic pyroclastic rocks (discussed in text) predominate in this part of the block, overlying more than 7 km of basalt flows and breccias.*

Figure GS-4-6: *Highly vesiculated scoria fragments in scoria breccia, Hook Lake block. Note the increase in vesicle size towards the core of the fragment, suggesting that upon eruption the margin chilled whereas vesiculation continued in the still-plastic core.*

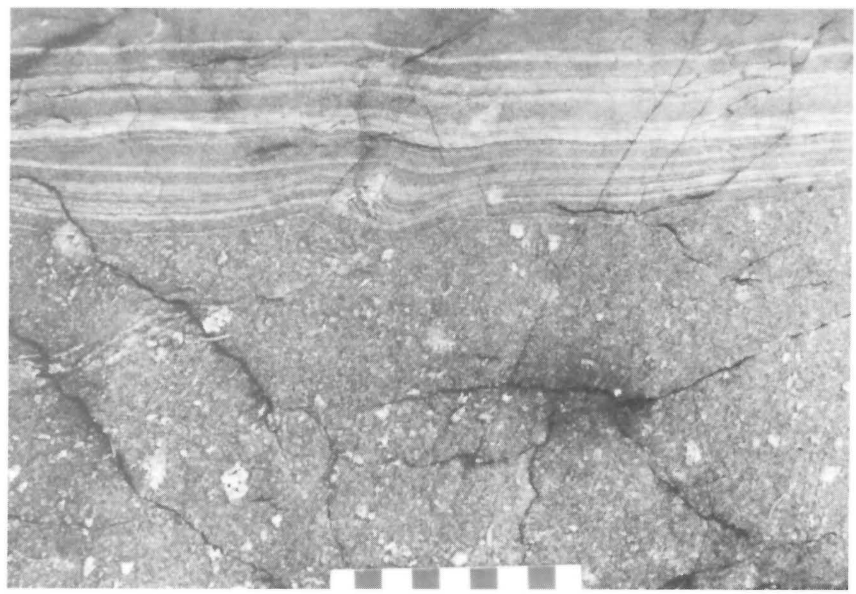


Figure GS-4-7: *Layered tuff, Hook Lake block. This material occurs in a 3 m thick unit at the base of the pyroclastic sequence, directly overlying mafic flows, and overlain by coarse scoria breccia. The tuff is composed of scoria lapilli and recrystallized ash in massive to delicately laminated beds.*

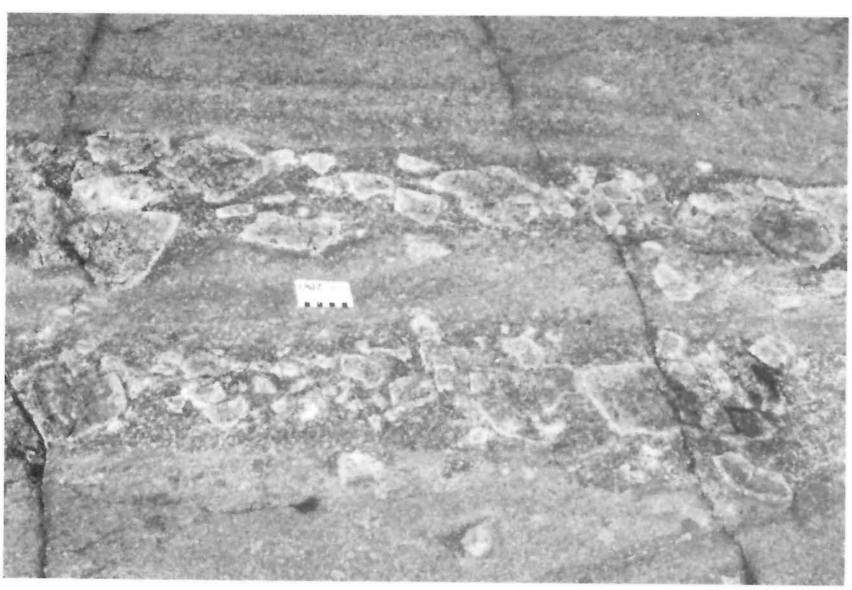


Figure GS-4-8: *Layers of scoria blocks and lapilli in a tuff composed of scoria granules, Hook Lake block. Such well layered material occurs sporadically in the unit of scoria breccia.*

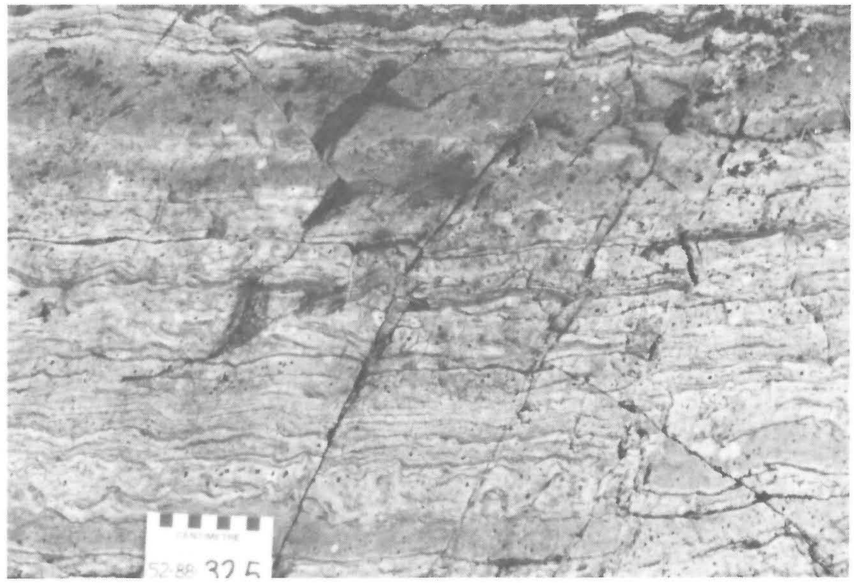


Figure GS-4-9: *Fine grained, bedded tuff, Hook Lake block.*

Figure GS-4-10: *Plagioclase crystal-lapilli tuff characterized by very large plagioclase crystals, Hook Lake block. Plagioclase crystals (light) in this unit are up to 13 mm long, much larger than phenocrysts in other units. Subangular plagioclase-phyric blocks and lapilli occur in a crystal-rich matrix.*

mation, Payuk Lake fault, Millwater fault and north Athapapuskow fault (Fig. GS-4-1). These structures are linked by a number of more northerly-trending dextral splays. The western boundary of the domain dominated by northeast-trending structures is the North Arm fault; to the west, fault orientations are north to north-northeast (Fig. GS-4-1).

The *North Neso Lake fault* produces 300 m of dextral offset on the east margin of Neso Lake pluton, juxtaposes internal zonation within the pluton, and is expressed by a several metre wide zone of intense schistosity in supracrustal rocks on Mistik Creek. This fault is linked to the Mistik Creek shear zone (below) by a dextral fault through Neso Lake.

The *Mistik Creek shear zone* is up to 420 m wide south of Neso Lake. To the southwest, on Athapapuskow Lake, the bounding faults diverge to form a lens-shaped block containing Missi Group sandstone and conglomerate; an associated structure or splay may be represented by a wide zone of felsic schists southwest of Paradise Lodge (Preliminary Map 1988F-2). South of Neso Lake, however, the shear zone is represented by chlorite schists derived from pillowed basalt; strain is inhomogeneously distributed through the shear zone so that the primary features of the basalt (selvages, amygdales, spherulites) are locally preserved. The southern bounding fault is very well defined as it juxtaposes chlorite schist against undeformed mafic intrusives (diabase and gabbro), with the intrusive rocks displaying shear fabrics only immediately adjacent to the shear one. The northern bounding fault is less well defined, placing sheared basalt against foliated rhyolite (in the west) and less deformed mafic flows (in the east). Within the shear zone, features of ductile deformation (stretching of pillows, development of schistosity) are locally overprinted by later brittle deformation in the form of breccia zones (Fig. GS-4-11) and fractures. Kinematic indicators suggest dextral displacement, and lineations within the foliation plane plunge steeply (50-70°) east, indicating a significant component of vertical slip. The presence of Missi Group rocks in the zone to the southwest also suggests that the system is dominated by dip-slip movement.

On Payuk Lake, a wide zone of *brittle deformation* parallels the Payuk Lake fault. The deformation is developed in mafic extrusive and high level intrusive rocks, in contrast to a rhyolite-dyke-dominated supracrustal assemblage north of the zone. The deformation zone is incompletely exposed on islands in Payuk Lake, where it is a maximum of 820 m wide. The zone abruptly narrows to less than 150 m to the southwest towards Athapapuskow Lake. Rocks within the zone are generally only weakly foliated, but have been broken into parallel lens- or plate-like tectonic fragments set in a matrix of recessive saccharoidal white carbonate and crossed by crack-seal quartz veins. The brittle deformation

Figure GS-4-11: *Late, brittle deformation within the Mistik Creek shear zone. Mafic schists (derived from pillowed basalt) represent the dominant, ductile deformation exhibited in the shear zone. Locally the schists are brecciated, with angular, slabby fragments in a matrix of quartz and carbonate.*

is overprinted by discrete shear zones (generally less than 50 cm wide) with strong foliation and carbonate-epidote veining. As in the Mistik Creek shear zone, there is a steep east-plunging stretching lineation developed in the plane of foliation.

Payuk Lake fault is a linear structure mapped from Western Athapapuskow Lake to the eastern border of the map area at Payuk Lake. The structure is a sharp tectonic break, with very little associated schistosity or brecciation in adjacent rocks. The fault truncates major units in Millwater block (Syme, 1987), juxtaposes a large layered gabbro complex against pillowed Millwater basalt northwest of Limestone Narrows, and slices through the margin of Lynx Lake pluton on Payuk Lake. Displacement of the pluton margin clearly indicates that the fault has oblique slip with the north side down and to the east, i.e. the same movement pattern as other NE-trending structures in the area.

Millwater fault is another sharp break that produces dextral offset on contacts in Lynx Lake pluton. A sharp intrusive contact between the biotite-muscovite core phase of the pluton and hornblende-biotite margin phase provides a marker which is displaced not only on Millwater fault but also on more northerly trending associated structures (Preliminary Map 1988F-2). Within the pluton the faults are expressed as topographic linears; adjacent granodiorite outcrops contain fractures and narrow shears parallel to the larger structure, and the feldspars are commonly hematized.

NORTH ATHAPAPUSKOW LAKE FAULT

The north Athapapuskow Lake structure is an east-trending, almost entirely lake-covered fault or shear zone south of Limestone Narrows (Fig. GS-4-1). There are several indirect lines of evidence for this structure, including:

(a) in eastern Athapapuskow Lake, islands adjacent to the presumed structure have many 30 cm-2.5 m wide east-trending dextral shear zones which suggest the presence of a larger structure to the south,

(b) a linear trend on vertical gradient aeromagnetic maps that truncates adjacent magnetic domains,

(c) the presence south of Limestone Narrows of a large linear magnetic anomaly that corresponds to sporadically exposed magnetiferous diabase; the eastern extrapolation of this intrusion crosses the structural grain in supracrustal rocks south of Tincan Narrows (Fig. GS-4-3), and the northern contact of the diabase is sheared.

The north Athapapuskow structure is interpreted to juxtapose the large, sill-like body of diabase against folded Millwater and Athapapuskow basalt, to truncate northeast-trending faults in the Millwater-Lynx Lake area, and to join other major faults in the southwest-trending Namew Lake structure (Fig. GS-4-1).

SOUTH ATHAPAPUSKOW SHEAR ZONE

The South Athapapuskow shear zone is exposed only on a few islands in the southern part of the lake, adjacent to the Paleozoic edge. This incomplete exposure suggests the east-northeast-trending zone is about 1000 m wide. Deformation is strongest in the islands off the south shore of the lake, due south of Tincan Narrows (Fig. GS-4-1). There the rocks are mafic schists with fine compositional layering expressed by variation in colour: light grey, grey and bright green. The schist contains a large amount of disseminated fine grained magnetite and sporadic lensoid epidosite domains. The foliation and compositional layering are generally folded and crenulated (Fig. GS-4-12); the folds have near-vertical axial planes and axes which plunge shallowly to moderately east northeast, parallel to the trend of the deformation zone. Kinematic indicators, in the form of z-shaped intrafolial folds and rolled epidosite domains, suggest that the shear is dextral.

The layered schists are derived from flows; less deformed material from the eastern part of the zone is similarly compositionally banded but pillow selvages and amygdales are readily recognizable. In the area south of Tincan Narrows no selvages remain but relict amygdales occur both in epidosite domains and sporadically through the layered schist. The very strong schistosity, tectonic lamination and subsequent tight crenulation all attest to very high strain within the south Athapapuskow shear zone. Absence of outcrop makes it impossible to map the lateral extent of this zone; vertical gradient aeromagnetic maps do not show a well defined magnetic linear where the zone has been mapped, possibly because fine grained porphyroblastic magnetite has developed in the thermal aureole of an adjacent granitoid pluton, masking effects of shear.

NAMEW LAKE STRUCTURE

All of the major faults in the Flin Flon-White Lake area (Bailes and Syme, 1987) and Athapapuskow project area have now been mapped to the north shore of the large southern portion of Athapapuskow Lake (Fig. GS-4-1). There, exposure ceases and the Proterozoic rocks are covered by lake and Paleozoic carbonates. The mapping indicates that all faults between the Ross Lake fault in the west and the north Athapapuskow fault in the south converge in the western part of the lake. Vertical gradient aeromagnetic maps of the covered area strongly suggest that all of these structures splay from a single feature trending southwest from Athapapuskow Lake, through western Namew Lake. This structure was located independently by Blair et al. (1988) using truncation of large magnetic domains in the sub-Paleozoic of Manitoba and easternmost Saskatchewan (Project Cormorant). This large-scale feature, informally referred to here as the

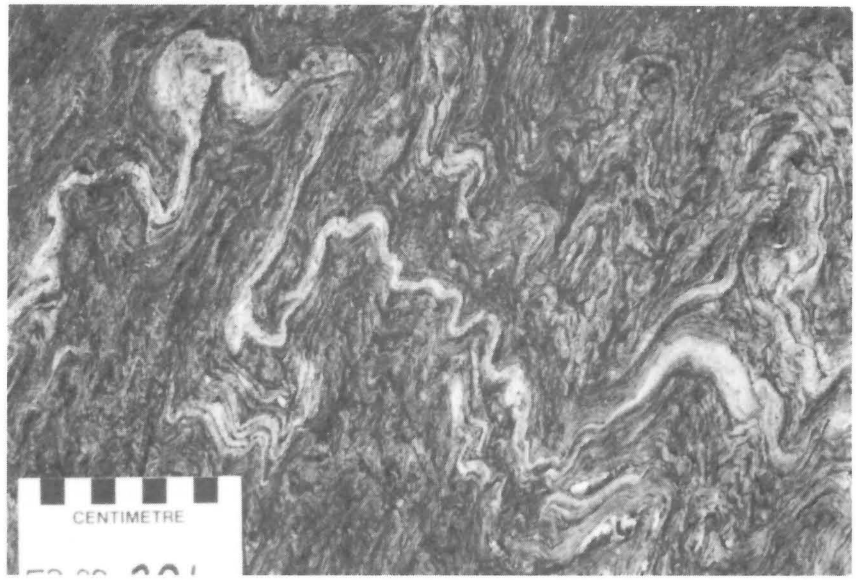


Figure GS-4-12: Crenulated mafic schist, South Athapapuskow shear zone. Compositional layering expressed by variable weathering colour is tectonic; relict amygdales, and selvages in less deformed material, indicate the shear is developed in pillowed Athapapuskow basalts. Fold hinges plunge shallowly ENE, parallel to the trend of the shear zone.

Namew Lake structure, appears to be the master zone from which many of the major faults in the western Flin Flon belt were derived.

Previously it was noted that faults and shear zones east of the North Arm fault (Fig. GS-4-1) trend northeast whereas all of those to the west of the North Arm fault trend north-northeast to north-northwest. Several of these northerly trending faults are folded into westerly orientations in the northern part of the belt, about a late, large-scale upright fold (Stauffer and Mukherjee, 1971; Bailes and Syme, 1987; Gilbert, this volume). Some faults (e.g. Ross Lake fault) are unfolded, which led Stauffer and Mukherjee (1971) to suggest that the faults were initiated at different times during the final deformational event that affected the Flin Flon area. The interpretation here that all of the faults are rooted in the Namew Lake structure is consistent with that view. It may be that the earliest splays from the Namew Lake structure are dextral, northeast-trending faults and shears in the eastern part of the area; later splays form the north-trending bundle of faults with the latest, the Ross Lake fault, being the westernmost bounding fault of the system. These later, northerly faults include both sinistral (Stauffer and Mukherjee, 1971) and dextral types.

GEOCHEMISTRY

Part of the Athapapuskow project involves documentation of compositional variation in Proterozoic igneous rocks: Amisk Group metavolcanic rocks and later mafic to felsic plutons. Nearly every major volcanic and intrusive unit has now been sampled and analyzed. Preliminary findings for some of the more interesting units are described below.

ATHAPAPUSKOW AND MILLWATER BASALTS

The two major mafic extrusive units on Athapapuskow Lake are the strikingly different Athapapuskow and Millwater basalts (Table GS-4-1). Unfortunately, the stratigraphic relationship between these units is unknown as they are everywhere in fault contact (Fig. GS-4-3).

In the Flin Flon-White Lake area (Bailes and Syme, 1987), most of the basaltic units have trace element characteristics that strongly suggest that they represent island arc assemblages (Syme, in press). A representative unit, Bear Lake basaltic andesite, is shown on Figure GS-4-13 and demonstrates the characteristics of the group: compared to ocean ridge basalts (N-MORB) it is strongly enriched in LIL elements (Rb, Ba, K, Th, Sr) and moderately to strongly depleted in HFS elements (Hf, Zr, Ti, Y), Ni and Cr. Similar basalts in the Athapapuskow project area occur in the Flin Flon, Hook Lake, Bear Lake, and Bakers Narrows blocks (defined in Syme, 1987). Magnesia (MgO) contents in these basalts generally fall in the 4-6% range.

Athapapuskow and Millwater basalts are considerably more magnesian than the low-HFS basalts (Table GS-4-1), and display MORB-normalized patterns quite different than those rocks (Fig. GS-4-13). Athapapuskow basalts have much lower LIL element contents, approaching MORB values. HFS elements are not nearly as depleted, and Ni and Cr are much higher than Bear Lake-type basalts. Athapapuskow basalts more closely resemble basalts erupted in oceanic rifts (e.g. back arc basins) than the "classic" arc-type basalts typified by the Bear Lake suite (Syme, in press).

Millwater basalts are in some ways transitional between the Athapapuskow and low-HFS basalts: LIL element contents are slightly higher and, although average HFS element contents are even closer to MORB than Athapapuskow basalts, Ni and Cr contents are much lower. The tectonic affinity of these rocks is at present unknown.

SHOSHONITES; NESO LAKE PLUTON

Five boulder-sized clasts in the Schist Lake volcanic conglomerate, a 200 m thick, fault-bounded unit of conglomerate and greywacke in the Hook Lake block (Fig. GS-4-5; Preliminary map 1988F-1) were sampled and analyzed for major and trace elements. During mapping it was noted that these clasts differed petrographically from other volcanic rocks in the area in their high content of plagioclase phenocrysts and presence of magmatic amphibole phenocrysts. The clasts range in SiO_2 content from 52 to 62% and have all of the features displayed by shoshonitic suites (e.g. Brooks et al., 1982): they have high contents of Al_2O_3 (16.86-18.58%), Na_2O + K_2O (6.56-8.71%), Rb (12-54 ppm), Sr (382-929 ppm), Ba (100-1137 ppm), Zr (131-167 ppm), and Y (23-36 ppm). These rocks also have high abundances of light rare earth elements (LREE), flat to concave heavy rare earth element (HREE) patterns, high La_N/Yb_N ratios and a systematic decrease in REE abundances with increasing SiO_2 content (Fig. GS-4-14).

Due to the extreme structural complexity in the Hook Lake block (Fig. GS-4-5) the exact structural position of the shoshonitic volcanogenic sediments is not known. These rocks are significant, however, because shoshonites are associated with waning volcanism, and document a "senile" stage in the history of arc magmatism (Brooks et al., 1982). Schist Lake shoshonitic conglomerates, possibly derived from subaerial shoshonitic volcanism, indicate that the Flin Flon arc ultimately matured to a stage occurring in modern, evolved island arcs.

Mature-arc-stage magmatism may also be documented in the compositional diversity exhibited in the Neso Lake pluton. This pluton (Fig. GS-4-1) is unique in the Flin Flon-Athapapuskow region in that it contains a wide spectrum of phases (Syme, 1987) ranging from pyroxenite and melagabbro through gabbro and diorite to quartz diorite and tonalite. The trace element content in these rocks is similar to that in Schist Lake conglomerate shoshonite clasts, especially in Rb, Sr, Ba, Zr, Y and REE con-

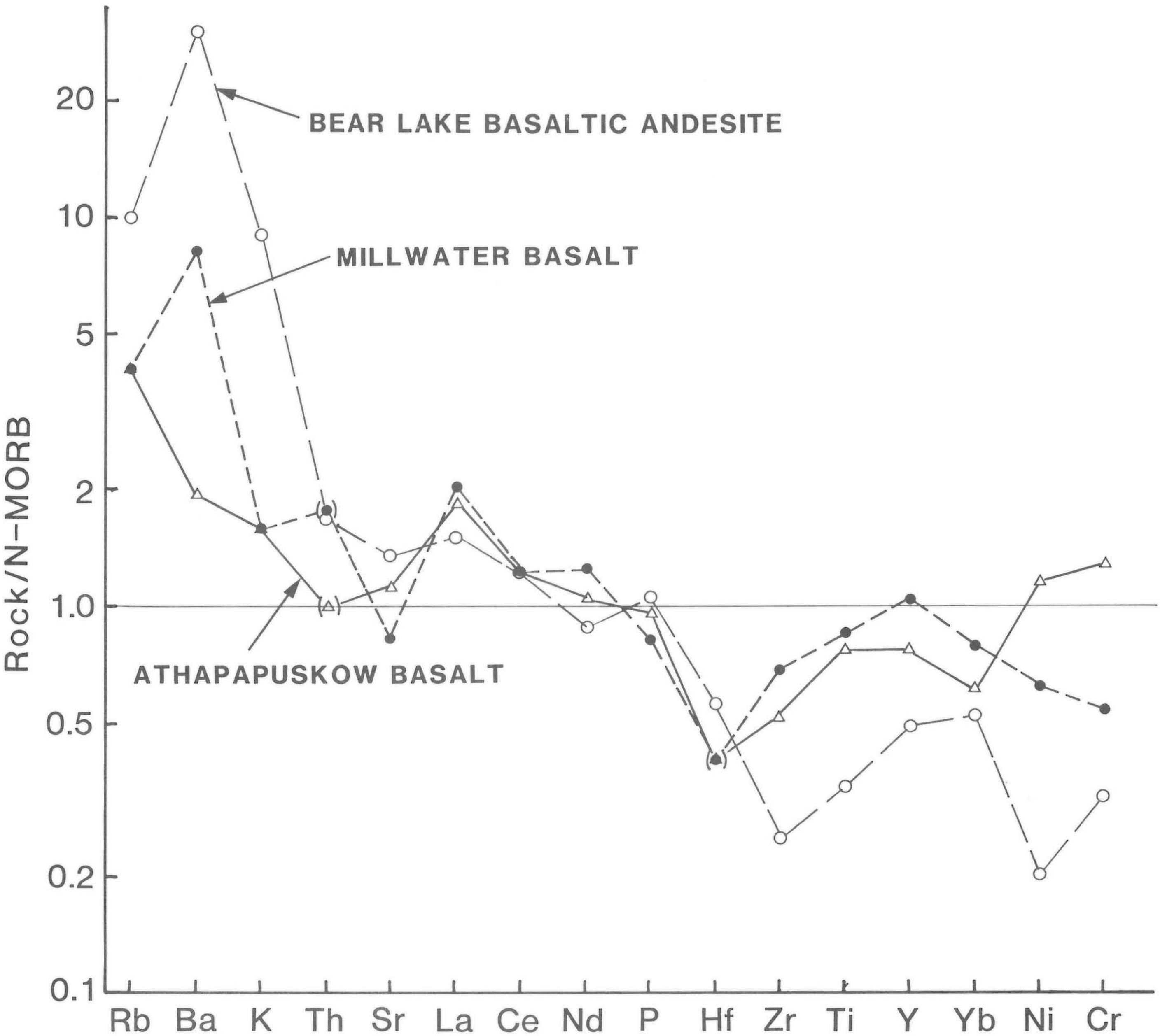


Figure GS-4-13: *MORB (ocean ridge basalt) — normalized trace element patterns for three contrasting basaltic units in the Athapapuskow project area. Bear Lake basaltic andesite has the trace element pattern of island arc tholeiites, Athapapuskow basalt more closely resembles basalts in back-arc basins. See text for discussion. Curves represent average compositions; number of samples in each average is between 9 and 13. N-MORB normalizing values are those of Saunders and Tarney (1984).*

tents (e.g., Fig. GS-4-14). As in the shoshonitic suite, REE abundances in the Neso Lake pluton decrease with increasing SiO_2; LREE contents of the mafic (50% SiO_2) plutonic rocks are much higher than in gabbros from other intrusions. Samples for zircon U-Pb isotope analysis were obtained from two phases of the pluton, to test whether the age of the intrusion is younger than that obtained from a portion of the Amisk Group representing a juvenile to intermediate stage in arc development (1886 Ma: Syme et al., 1987).

ECONOMIC GEOLOGY

The potential for massive sulphide, gold and platinum group element deposits in the Athapapuskow project area was reviewed in Syme (1987). The well known association between rhyolite flows and massive sulphide deposits in the Flin Flon region was emphasized, and the recent discovery of Zn-rich sulphides stratigraphically associated with rhyolite flows in the Westfield deposit (Ferreira and Gale, this volume) only reinforces this association as a first-pass exploration target. At least three thick rhyolite flows occur in the Bakers Narrows block (Syme, 1987), but in the areas mapped in 1988 no further rhyolite flows were encountered. The abundant rhyolites in the Neso Lake-Payuk Lake areas are not flows, but a dyke complex intruding older mafic flows. The potential for volcanogenic stratabound massive sulphides in this area dominated by high-level intrusive rocks is therefore probably low.

Structurally controlled Au deposits are common in the Flin Flon belt (e.g. Galley and Franklin, 1987; Galley et al., 1987). In the Athapapuskow project area abundant faults and shear zones vary widely in style, size and host lithology. In felsic plutons, guides to the location of major structures include topographic linears, local strongly developed fracture cleavage

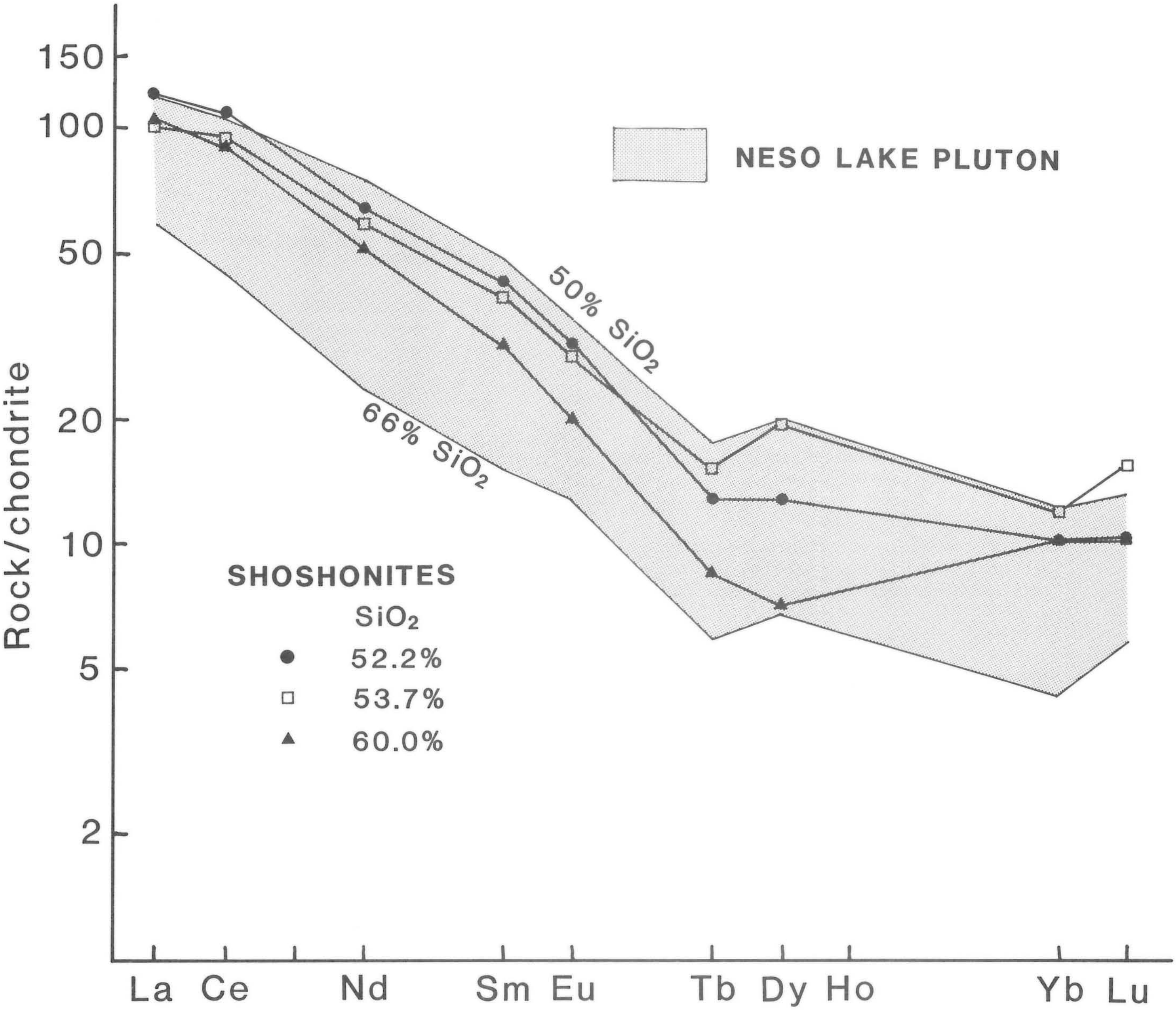


Figure GS-4-14: *Chondrite normalized REE plots of three shoshonite boulders in Schist Lake volcanic conglomerate (Fig. GS-4-5), compared to the compositional spectrum exhibited by rocks in Neso Lake pluton (shaded area, n = 6). Both suites are characterized by light rare earth enrichment and systematic decrease in REE abundance with increasing SiO_2.*

and/or quartz veining, and intense hematization along closely spaced fractures. In supracrustal rocks, small-scale faults and shear zones abound, but the surest guide to major faults remains detailed stratigraphic mapping and the recognition of stratigraphic truncations and repetitions.

In the Limestone Narrows layered mafic complex, fieldwork in 1988 encountered more pyroxenite and a narrow (30 m) peridotite layer within the dominantly gabbroic sequence. The amount of exposure in this complex significantly decreases towards the southwest, and consequently a reliable evaluation of this body for Cr or Pt-group elements (PGE) is difficult from surface exposures alone. The West Arm ultramafic intrusion does contain igneous layering and may have some potential for PGE; however, much of the body is under Athapapuskow Lake and the portion that is exposed appears to have been thoroughly prospected.

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GS-5 GEOLOGICAL INVESTIGATIONS IN THE TARTAN LAKE-EMBURY LAKE AREA

by H.P. Gilbert

INTRODUCTION

Field work was based at Embury Lake for one month and extended the area previously mapped around Tartan Lake to the west and south (Gilbert, 1987a). A minor injury foreshortened the field season and prevented completion of mapping to the Manitoba/Saskatchewan border. Brief visits were made to Trout Lake Mine and Westfield Mineral's Big Island Lake property adjacent to the south margin of the map area. The project is directed toward completion of mapping of the north part of the Flin Flon volcanic belt, with concurrent investigations of the stratigraphy, structure, economic geology and volcanic geochemistry of the Amisk Group.

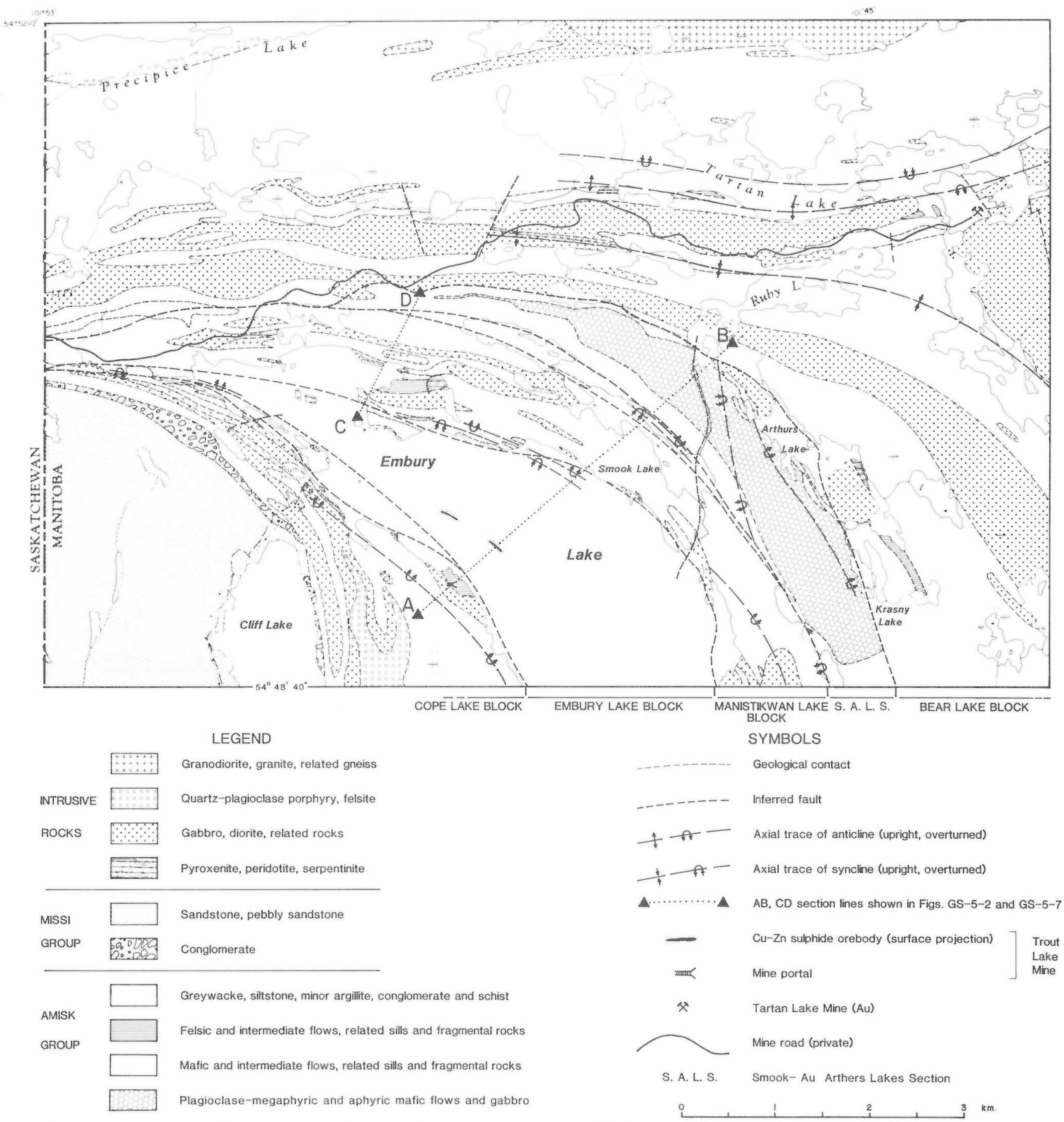


Figure GS-5-1: Geology and major structural subdivisions of the Tartan Lake-Embury Lake area.

MAJOR STRUCTURAL SUBDIVISIONS

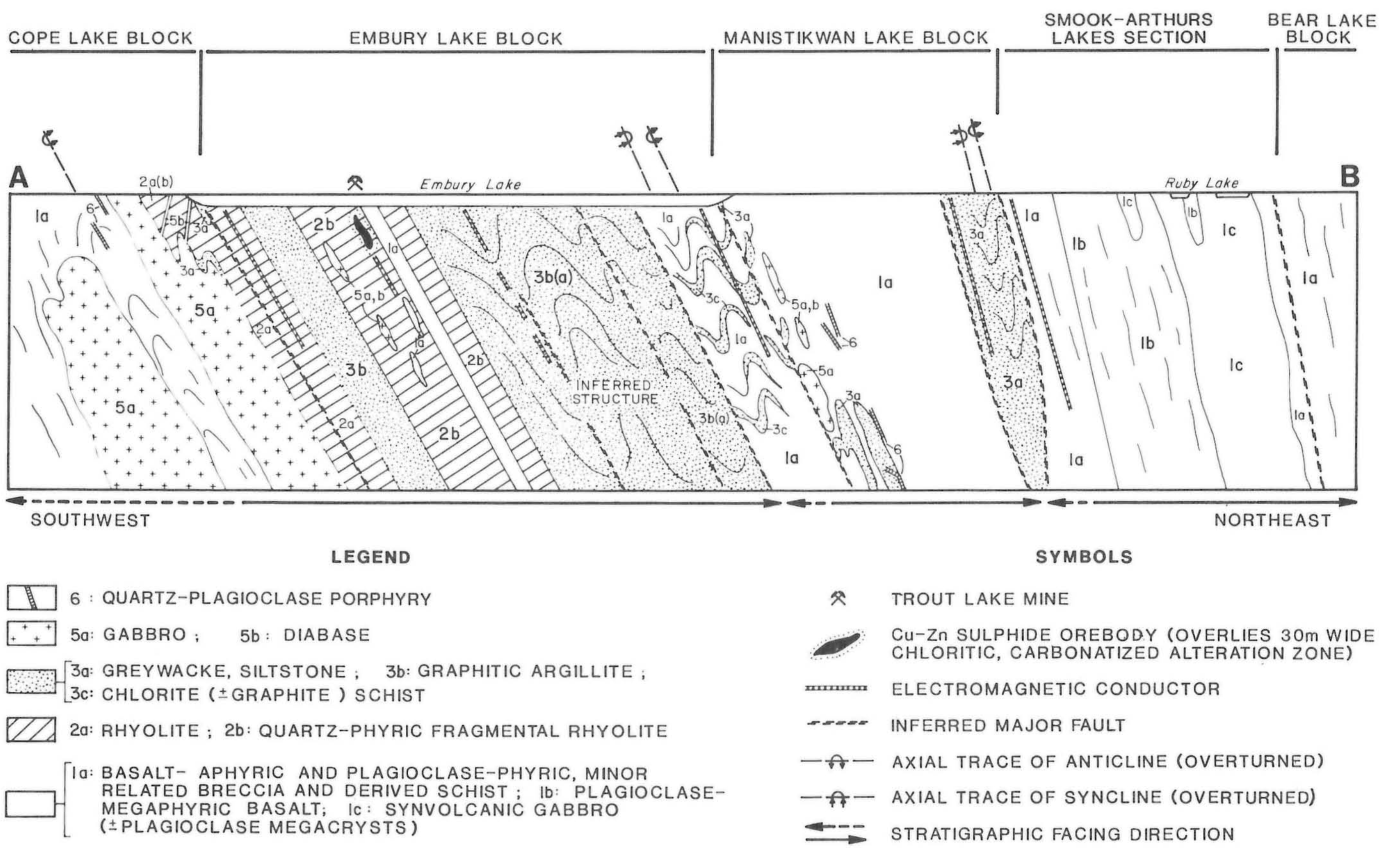
Fault blocks identified in the Flin Flon-White Lake area (Bailes and Syme, 1987) extend north into the Tartan Lake-Embury Lake Lake area, bounded by four major faults which extend northwest along the west and east shores of Embury Lake, through the north end of Manistikwan Lake, and through the west part of Krasny Lake (Fig. GS-5-1). These faults define a series of major blocks, trending north to northwest through the Tartan Lake-Embury Lake area. An overall north to northeast direction of facing is recognized in the section between the west shore of Embury Lake and Ruby Lake, but the relative ages and stratigraphic relationships of the fault blocks in the area are not known (Fig. GS-5-2.)

The Bear Lake block, defined in the Flin Flon-White Lake area (Bailes and Syme, 1987) extends northwest through south Tartan Lake and Ruby Lake (Gilbert, 1988). The Manistikwan Lake block is bounded to the northeast by a major fault extending southeast through Smook Lake and south through Manistikwan Lake, into the Inlet Arm fault (Bailes and Syme, op. cit.). The section between Smook and Arthurs Lakes, which contains aphyric and plagioclase-megaphyric basalt, gabbro, and minor fine grained sedimentary rocks, occurs between the Bear Lake and Manistikwan Lake blocks, on strike with the Grassy Narrows zone to the south (Bailes and Syme, 1983). However, the Smook-Arthurs Lakes section is lithologically and structurally different from the Grassy Narrows zone, which comprises a series of fault slices containing basalt, rhyolite and gabbro. The Smook-Arthurs Lakes section and the Grassy Narrows zone are apparently tectonically distinct, lensoid fault blocks occupying the zone between the Bear Lake and Manistikwan Lake blocks.

The geology of the Embury Lake block (Bailes and Syme, 1987) is based on incomplete sections exposed at Embury Lake, diamond drill hole data, and underground mapping at Trout Lake Mine (Ko, 1986). A predominant northeast direction of facing is inferred from sporadic top indicators in greywacke and the setting of the massive sulphide lenses in the mine, which display metal zonation and overlie alteration zones to the southwest (Ko, op. cit.). The Cope Lake block (Bailes and Syme, op. cit.) is bounded to the northeast by a northwest-trending fault which passes under the ore zone at Trout Lake Mine. The geology of the block and the area to the west will be the subject of future mapping.

FAULTING AND FOLDING

Faults parallel to the regional structure include major block-bounding faults and intra-block faults and shear zones. Northwest- to north-trending sheared zones (Fig. GS-5-3) are locally conspicuous along the east and west shorelines of Embury Lake and may, in part, represent branches from the major faults inferred parallel to the shorelines (Gilbert, 1988). Faults are defined by narrow zones of chloritic schist ($\pm$ sericite) or, less commonly, by fault breccia with a carbonatized matrix. Cataclasite derived from quartz-plagioclase porphyry occurs adjacent to the major fault at Annabel Creek (Fig. GS-5-4). Faults commonly occur between sedimentary and volcanic units, and major faults are generally assoc-



Geology based on Gilbert (1987a, 1988); additional information in the Embury Lake block from Ko (1986) and cancelled assessment data.
A-B section line is shown in Fig. GS-5-1.

SCALE

km 0.5 0 0.5 1.0 km

Figure GS-5-2: Transverse section through part of the Flin Flon volcanic belt from the west side of Embury Lake to Ruby Lake.

iated with marked topographic lineaments, e.g., Smook Lake fault (Fig. GS-5-1), extending northwest from the Inlet Arm fault to the south, which is conspicuous on Landsat satellite photographs).

Several faults discordant to the regional structure have been mapped (Gilbert, 1987b and 1988). The fault extending south from Ruby Lake is inferred from a marked topographic lineament and displacement of lithologic units. Stratigraphy is offset by at least 60 m along an inferred east-northeast-trending sinistral fault 1 km northwest of the Pump House in the north part of Embury Lake.

Stratigraphic facing direction in the Embury Lake-Ruby Lake section is predominantly north to northeast; local reversals within greywacke-mudstone formations indicate folding at Annabel Creek and at the north shore of Embury Lake (Gilbert, 1988). A northwest-trending overturned anticline is indicated by pillows in basalt within the Manistikwan Lake block near the south margin of the area (Gilbert, op. cit.); the south part of the Manistikwan Lake block (in the Flin Flon-White Lake area) may form the west limb of the anticline, since it is homoclinal and west-facing (Bailes and Syme, 1983, 1987); the possible northwest extension of the fold will be the subject of future mapping.

A north-northwest-trending major syncline occurs within the Smook-Arthurs Lakes section; the north end of this structure is truncated by an inferred northwest-trending fault through the south end of Ruby Lake. The

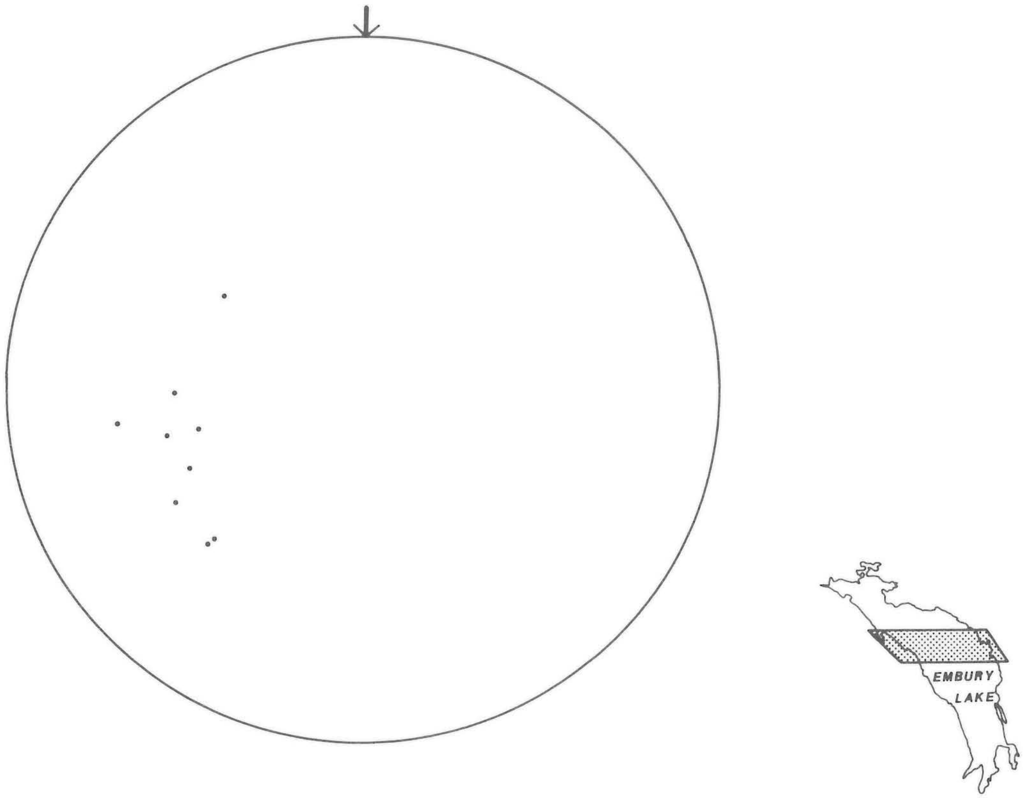


Figure GS-5-3: *Lower hemisphere stereographic plot of poles to sheared zones and faults in the central part of Embury Lake; data are from the shaded area on the inset map.*

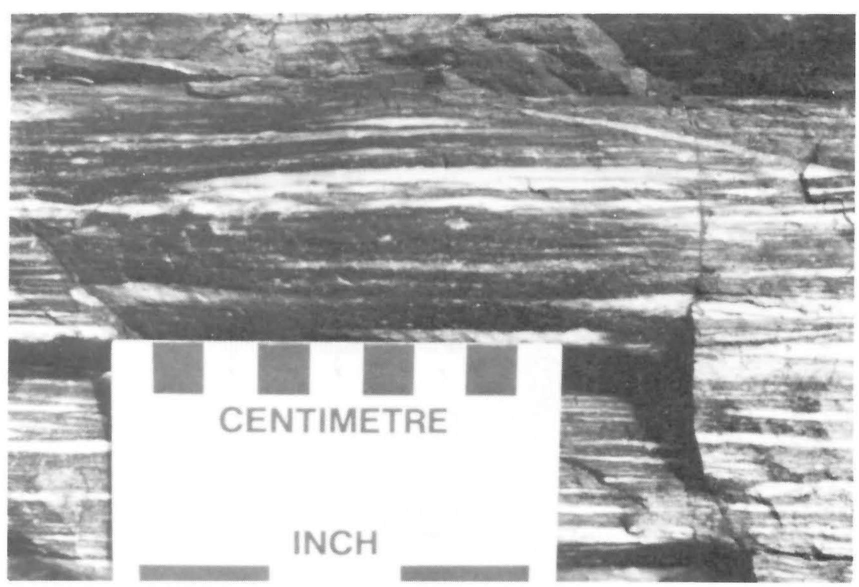


Figure GS-5-4: *Cataclasite derived from quartz-plagioclase porphyry close to the inferred major fault at Annabel Creek.*

south end of the fold is apparently continuous with an overturned syncline that extends through the north end of Manistikwan Lake and is coincident with the south end of the Smook Lake fault (Gilbert, 1988). Northeast of the syncline, a subparallel anticline extends northwest in the mafic flows along the southwest sides of Arthurs and Krasny Lakes.

North- to northeast-facing tops in the north part of the Cope Lake block and west-facing pillowed flows in the block farther south (Gilbert, 1988; Bailes and Syme, 1987) indicate a major anticline with axial trace subparallel to the west shore of Embury Lake. A single outcrop of northwest-facing, overturned pillowed basalt 1 km southeast of the Pump House is coincident with the axial zone of the proposed fold and suggests the anticlinal fold axis is overturned with a steep southeast plunge. Prominent mineral lineations and lineated clasts plunge southeast, subparallel to the major anticline along the west shore of Embury Lake (Fig. GS-5-5 and GS-5-6).

STRATIGRAPHY

The stratigraphy of the Bear Lake block has been described by Bailes and Syme (1979, 1980) and Gilbert (1987b). The Smook-Arthurs Lakes section was originally interpreted as the lower part of the Bear Lake block (Gilbert, op. cit.); however, the stratigraphic position of this section is uncertain because it is apparently fault bounded. The section is distinguished by the widespread occurrence of plagioclase megaphenocrysts up to 6 cm across in basalt and related gabbro, which are predominant

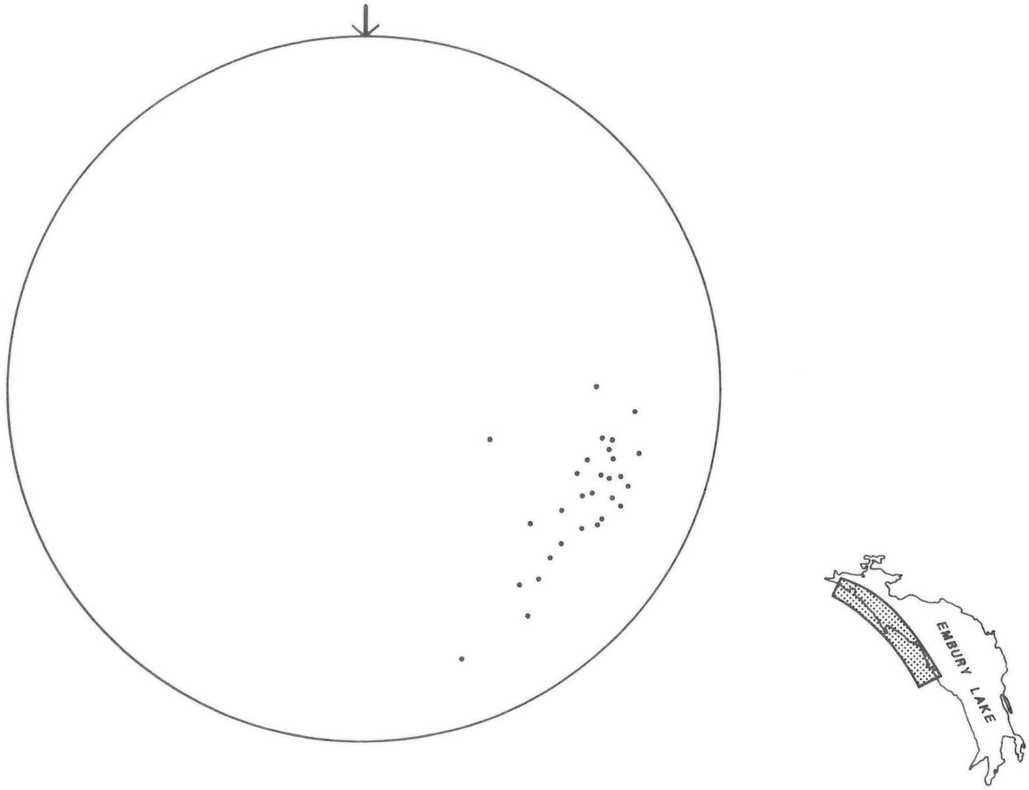
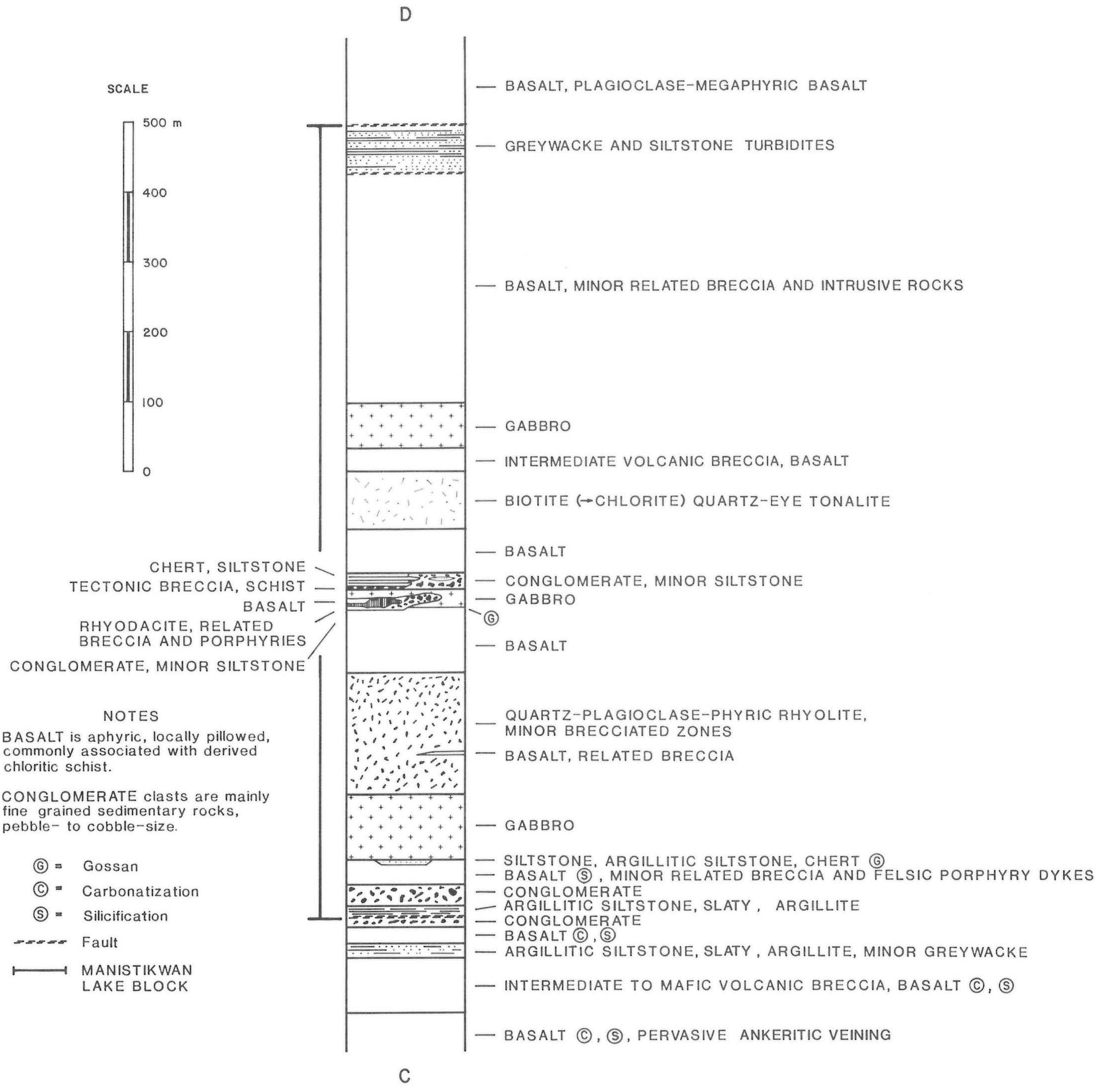


Figure GS-5-5: *Lower hemisphere stereographic plot of mineral lineations and lineated conglomerate clasts at the west shore of Embury Lake; data are from the shaded area on the inset map.*

Figure GS-5-6: *Lineated conglomerate clasts at the west shore of Embury Lake.*

in the section; lensoid bodies of siltstone, greywacke and subordinate slaty argillite up to 200 m wide occur in the uppermost part of the section along the southwest side of Arthurs Lake (Fig. GS-5-1; Gilbert, 1987b, p. 41).

The stratigraphy of the Manistikwan Lake block in the north part of Embury Lake, where the section apparently faces northeast, is shown in Figure GS-5-7. Fine grained turbidites in the fault slice at the northeast margin of the Manistikwan Lake block are folded, within an overall northeast-facing sequence; fine grained sedimentary rocks in the basal part of the section are also folded, but indicate a predominant northeast direction of facing. At least six minor fine grained sedimentary units are intercalated with mafic volcanic rocks along the south margin of the Manistikwan Lake block at the north shore of Embury Lake. Several or all of these units have been interpreted as part of the same formation, possibly representing the northeast (upper) part of the Embury Lake block section where it is in contact with mafic volcanic rocks of the Manistikwan Lake block; the irregular configuration of this contact is attributed to folding. Later block faulting may have detached these sedimentary inliers from the Embury Lake block.



Note: Stratigraphic section line C–D is shown in Fig. GS-5-1

Figure GS-5-7: Stratigraphic section through the Manistikwan Lake block in the north part of Embury Lake.

The Manistikwan Lake block consists largely of aphyric basalt (locally sparsely plagioclase-phyric) and gabbro. The flows locally are vesicular and/or amygdaloidal and contain interlayers of autoclastic breccia; subordinate fine grained schistose amphibolite units may represent mafic tuffs. Plagioclase (± quartz) porphyries and minor felsitic dykes occur sporadically. A dacite or rhyolite formation up to 160 m wide occurs in the section in the north part of Embury Lake. The rhyolite is finely porphyritic (plagioclase ± quartz) and locally tectonically brecciated and pervaded by chloritic microfractures; it is not clear whether this unit is extrusive or intrusive. A body of quartz-eye biotite (-chlorite) tonalite at least 40 m wide is emplaced in basalt in the north part of Embury Lake, where subordinate units of greywacke, siltstone, argillite, chert and conglomerate are interlayered with the mafic volcanic rocks in the lower half of the Manistikwan Lake block section (Fig. GS-5-1 and GS-5-7).

The Manistikwan and Bear Lake blocks are clearly distinguished stratigraphically, and by the character of their mafic volcanic rocks. In the Manistikwan Lake block, green-weathering aphyric basalt is predominant and is moderately to intensely deformed; subordinate sedimentary rocks are largely confined to the north part of the block except for a 160 m wide turbidite section, interpreted as a fault slice, which extends along the northeast side of the block. The lower part of the Bear Lake section, in contrast, consists largely of pyroxene ± plagioclase-phyric basalt and aphyric basalt which are invariably pillowed and intercalated with autoclastic breccia. Mafic volcanics are typically beige to pale grey-green weathering; amygdales are widespread and commonly abundant. Synvolcanic mafic dykes and sills are common. Deformation is minor and a wide variety of flow-related structures is preserved in the mafic flows. The upper part of the Bear Lake section consists largely of intermediate subaqueous pyroclastic rocks and minor sedimentary rocks in the south (Bailes and Syme, 1979, 1980); a 330 m thick section of fine grained volcanogenic sedimentary rocks in the north is provisionally interpreted as the upper part of the Bear Lake section (Gilbert, 1987b).

The Embury Lake block consists largely of greywacke, siltstone and graphitic argillite (Bailes and Syme, 1983; Ko, 1986); a 100 m wide greywacke-mudstone sequence represents the block at Annabel Creek, close to the faulted-out west end (Gilbert, 1988). Subordinate lithologies in the block include conglomerate and aphyric basalt (at least 100 m thick) which underlie islands in the north part of Embury Lake; andesite intercalated with mafic schist (at least 450 m wide) at the east side of the fault block (cancelled assessment diamond drill hole data); and felsic volcanic rocks (up to 210 m thick) which constitute the host rock of the orebodies at Trout Lake Mine (Ko, op. cit.). Minor amygdaloidal andesite also occurs in the mine section.

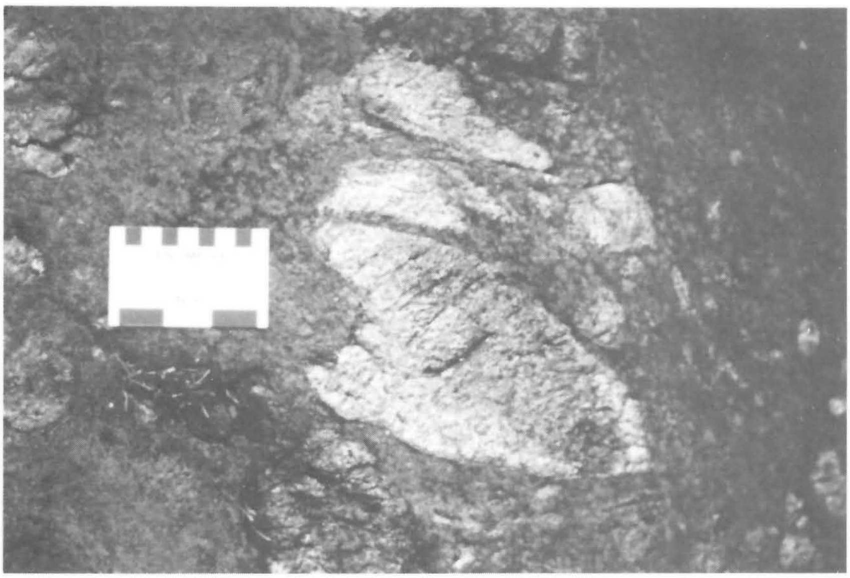


Figure GS-5-8: *Intermediate to mafic autoclastic breccia within plagioclase-phyric basalt at the northeast margin of the Cope Lake block at Embury Lake.*

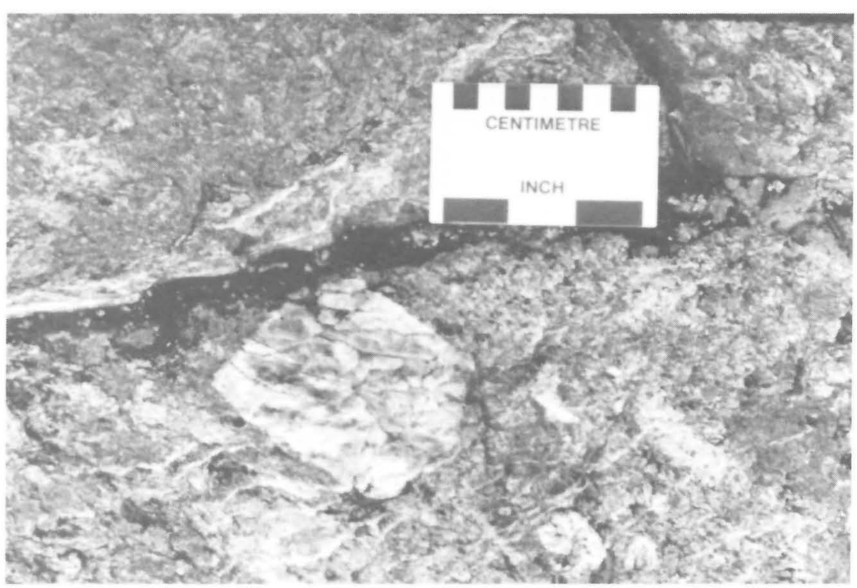


Figure GS-5-9: *Intermediate to felsic volcanic breccia at the northeast margin of the Cope Lake block at Embury Lake.*

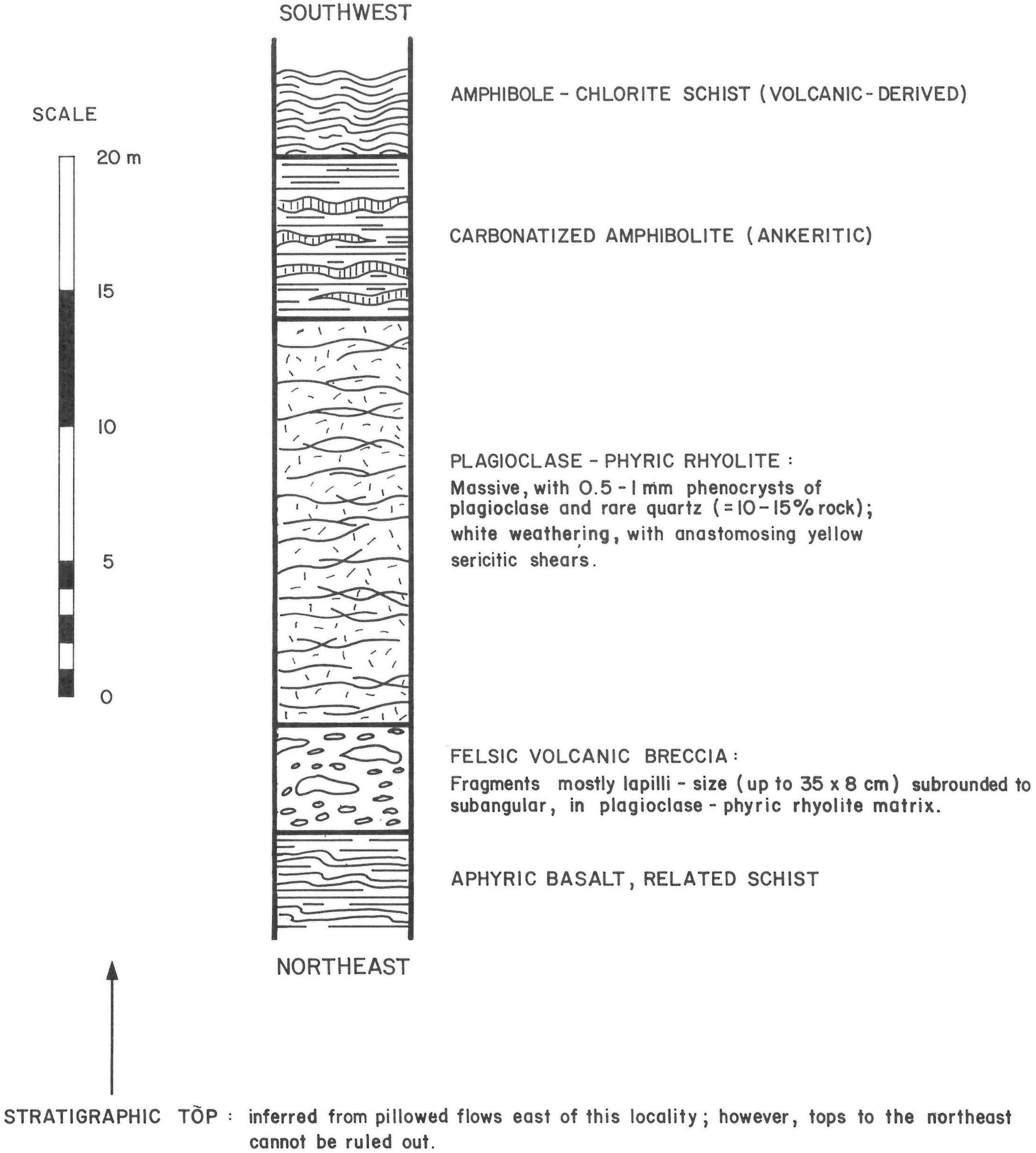


Figure GS-5-10: *Stratigraphic section through the plagioclase-phyric rhyolite unit at the east side of the Smook Lake fault, 300 m northwest of the north end of Manistikwan Lake.*

The Cope Lake block immediately west of Embury Lake (Bailes and Syme, 1987) contains mafic volcanic flows, related breccia (Fig. GS-5-8) and subordinate interlayers of greywacke, siltstone and argillite. Felsic volcanic units at least 50 m thick occur close to the northeast margin of the block; these include massive units with local zones of breccia, intermediate to felsic volcanic fragmentals (Fig. GS-5-9), and quartz-plagioclase porphyries. The proximity of felsic volcanic and fine grained sedimentary rocks in both the Embury Lake and Cope Lake blocks close to the dividing fault may be a result of tectonic repetition by faulting parallel to the west shore of Embury Lake.

ECONOMIC GEOLOGY

Sulphide showings associated with minor fine grained sedimentary units were observed at the shoreline of Embury Lake, commonly located between mafic volcanic flows and gabbro sills, or within mafic volcanic sections. Mineralized lithologies include argillite, siltstone, chert, amphibolite and, in one showing, conglomerate. Sulphides (pyrite ± pyrrhotite) are disseminated and commonly largely oxidized. Basalt is locally silicified adjacent to the mineralized zones, which are generally 20 cm to 1.5 m wide. Local traces of malachite were observed. At the northwest end of Embury Lake, a 4 m wide zone of felsitic dykes and porphyries in volcanic-derived mafic schist contains disseminated pyrite. Several sulphide showings were observed within aphyric basalt adjacent to gabbro or plagioclase-quartz porphyry intrusions. The proximity of massive sulphide orebodies close to the major fault at Trout Lake Mine indicates the possible economic importance of faults which define the major structural subdivisions in the Tartan Lake-Embury Lake area. A locality on the Smook Lake fault warrants investigation where a 20 m thick plagioclase-phyric rhyolite unit (Fig. GS-5-10 and GS-5-11) occurs 300 m northwest of the north end of Manistikwan Lake (Fig. GS-5-1). An electromagnetic conductor occurs on the fault 300 m northwest of the rhyolite, and continues intermittently for a further 2.8 km along the fault (cancelled assessment data, Hudson Bay Exploration and Development Company).

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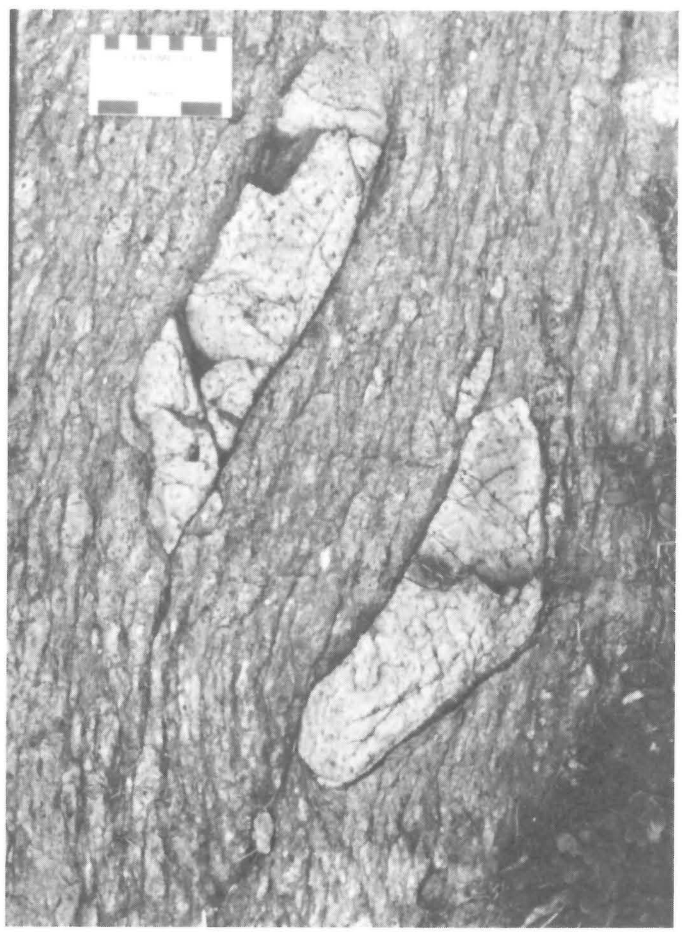

Figure GS-5-11: Felsic volcanic breccia within the rhyolite unit shown in Figure GS-5-10.

GS-6 KISSEYNEW PROJECT: KISSISSING LAKE

by D.C.P. Schledewitz

INTRODUCTION

In 1988 1:20 000 mapping for the Kississing Lake portion of the Kisseynew Project was continued and concentrated in the southeast and northeast corners of the Kississing Lake map area (63N/3, Fig. GS-6-1; Schledewitz, 1988) to:

1. investigate the variations in the previously established lithostratigraphy (Schledewitz, 1985, 1986, 1987);
2. examine the relationships of the previously defined suites of igneous rock;
3. further describe the geometry and relationships of major structures;
4. delineate mineralogical trends.

GENERAL GEOLOGY

LITHOSTRATIGRAPHIC CONSIDERATIONS

The Kisseynew gneisses of the Kississing Lake map area have been divided into four mappable components. These four components are considered to be sedimentary and/or volcanic derived metamorphic rocks. In addition the igneous rocks are divisible into three groups.

Two major lithostratigraphic units are the Burntwood River and the Missi metamorphic suites. Based on previously established field relationships the Burntwood River metamorphic suite (unit 2) (Nokomis Group, Robertson, 1953), an aluminous-graphite-bearing biotite gneiss to migmatite is the oldest. The younger Missi metamorphic suite (unit 5) is predominantly quartzofeldspathic rocks that are variably magnetiferous and hornblende-bearing. Field data from 1988 has defined an extensive area of conglomerate and interlayered quartz-rich metasediments (unit 5f) as part of the Missi metamorphic suite in the southern part of the map area. A fine grained, pink felsic rock (unit 5e) forms irregular shaped zones within the areas of conglomerate rocks in the south-central and southeastern parts of the map area. The fine grained, pink rock contains local quartz phenocrysts indicating an igneous protolith.

Two remaining lithostratigraphic entities have been placed into a category of rocks of uncertain affinity and/or age. A suite of amphibolite ± garnet, calc-silicates and hornblende-biotite-garnet feldspar-quartz gneiss (units 3a-3i) lies discontinuously between the Burntwood and Missi metamorphic suites. It is uncertain whether or not they are part of the Burntwood or Missi suite of rocks. In addition, similar appearing amphibolites such as the suite of amphibolites (units 3a-3c) at Bess Lake might be derived from volcanic rocks of the Amisk Group of the Flin Flon belt. The remaining suite of metamorphic rocks is the Sherridon metamorphic suite (unit 4) (Sherridon Group, Bateman and Harrison, 1946; Froese and Goetz, 1980). The suite comprises highly varied lithologies. The occurrence of sulphide-bearing zones and the past producing Sherritt Gordon deposit at Sherridon has focussed attention on this suite of metamorphic rocks. Detailed mapping by Froese and Goetz (1980) suggested correlation of the Sherridon metamorphic suite with the Missi metasedimentary rocks of the Flin Flon belt. However, they also indicate that the rocks at the type locality of the Sherridon Group (proposed Sherridon metamorphic suite) at Sherridon are not typical of the Sherridon Group (Missi) elsewhere in the Kisseynew gneiss complex. Tuckwell (1979), as a result of a brief study, suggested that the Sherridon metamorphic suite is an allochthonous body which was emplaced structurally and does not have a direct stratigraphic equivalent. Consequently, at this preliminary stage, the Sherridon metamorphic suite is considered to be a highly recrystallized and tectonized varied suite of rocks of uncertain age and affinity.

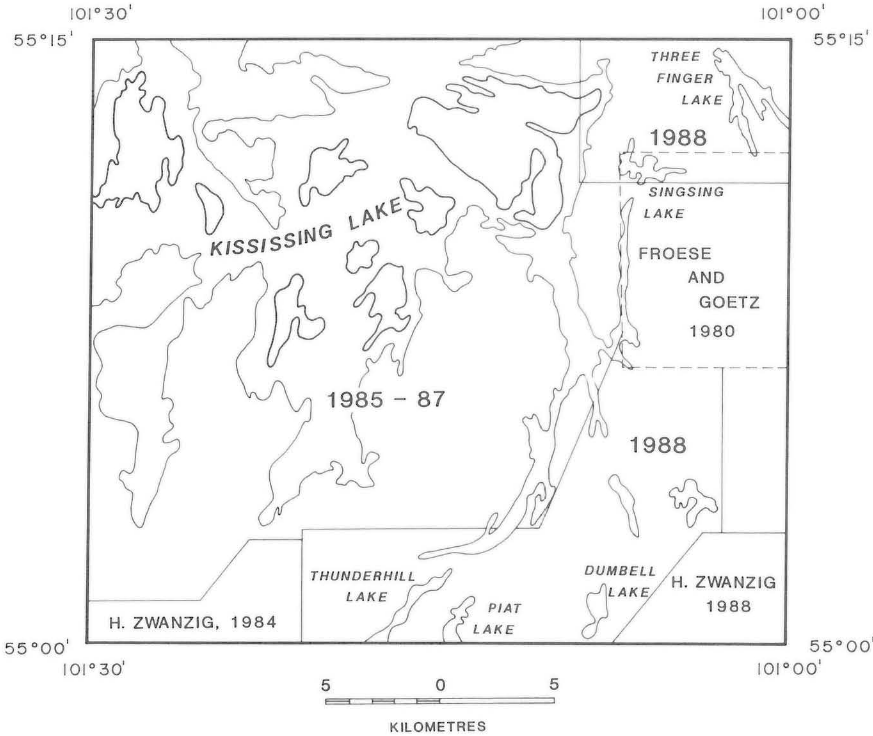

Figure GS-6-1: Location of mapping in 1988, Kississing Lake area.

IGNEOUS ROCKS

The igneous rocks are divisible into three groups: an older suite of tonalitic to granodioritic orthogneiss (unit 6) that contains varying amounts of amphibolite and metadiorite inclusions. These rocks are intruded by a younger leucocratic variably magnetiferous monzogranite to granodiorite (unit 9). The third and youngest suite of igneous rocks are quartz-rich granites (units 12-14) that intrude the othogneisses and monzogranites.

RESULTS OF 1988 MAPPING

LITHOSTRATIGRAPHY AND STRUCTURE

The Missi metamorphic units in the south central part of the map area from Cleunion Lake to Dumbell Lake are distinguished by the volume of fine grained leucocratic pink granoblastic rock (unit 5e) and also the volume of coarse clastic (unit 5f) and quartz-rich rocks (units 5c, 5d).

The fine grained pink rock forms discontinuous layers of varied width (1-3 km) and length (15-40 km). The rock is variably quartz-phyric but is more characteristically massive. The fine grained uniform composition suggests a high level intrusion and/or a thick sequence of felsic tuff. The probability of metavolcanic rocks in this region is consistent with observations by Zwanzig (1984) in the Cleunion Lake area, in the southwest corner of the map area, and in the Lobstick Narrows-Weldon Bay area immediately to the south of the map area where he has interpreted a similar pink felsic gniess as rhyolite and felsic tuff. The pink leucocratic rocks (5e) appear to have gradational contacts with a fine grained, light grey, variably magnetiferous, biotite-bearing (8-10%) quartzofeldspathic granoblastic rock. This light grey granoblastic rock (unit 5c) is interlayered with more quartz-rich epidote and hornblende-bearing grey quartz-feldspar gneiss (unit 5d) of the Missi metamorphic suite.

In addition to a major igneous rock component, coarsely clastic sedimentary rocks are prevalent in this part of the map area. The coarse clastic facies consists of cuspate lenses several metres in length and up to 1 m thick of conglomerate, possibly channel deposits, in a variably pebbly biotite (10-20%)-muscovite-feldspar-quartz matrix $\pm$ hornblende $\pm$ epidote. The matrix-supported clasts are dark grey hematite or magnetite-quartz, white to clear vein quartz, and very fine grained pale pink felsic rocks. The conglomerate and pebbly beds are interlayed with a more quartz-rich light grey fine grained quartzofeldsapthic gneiss characterized by biotite (8-10%) and discontinuous quartz-epidote $\pm$ hornblende layers (5d). The quartzofeldspathic gneiss with epidote layers (5d) is present within the Missi metamorphic suite throughout the map area. However, the conglomerate facies (5f) and also the fine grained pink leucocratic granoblastic rock (5e) are present as mainly small discontinuous lenses or layers outside the south central region.

Rocks of the Missi metamorphic suite are structurally overlain by garnet-graphite biotite gneiss (units 2a, 2e) of the Burntwood River metamorphic suite southwest of Piat Lake. All of these rocks are folded in a synform that plunges at a shallow angle to the south of east. The axial trace of this synform appears to wrap around the nose of a dome cored by magnetiferous monzogranite (unit 9). The axial trace of this synform can be projected into the area south of Finger Lake where it is refolded about northerly to northeasterly axial planes (Fig. GS-6-2). Within the area of refolding the garnet-biotite Burntwood River-type gneiss contains retrograde garnets and retrograde muscovite. Both the Burntwood River and Missi metamorphic suite rocks in the region from Finger Lake to Dumbell Lake contain extensive areas of quartz-rich muscovite-biotite granites and granite pegmatites. This zone of granite intrusion coincides with the area of refolding of an earlier developed fold axis and also the area of extensive retrograde metamorphism.

In the northeast corner of the map area mapping extended the previously defined belts of the Burntwood River metamorphic suite and the intervening belt of the Missi metamorphic suite from the northeast corner of Big Island 35 km east to the Three Finger Lake area. The Burntwood River metamorphic suite rock is a migmatitic garnet-graphite-biotite feldspar-quartz gneiss. An exception is an area 0.5 km west of Three Finger Lake and 1 km north of Contact Lake. In that region rocks that have been equated with the Burntwood River metamorphic suite vary from graphitic pyrite-biotite feldspar-quartz gneiss with localized areas of silicification to a graphite-biotite feldspar-quartz gneiss with 80-90% cream coloured granite *lits*. Discontinuous lenses of garnet-hornblende-biotite feldspar-quartz gneiss and biotite granodiorite are also present. This varied lithology extends east to Three Finger Lake along the north margin of this belt of the Burntwood metamorphic suite. It is in this region that the intervening or medial belt of the variably magnetiferous hornblende-biotite feldspar-quartz gneisses of the Missi metamorphic suite are attenuated in an area of faulting. This zone of attenuation is marked by large areas of pegmatitic granite and tight folds with shallow easterly plunges. This zone of faulting is related to large-scale asymmetric Z-folds. The asymmetric Z-folds are in turn related to faulting along a detachment zone that lies at the boundary of an orthogneiss complex and the overlying belt of gneisses of the Burntwood and Missi metamorphic suites (Fig. GS-6-3). This orthogneiss complex lies south and southwest of Three Finger Lake.

MINERALIZATION

Mineralization in both the southeastern and northeastern parts of the map area examined in 1988 was observed within amphibolites (units 3a-3c) that lie between the garnet-graphite-biotite feldspar-quartz gneisses of the Burntwood metamorphic suite and the variably hornblende-magnetite-bearing quartzofeldspathic rocks of the Missi metamorphic suite. Two occurrences were observed; one at the north end of Finger Lake in the southeast corner of the map area and the other along the southwestern edge of Three Finger Lake in the northeast corner of the map area. Both of these sites were previously trenched and the locations reported by Bateman and Harrison (1946).

The occurrence at the north end of Finger Lake lies within coarse grained calc-silicate and interlayered variably garnetiferous amphibolites (units 3a-3c) which are underlain by a fine grained biotite-rich gneiss to schist. The sulphides comprise pyrrhotite and minor chalcopyrite. The amphibolite lies on the eastern edge of a thin sliver of garnet-graphite-biotite feldspar-quartz gneiss (unit 2a) of the Burntwood River metamorphic suite. This sliver of garnet-biotite gneiss (unit 2a) pinches out to the north and is bounded on the west by a fault. The southern termination of this sliver is a tight fold which plunges east of north at a shallow angle.

The occurrence of mineralization at Three Finger Lake lies within very tightly folded and faulted variably garnetiferous amphibolite and interlayered calc-silicate (units 3a-3c). The folds plunge to the east at a shallow angle. The mineralization is primarily pyrrhotite with trace chalcopyrite. The sulphides are disseminated and also concentrated in fractures where the amphibolite is sheared.

SUMMARY OF REGIONAL STRUCTURAL GEOLOGY

The following sequence of events is postulated based on the combined results of mapping from 1985 to 1988.

- D_1 - an early period of recumbent folding (F_1),
- M_1 - upper amphibolite grade metamorphism,
- D_2 - refolding, and related faulting, of F_1 folds about northerly striking axial planes accompanied by the development of domal structures cored by orthogneiss and intrusive rocks of varied ages,
- M_2 - peak temperatures of amphibolite grade metamorphism but decreasing pressure.
- D_3 - intrusions of leucocratic granites, development of conjugate fault zones and related folding accompanied by varying degrees of retrograde metamorphism.

Deformation D_1

Recumbent folding is proposed on the basis of repetition and inversion of the shallow dipping gneisses of the Burntwood River and Missi metamorphic suites. Remnants of refolded early fold hinges (F_1) are preserved along the west to northeast flank of the Adamson Lake dome, the southeast end of the Big Island dome and at the south end of the South Bay dome (Fig. GS-6-4).

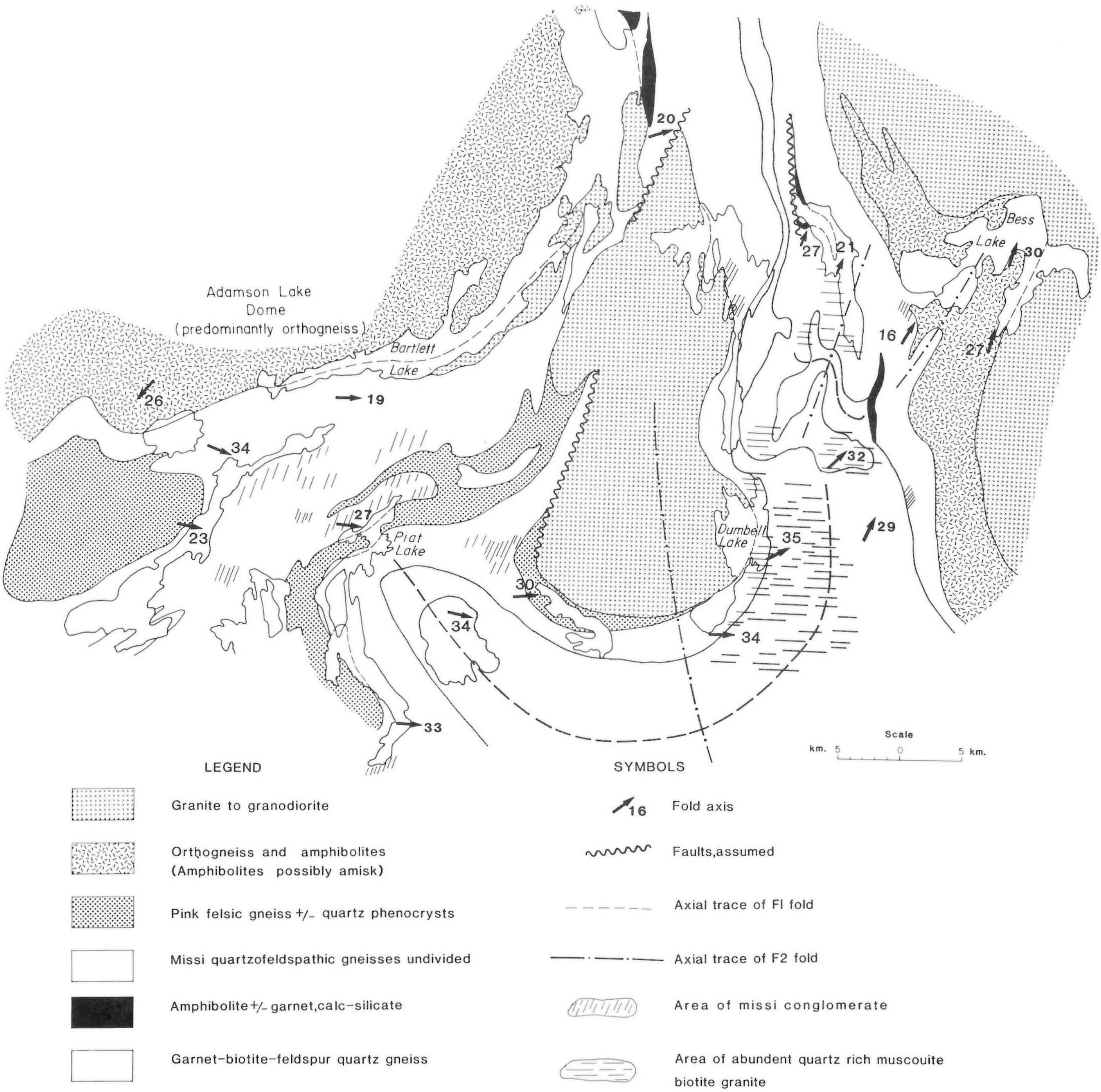

Figure GS-6-2: *Simplified geology of the southeast part of the Kississing Lake map area.*

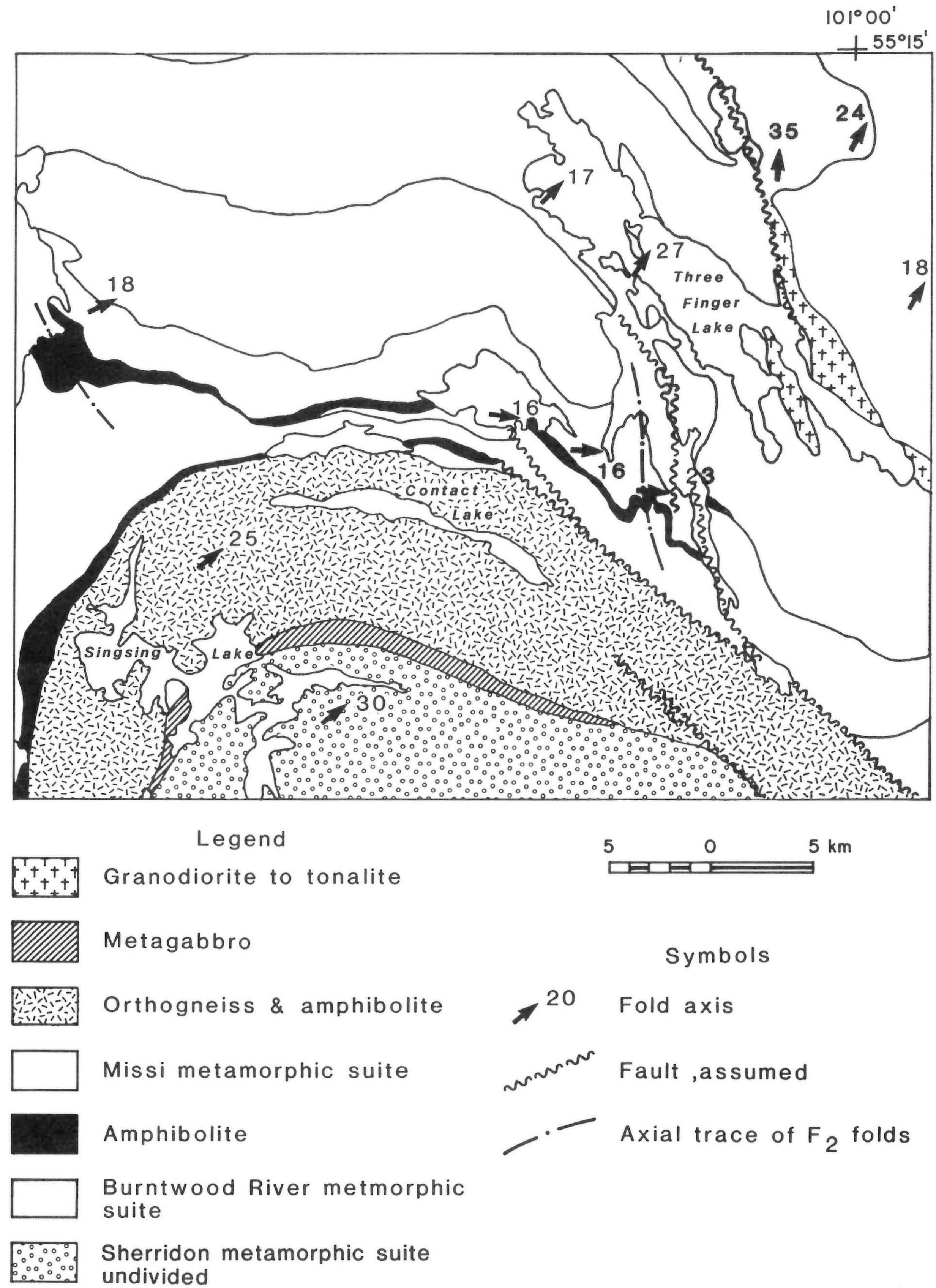

Figure GS-6-3: *Simplified geology of the northeast corner of the Kississing Lake map area.*

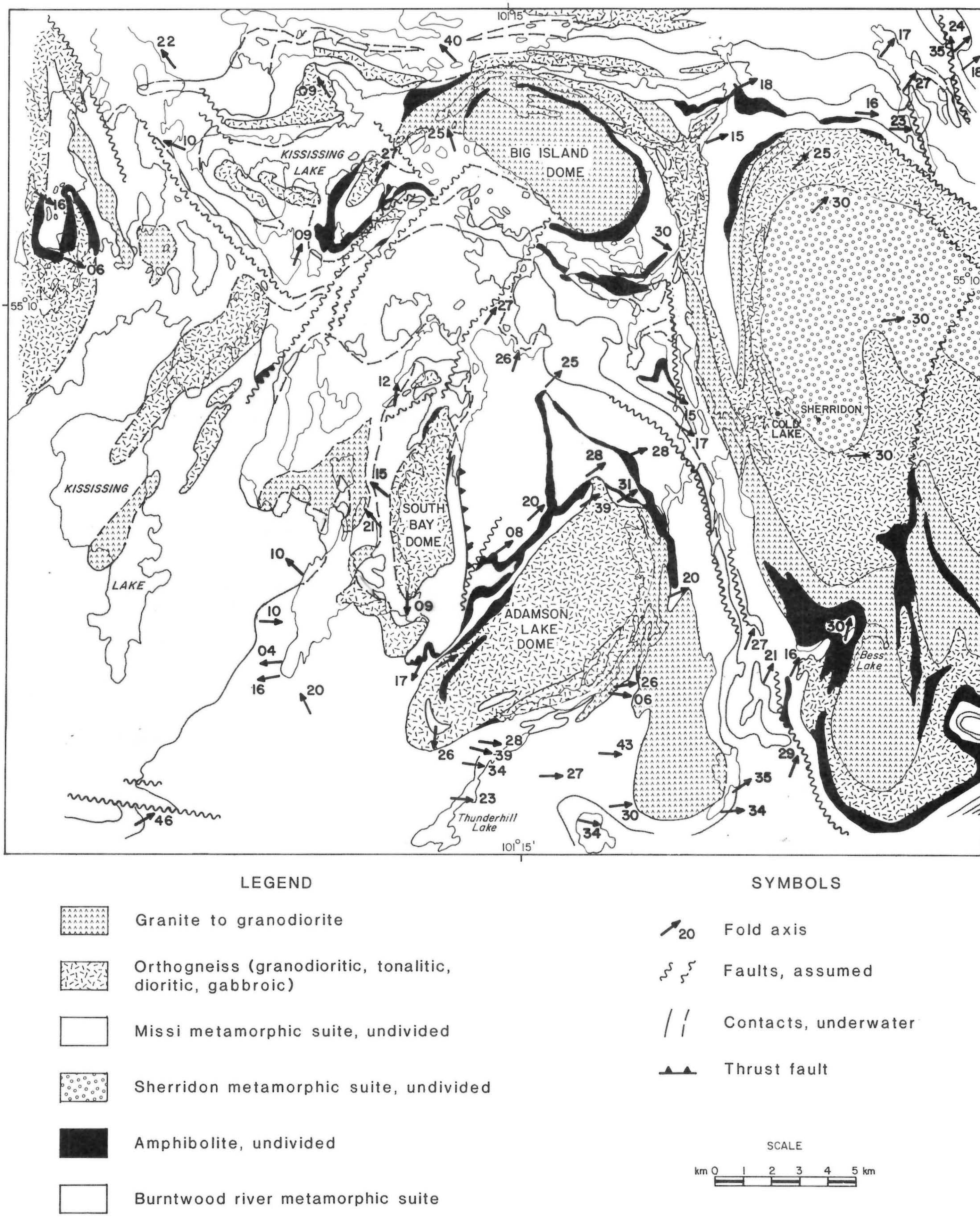

Figure GS-6-4: Simplified geology of the Kississing Lake map area.

Deformation D_2

The array of orientations for the azimuths of minor and small-scale folds indicates post-recumbent fold (F_1) deformation on a regional scale (Fig. GS-6-4). The refolding appears to be primarily about northerly striking axial planes. The complexity of the resultant structures is due to the presence of intrusive bodies which have behaved more competently than the surrounding rocks of the Burntwood River and Missi metamorphic suites. The margins and intervening areas of adjacent domes are commonly sites of faulting and broad shear belts. The region from Bess Lake to the east end of Big Island is an example of the style of deformation in a zone that lies between adjacent orthogneiss domes (Fig. GS-6-4). The region around Three Finger Lake is an example of F_2 asymmetric Z-folding and related faulting (Fig. GS-6-3) on the margin of an orthogneiss complex. This structure is on the north margin of a domal orthogneiss complex that is cored by the Sherridon metamorphic suite.

Deformation D_3

The presence of retrograde metamorphism is the main criterion for the the identification of D_3 structures. The D_3 structures are generally coplanar to D_2 shear zones and fold belts. However, the D_3 shears and faults and axial planes may also have steep dips. Fine grained to pegmatitic siliceous granites accompany this phase of deformation. This system of D_3 structures may be related to a conjugate set of shear zones, one at 330°-340° at intermediate to steep dips exhibiting an apparent dextral movement, and the second at 045°-055° at intermediate to steep dips exhibiting an apparent left lateral sense of movement.

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GS-7 KISSEYNEW PROJECT: BATTY LAKE REGION

H.V. Zwanzig

INTRODUCTION

A 325 km^2 area between Walton Lake, Puffy Lake and Martell Lake was mapped at 1:15 840 scale and compiled at 1:50 000 scale on Preliminary Map 1988K-2 (Zwanzig et al., 1988). The compilation includes previous maps of Limestone Point Lake (Zwanzig et al., 1987), Star Lake (Zwanzig and Miller, 1987) and Nokomis Lake (Zwanzig and Seneshen, 1984). The area lies within the Kisseynew metamorphic complex and rocks are upper amphibolite facies. A transition from weakly foliated granodiorite and fine grained metavolcanic rocks to strongly foliated intrusive rocks and sedimentary gneiss occurs in a northeast direction across the map area. Gold deposits and showings occur on the south side of the transition zone and along the northern limit of volcanic-derived gneisses.

STRATIGRAPHIC FRAMEWORK

The gneisses are divided into the Amisk Group and the Burntwood River, Sherridon and Missi metamorphic suites. The Amisk Group consists of predominantly metavolcanic rocks and is clearly recognizable only on the south margin of the area (Fig. GS-7-1). Some units of amphibolite and felsic gneiss in the central and northern part of the area are probably highly deformed equivalents of the Amisk Group. The Burntwood River metamorphic suite[1] outcrops north of the well preserved Amisk Group rocks. It is considered to be derived from metagreywacke and mudstone deposited penecontemporaneously with Amisk volcanism (Bailes, 1980; Ashton, et al., 1986).

The Missi metamorphic suite is derived from younger continental sandstone and apparently subaerial volcanic rocks. The base of the Missi suite is locally marked by a metaconglomerate that unconformably overlies the older supercrustal rocks and some early intrusions.

The Sherridon metamorphic suite[2] comprises coarse grained felsic to mafic gneiss of uncertain age. A new structural interpretation suggests that it may be older than the Missi suite. Sherridon gneisses have been considered to be younger than the surrounding gneisses (Bateman and Harrison, 1946; Froese and Goetz, 1981) but the type section at Sherridon is surrounded by granitoid rocks and has an unknown stratigraphic position. Similar gneisses north and east of Walton Lake lie between two belts of Burntwood River metagreywacke. The contact is locally grada-

[1]Much of this unit was mapped as Nokomis Group by Robertson (1953).

[2]Sherridon Group of Bateman and Harrison (1946).

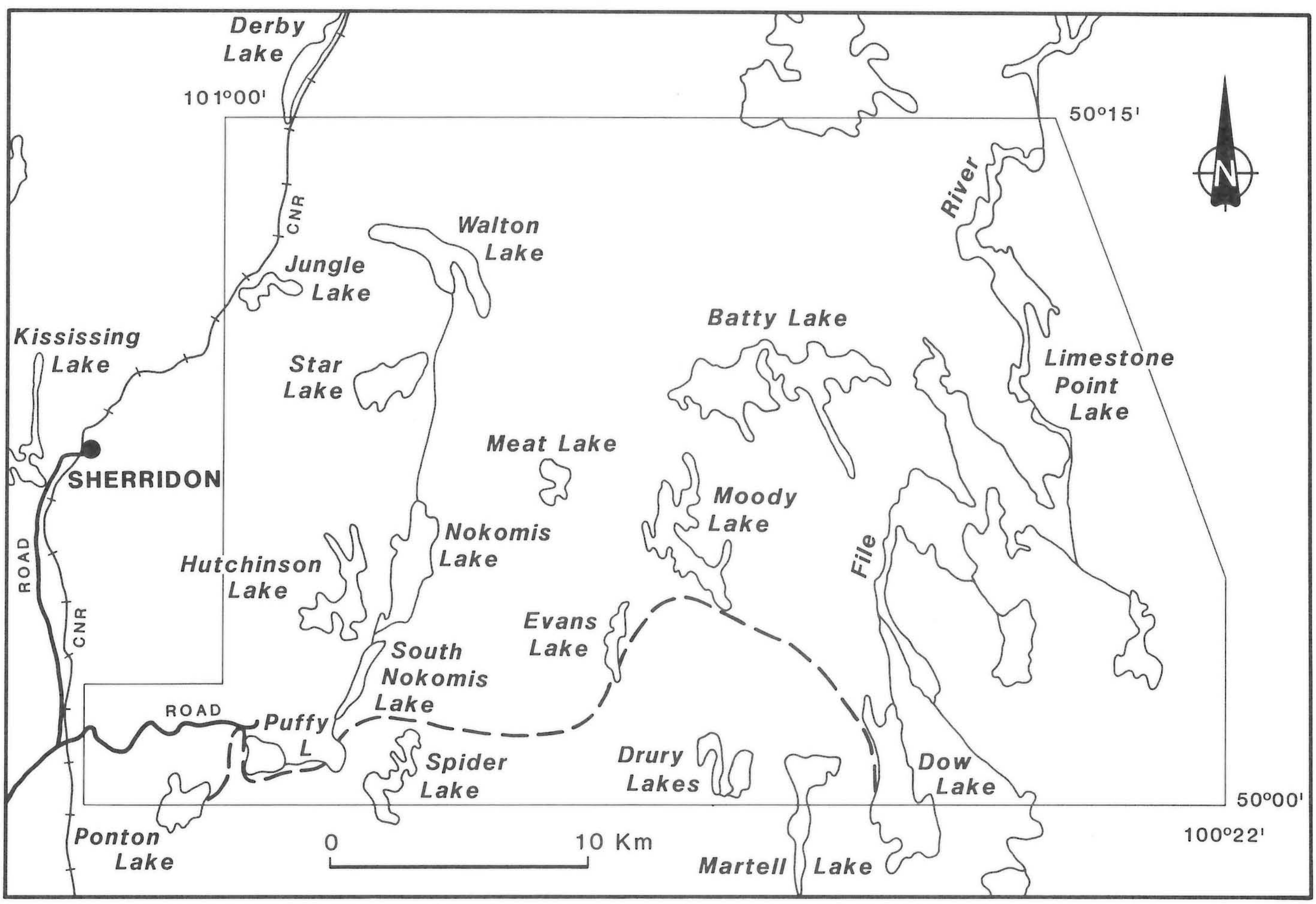

Figure GS-7-1: *Outline of compiled map area (solid line). Clearly recognizable Amisk Group metavolcanic rocks and moderately foliated intrusions in the south are separated (by the dashed line) from gneissic metasedimentary rocks and meta-igneous rocks in the north.*

tional. The metagreywacke is stratigraphically overlain by the Missi suite (Fig. GS-7-2). This distribution of units suggests that the Sherridon suite lies in the core of an anticline and is equivalent to or older than the Burntwood River suite. Southwest of Meat Lake Sherridon-type gneiss is traced laterally into less coarsely recrystallized rocks that appear to represent basaltic, dacitic and intermediate metavolcanic rocks, locally interlayered with greywacke-derived gneiss. This part of the Sherridon suite is tentatively correlated with the Amisk Group (see also Ashton and Froese, GSC-18, this volume).

A fourth lithologic suite comprises granitoid rocks in large bodies which are progressively more foliated and less uniform towards the northeast. Much of the rock has lost its primary intrusive texture and is mapped as orthogneiss (Zwanzig and Lenton, 1987). These rocks were orignally mapped as metasedimentary rocks of the Sherridon Group (Robertson, 1953; Kornik, 1968).

STRUCTURAL FRAMEWORK

The map area lies on the south flank of the Kisseynew metamorphic complex. Sheet-like, recumbent folds dominate the area. Their axial surfaces lie within individual units of gneiss that extend northwest for more than 40 km without closure. These early folds are molded around (i) prominent structural domes of early-kinematic intrusions and (ii) recumbent sheath-folds of orthogneiss which were derived from early intrusions hybridized by younger granite. The early folds were realigned along northwesterly and northerly trending crossfolds and fault zones.

The later folds are developed in well layered successions above decollements. These folds are S-shaped or box-shaped with two converging axial surfaces trending northwest and north-northeast. Adjacent fault zones which generally flank granitoid bodies act as decollement. Typical structures of this kind occur at Nokomis Lake, east of the Hutchinson dome and its flanking fault zone (Zwanzig and Seneshen, Preliminary Map

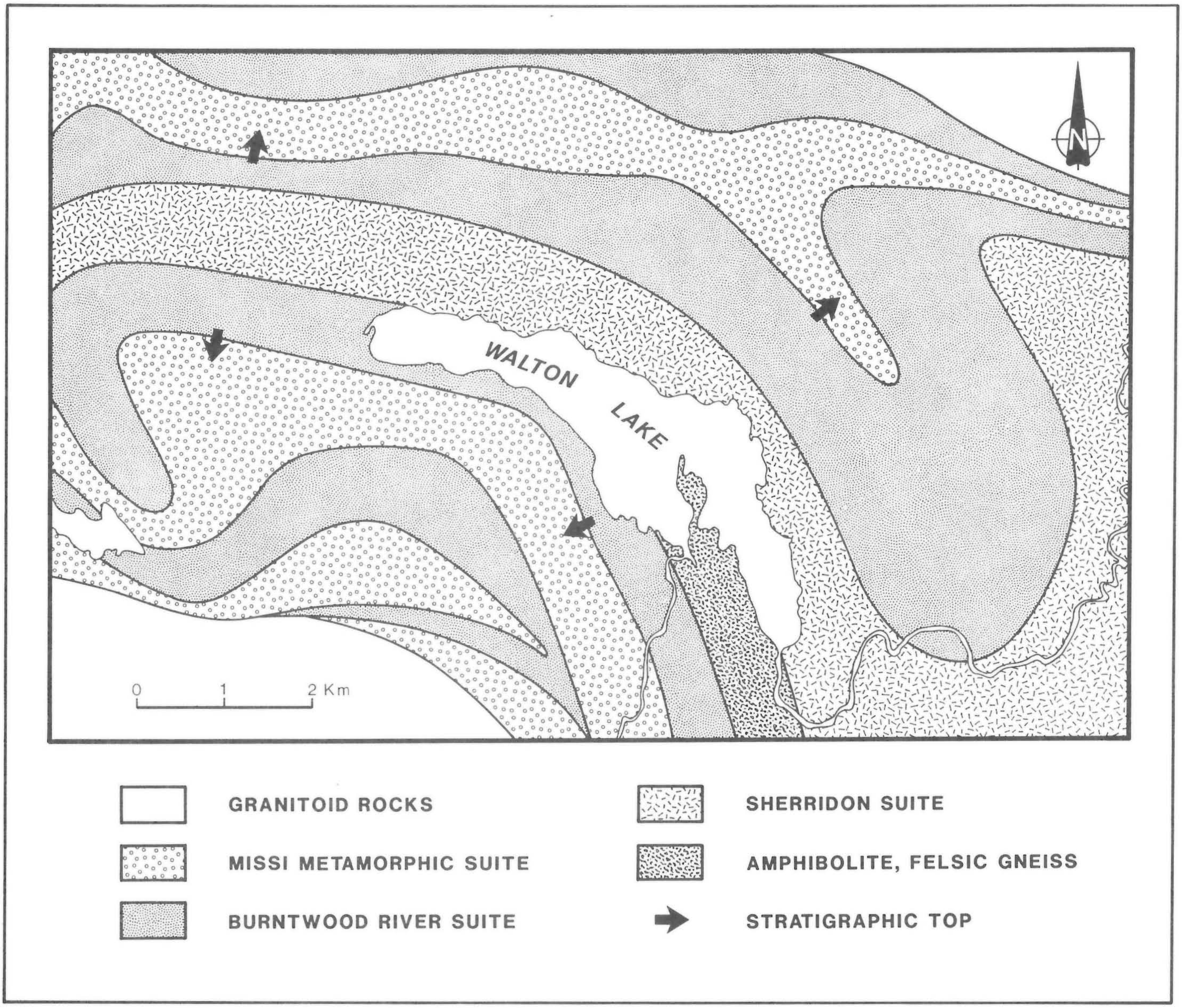

Figure GS-7-2: Simplified geology of the Walton Lake area and structural interpretation of the Sherridon suite as the core of an overturned anticline with Burntwood River metagreywacke in the limbs of the fold and younger Missi suite gneisses in adjacent synclines. Stratigraphic tops depend on regional lithologic correlations.

1984K-3) and at Evans Lake, west of the Drury Lakes dome (Preliminary Map 1988K-2). These late structures impart a complex geometry to gold-bearing units at both localities.

Mylonite and late crossfolds trend east-northeast at Puffy Lake (Zwanzig, 1984; Ostry, GS-14, this volume). These structures are parallel to the regional trend of the break between predominantly volcanic supracrustal rocks to the south and sedimentary gneisses to the north.

Lithology

Unit descriptions are given in Zwanzig and Lenton (1987). Additional data are summarized below. Unit numbers refer to Preliminary Map 1988K-2.

AMISK GROUP (1)

An area of well preserved volcanic rocks with only a weak foliation was mapped at Spider Lake. Aphyric and finely plagioclase-phyric basalts (1a) are generally present and basalt with deformed pillow selvages (1b) is locally preserved. Metadacite (1e) is intercalated with the basalt at Spider Lake. Some dacite layers contain 2 mm long plagioclase phenocrysts and elongate hornblende-biotite aggregates derived from mafic phenocrysts. These volcanic rocks extend northeast for 10 km to Evans Lake where they are strongly foliated.

BURNTWOOD RIVER METAGREYWACKE AND MIGMATITE (2)

A distinctive garnet-free, schistose variety of metagreywacke (2e), intruded by muscovite-bearing pegmatite and granite, extends from South Nokomis Lake to Evans Lake. The rock contains retrograde muscovite porphyroblasts and dismembered veins of quartz-rich mobilizate. Cores of garnet rimmed with retrograde biotite are locally preserved. The texture suggests that unit 2e was derived from unit 2a after the metamorphic peak. The atypical mineralogy of this unit appears to be the result of potassium metasomatism caused by associated intrusions.

ROCKS OF UNCERTAIN AGE (3)

Amphibolite, felsic gneiss and garnet-biotite gneiss forms a distinctive belt south of Batty Lake (Zwanzig and Lenton, 1987). They extend northwest to Walton Lake where they are locally interlayered with typical Sherridon gneiss. They are interpreted to lie stratigraphically below the Burntwood River Metagreywacke and are tentatively correlated with the Amisk Group. West of Ponton Lake similar rocks extend east into a belt of predominantly metabasalt mapped as Amisk Group in the Puffy Lake area.

SHERRIDON METAMORPHIC SUITE (4)

The Sherridon suite contains orthogneiss and paragneiss, but individual units have not been traced across the map area. The suite appears to be a structural succession rather than a stratigraphic sequence. Typical quartzofeldspathic gneiss (4a) at Star Lake is highly recrystallized and deformed. Flattened lenses of quartz, 1 mm to several centimetres thick, constitute up to 40% of the rock. Garnet occurs in porphyroblasts up to 1 or 2 cm in diameter and is commonly cut by quartz-filled tension gashes. The protolith of this rock is unknown. At Walton Lake and Meat Lake the garnetiferous gneiss (4i) contains up to 25% coarse biotite and may be a migmatitic equivalent of Burntwood River metagreywacke. South of Meat Lake the Sherridon suite is highly variable and contains units of amphibolite (4c), calc-silicate rock (4d) and fine grained felsic gneiss (4j) that may have had a volcanic protolith. Medium grained felsic gneiss is interpreted as metamorphosed tonalite. Garnet-rich units (4b) and garnet-cordierite-anthophyllite rock (4f) have been interpreted as alteration products (Zwanzig and Lenton, 1987).

MISSI METAMORPHIC SUITE (5)

The fine grained, magnetite-bearing quartzofeldspathic rocks of the Missi metamorphic suite (5a-5d) occur in six long, narrow, overturned synclines in the Batty Lake region. Stratigraphic details vary between adjacent folds. Metavolcanic rocks (5e,g) and metaconglomerate (5h) become increasingly important components in successive synclines towards the southwest and are absent in the northeast.

Basal Missi conglomerate (5f) exposed in the most southerly syncline unconformably overlies Amisk Group metavolcanic rocks. The unconformity is marked by abundant garnet porphyroblasts in a 1 m thick metamorphosed regolith north of Spider Lake. The basal conglomerate overlies amphibolite (unit 3) or metagreywacke (Burntwood River suite) on the north limb of the syncline. Similar complex stratigraphic relationships exist at the base of the Missi suite in the syncline that extends from Puffy Lake to Nokomis Lake.

Metavolcanic rocks form 3-100 m thick units in the southwestern synclines . Pink felsic gneiss (5e) is similar to units that have been interpreted as ignimbrites elsewhere (Gordon and Lemkow, 1987). Laterally extensive units of fine grained amphibolite with highly amygdaloidal zones (5g) are interpeted to be derived from subaerially erupted basalt. Mafic to intermediate rocks interpreted as metamorphosed tuff locally contain up to 2 cm long pseudomorphs after plagioclase phenocrysts. This unit is prominent in the syncline extending from Jungle Lake towards the southeast across the central part of the map area, to the vicinity of Dow Lake.

ORTHOGNEISS (6), GRANITIC ROCKS (7, 8)

A systematic transition from massive granodiorite and tonalite (7) to highly remobilized, sheared orthogneiss (6) is well displayed between Spider Lake and Limestone Point Lake. The change corresponds to increased deformation and recrystallization towards the northeast, across the map area. The examined portion of the pluton west of Spider Lake comprises weakly foliated, uniform granodiorite with a medium- to coarse-grained igneous texture. Thin sheets of younger granite (9) intrude the tonalite pluton east of Spider Lake. The same granite forms a mantle around the foliated tonalite dome between Evans Lake and Drury Lakes. Locally the granite makes up 50% of the interior of the dome. Tonalite and granodiorite in the Moody Lake dome are gneissic and locally contain garnet porphyroblasts. The associated granite gneiss contains local sillimanite or retrograde muscovite. The large granitoid body centred on Limestone Point Lake is medium- to fine-grained tonalite gneiss with accessory garnet and diffuse veins of granitoid mobilizate.

YOUNGER GRANITE ROCKS (11, 12, 14)

Tonalite plutons (11) at Guthrie and Derby lakes lie within highly deformed supracrustal rocks north of the orthogneiss units (6). The tonalite has regionally crosscutting contacts and is less deformed than unit 6. It is therefore considered to be younger (late kinematic).

Young, two-mica granite (12) and pegmatite (14) intrude the belt of retrogressed Burntwood River metagreywacke between Nokomis Lake and Evans Lake. The rocks postdate regional metamorphism.

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GS-8 CHISEL-MORGAN LAKES PROJECT

by Alan H. Bailes

INTRODUCTION

The Chisel-Morgan Lakes project entails 1:15 840 mapping of Early Proterozoic metavolcanic, metasedimentary and intrusive rocks at the east end of the Flin Flon metavolcanic belt. Six significant volcanogenic base-metal sulphide deposits, including the Chisel Lake and Ghost Lake mines, occur in the project area (Fig. GS-8-1). The objective of the mapping program is to provide an improved detailed geological data base for future mineral exploration in the project area and to better define the stratigraphic setting of known mineral deposits.

Most field mapping in the project area was completed during 1986 and 1987 field seasons (Bailes, 1986, 1987). A short field season in 1988 was undertaken to complete mapping of a small area north and east of Chisel Lake, to re-examine critical outcrops, and to collect samples for chemical analysis. Samples for zircon geochronology were collected from the Sneath Lake pluton (a previously collected sample proved unsuitable for dating) and the Bujarski Lake pluton. An age date from the Sneath Lake pluton will assist in establishing whether or not this intrusion is subvolcanic as suggested by Walford and Franklin (1982) and Bailes (1986, 1987). The Bujarski Lake pluton cuts late faults that postdate regional metamorphic and folding events. An age date from this pluton will, therefore, provide a lower age limit for the faults, regional metamorphism and folding.

Some of the more important outcomes of the 1988 field program are:

1. The presence of the F_1 Ghost Lake syncline (Fig. GS-8-1) north of Chisel Lake is confirmed. This has important implications as much of the stratigraphic section exposed on the north limb of the fold is very different from that exposed on its south limb.
2. The geology on Cook Lake has been modified such that a quartz-feldspar porphyry previously recognized only south of Cook Lake now is known to extend to the north end of Cook Lake. A zone of intense, base-metal related alteration underlying Cook Lake (Jackson, 1983) appears to overprint this quartz-feldspar porphyry.
3. An altered fault 0.75 km east-southeast of Snell Lake has been identified. This fault is likely synvolcanic and was probably a conduit for hydrothermal solutions.
4. Altered rocks on the east shore of Cook Lake, previously included in the Richard Lake pluton, are now known to be older than and intruded by the pluton. This means that the only significant zone of alteration in the pluton is on the east shore of Richard Lake.

Preliminary examination of 112 chemical analyses of rocks from the Chisel-Morgan Lake area indicates that:

1. Mafic volcanic rocks have arc tholeiite trace element characteristics and are similar in overall chemistry to major basalt and basaltic andesite sequences of the Flin Flon-White Lake area (Syme, 1988; Bailes and Syme, in prep.).
2. Dacite tuff and lapilli tuff in the immediate stratigraphic footwall of the Chisel-Lost-Ghost base metal zone have a distinctive fractionated trace and REE pattern which will assist in recognizing this economically important marker unit elsewhere.
3. The Richard Lake pluton has a distinctly different chemical signature than the Sneath Lake pluton and, therefore, they are not related.

SUPRACRUSTAL ROCKS

CHISEL STRUCTURAL BASIN

The Chisel structural basin, located between Chisel Lake and Ghost Lake, is formed by interference of two major folds, the northwest-trending F_1 Ghost Lake syncline and an unnamed north-northwest-trending syncline (Fig. GS-8-1; Bailes, 1988: Preliminary Map 1988S-1). The core of the structural basin is occupied by mafic tuff and lapilli tuff, with minor associated pillowed and massive flows. These rocks, informally referred to as the Chisel basin sequence (Table GS-8-1), are all strongly plagioclase and plagioclase-pyroxene-phyric. Massive flows in this unit are virtually impossible to distinguish from associated bodies of plagioclase and plagioclase-pyroxene-phyric gabbro, an observation also made by Williams (1966). Vertical diamond drill holes in the centre of the structural basin encounter up to 600 m of the Chisel basin mafic pyroclastic sequence before intersecting the Chisel-Lost-Ghost zone and underlying hydrothermally altered footwall rocks (G. Kitzler, pers. comm. 1988). Since the Chisel basin mafic pyroclastic rocks are not altered it is clear that the hydrothermal alteration and associated massive sulphide deposits are synvolcanic.

Chisel-Lost-Ghost base metal mineralization occurs just below the Chisel basin mafic tuff and lapilli tuff on the south side of the structural basin. It is logical to assume that similar mineralization may be found at this stratigraphic position elsewhere in the Chisel basin structure and in other structural basins. Attitudes of bedding in the Chisel structure indicate its centre is located approximately 1400 m north-northeast of the Chisel Mine headframe. This suggests that, at this locality, maximum depths to base metal mineralization are encountered and that sulphide lenses are near-horizontal.

Froese and Moore (1980) and Gale and Koo (1977) have suggested that mafic tuff and lapilli tuff (Threehouse basalt of Walford and Franklin, 1982), which occur 250 m stratigraphically above the Anderson Cu-Zn sulphide deposit, may be equivalent to the Chisel basin mafic tuff and lapilli tuff. Examination of outcrops of this unit in 1988, north of the Anderson deposit and on Threehouse Lake, supports such a correlation. On Threehouse Lake this correlation is further strengthened by the occurrence of a distinctive underlying unit of plagioclase-phyric dacite tuffs that is identical to dacite tuffs that underlie the Chisel-Lost-Ghost base metal zone south of Chisel Lake. The base of the "Threehouse basalt" is therefore, as was pointed out by Gale and Koo (1977), a promising exploration target for base metal sulphide mineralization of the Chisel-Lost-Ghost type.

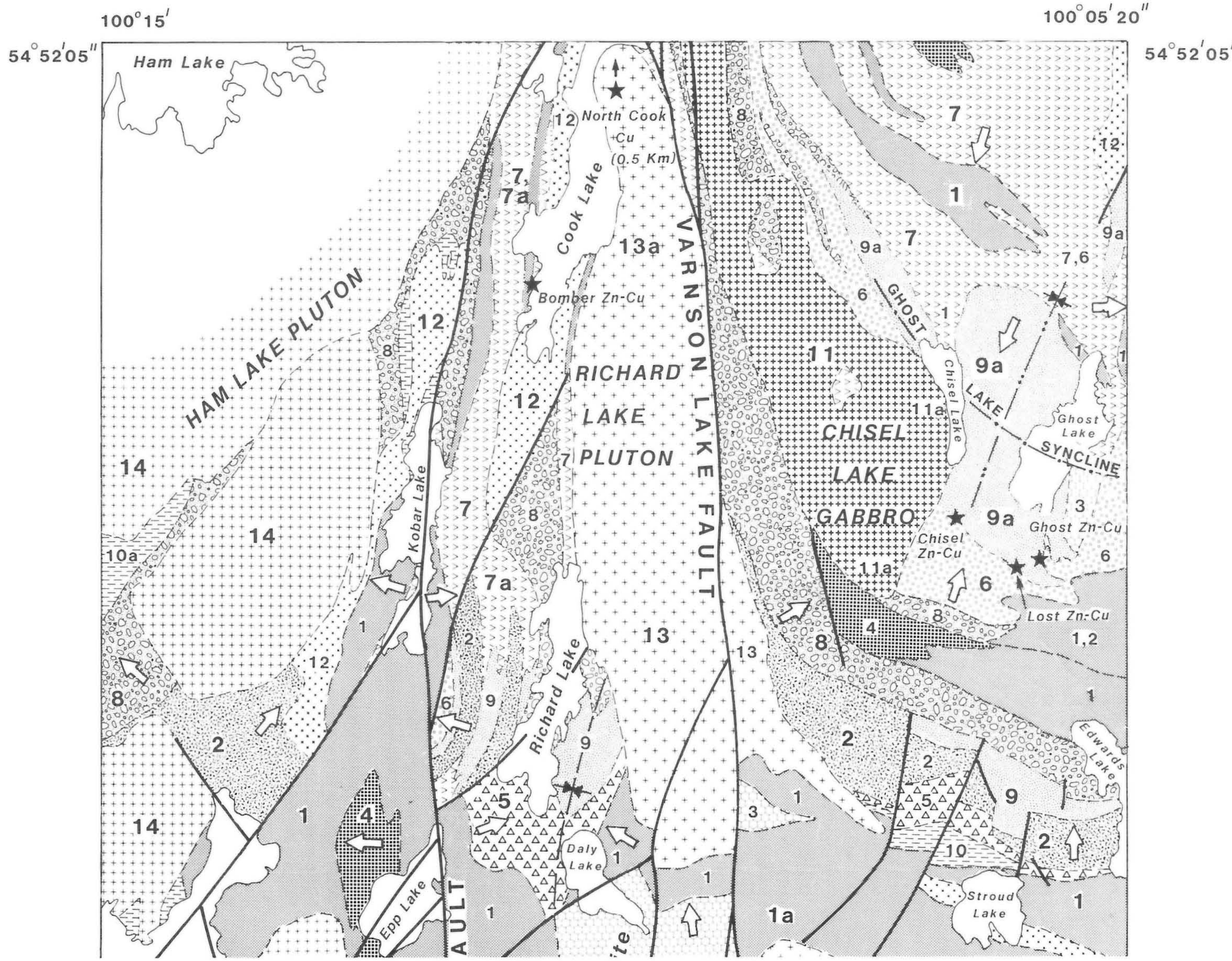
NORTHEAST LIMB OF GHOST LAKE SYNCLINE

Supracrustal rocks north of the Chisel basin sequence, on the northeast limb of the Ghost Lake syncline, are distinctly different from those that occur south of the Chisel basin sequence, on the south limb of the syncline. They are predominantly aphyric and sparsely quartz or placioclase-phyric felsic recrystallized rocks. Some of these resemble the plagioclase-phyric dacite south of Lost Lake, whereas others correlate directly with and are recrystallized equivalents of the Ghost Lake rhyolite. As felsic metavolcanic rocks are rare in the sequence south of Chisel Lake, this suggests a dramatic stratigraphic thickening of the felsic sequence north of Chisel Lake.

Locally, felsic recrystallized rocks north of Chisel Lake and Ghost Lake contain 2-3%, 5-20 mm quartz amygdales (unit 9d, Preliminary Map 1988S-1). In some instances this simply indicates that these rocks are recystallized felsic flow rocks. However, east and north of Ghost Lake enclaves of coarsely quartz amygdaloidal mafic flows display gradational contacts with these quartz amygdaloidal felsic rocks, with the latter clearly formed by alteration of the mafic flows. It is not possible at this time to say whether this type of alteration of mafic flows is volumetrically significant and whether, for example, widespread alteration of mafic rocks might be responsible for the high proportion of rocks with felsic composition north of Chisel Lake.

WOOSEY AND MORGAN LAKES

A massive Zn-rich volcanogenic base metal sulphide zone, the Morgan Lake deposit (Fig. GS-8-1), occurs within a mafic heterolithic breccia sequence at the south end of Morgan Lake. To the west, and up-section,


100°15′
100°05′20″
54°52′05″
54°52′05″
Ham Lake
HAM LAKE PLUTON
North Cook Cu (0.5 Km)
Cook Lake
Bomber Zn-Cu
RICHARD LAKE PLUTON
VARNSON LAKE FAULT
CHISEL LAKE GABBRO
GHOST LAKE SYNCLINE
Chisel Lake
Ghost Lake
Ghost Zn-Cu
Chisel Zn-Cu
Lost Zn-Cu
Kobar Lake
Richard Lake
Daly Lake
Epp Lake
Edwards Lake
Stroud Lake
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ite

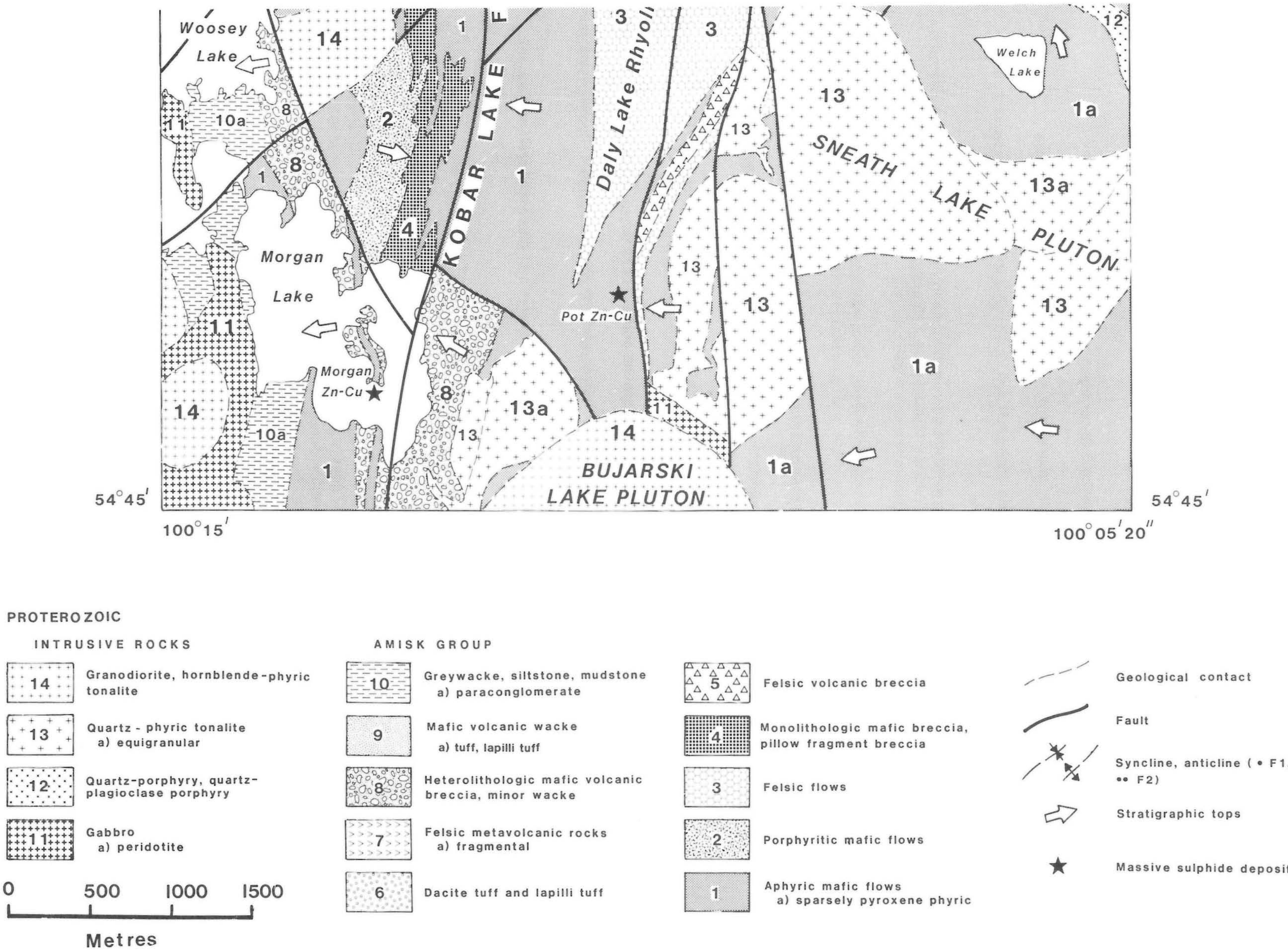

Figure GS-8-1: Simplified geology of the Chisel-Morgan Lakes area.

TABLE GS-8-1
STRATIGRAPHY OF THE SOUTH CHISEL LAKE SECTION

Thickness (metres)	Unit No. (Preliminary Map 1988S-1)	Lithology (Names of units are informal)
(Ghost Lake syncline)		
400	10	**Chisel basin mafic tuff, tuff breccia, lapilli tuff and wacke**, minor pillowed porphyritic basalt flows; well stratified with turbidite bedforms and local accretionary lapilli
0-150	1	**Aphyric basalt flows**, mainly massive
0-30		**Massive Zn-Cu sulphides** (Chisel-Lost-Ghost zone)
0-100	7	**Ghost Lake aphyric and sparsely quartz- and plagioclase-phyric rhyolite flows**
100-250	13, 16b	**Powderhouse plagioclase-phyric dacite tuff and lapilli tuff**, minor stratified heterolithic breccia and wacke
400-600	1, 1b, 3, 15	**Moore Lake basalt and basaltic andesite flows and amoeboid pillow breccia**, characterized by high vesicularity and radial pipe vesicles; includes minor plagioclase-phyric mafic flows and intercalated monolithologic and heterolithologic mafic beccia
250	16a	**Edwards Lake heterolithologic volcanic breccia**, minor intercalated mafic wacke; stratified with 1 to more than 35 m thick beds; includes mafic and felsic debris with mafic detritus more prominent
0-400	12a	**Edwards Lake mafic volcanic wacke** and minor breccia
200-500	3, 4	**Snell Lake plagioclase- and plagioclase-pyroxene-phyric massive and pillowed basalt and basaltic andesite flows**; flows are up to 100 m thick
100-600	14, 17	**Stroud Lake stratified heterolithic and monolithic felsic breccia and wacke** with intercalated units of intermediate to mafic greywacke, siltstone and mudstone, local strong gossan zones
300-1000*	1	**Welch Lake aphyric pillowed basaltic and andesite and andesite flows**, locally strongly silicified
0-750*	7	**Daly Lake quartz-phyric, quartz-plagioclase-phyric and aphyric subaqueous rhyolite flows,** minor breccia
3300	2	**Welch Lake aphyric and sparsely pyroxene-phyric massive and pillowed basalt and basaltic andesite flows**, minor strongly porphyritic flows
(Limit of Mapping)		

*Includes portions of these units exposed south and southwest of Daly Lake

the Morgan Lake deposit is overlain by approximately 300 m of the heterolithic mafic breccia, approximately 300 m of aphyric mafic flows and topped by paraconglomerate with minor greywacke and mudstone of the Parisian Formation (Bailes, 1988b: Preliminary Map 1988S-1). Mapping completed in 1988 allows this package of rocks, characterized by the lower unit of heterolithologic mafic breccia and the upper unit of Parisian Formation paraconglomerate, to be traced with minor fault offset to the north onto southeast Woosey Lake and finally to Parisian Creek. In the Parisian Creek area these rocks are extensively altered making this succession, between Morgan Lake and Parisian Creek, an attractive target to explore for base metal sulphide mineralization.

SYNVOLCANIC FAULT

One of the more interesting discoveries in 1988 was identification of a possible synvolcanic faults 0.75 km east southeast of Snell Lake. The fault is a north-northwest-trending structure that truncates a diorite intrusion and juxtaposes highly altered monolithologic mafic breccias to the east against less altered heterolithologic breccia to the west. The diorite intrusion is characterized by 10-15% garnet porphyroblasts in a zone up to 30 m wide adjacent to the fault and by 10-50 cm wide north-trending zones composed entirely of chlorite and garnet close to the fault. The monolithologic mafic breccias are strongly altered up to 50 m east of the fault. The alteration in the mafic breccias is zoned from east to west (i.e. going towards the fault) on one outcrop as follows:

- 35 m of mottled "silification" (Fig. GS-8-2) that increases in intensity to the west.
- 10 m of completely "silicified" rocks composed of 45% plagioclase, 40% quartz, 7-8% garnet, 2% magnetite, 3-4% biotite and 1-2% chlorite. The contact between this zone and the previous zone of mottled "silicification" is gradational over 3-4 m.
- 3-4 m of staurolite-porphyroblastic rocks directly adjacent to the fault that are composed of 5-10%, 5-20 mm staurolite porphyroblasts, 5% garnet, 5% chlorite, 5% biotite, 50-60% quartz and 20-25% feldspar.

The fault can be traced along strike in outcrop for 400 m. To the north it is covered by a large swampy area formerly occupied by the now drained

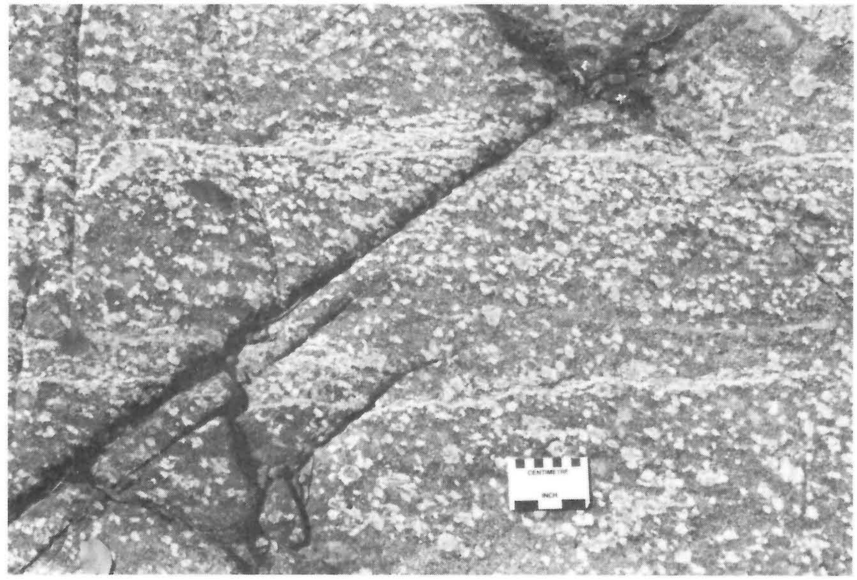

Figure GS-8-2: Orbicular quartz-feldspar alteration domains (white) in a mafic volcanic wacke 50 m east of a hydrothermally altered north-northeast-trending synvolcanic fault. Intensity of alteration increases towards fault.

Tent Lake. If this fault is synvolcanic, as hypothesized, and was a conduit for hydrothermal solutions, as evidenced by extensive alteration of adjacent rocks, then the area to the north (up-section) represents an excellent base metal exploration target.

GEOCHEMISTRY

In 1988, 112 whole rock chemical analyses were made of volcanic rocks, intrusive rocks and altered rocks from the Chisel-Morgan Lakes area. Average whole rock chemical analyses of major volcanic units from the south Chisel section (Table GS-8-1) are given in Table GS-8-2 along with averages of selected intrusions. Trace elements and rare earth elements have also been analyzed for selected units, but are not included in Table GS-8-2.

Mafic volcanic rocks display tholeiitic chemistry (Fig. GS-8-3) and show trace element characteristics comparable to Cenozoic arc lavas (Fig. GS-8-4 and GS-8-5). They are similar to the prominent basalt and basaltic andesite sequences at Flin Flon (Syme, 1988) and like the latter have low Zr contents (Fig. GS-8-4). MORB normalized trace element data (Fig. GS-8-5) show the mafic flows to be enriched in LIL elements (Rb, Ba, K. Th, Sr) and moderately to strongly depleted in HFS elements (P, Hf, Zr, Ti, Y), a feature characteristic of subduction related magmas (Saunders et al., 1980; Gill, 1981; Tarney et al., 1981). Mafic volcanic rocks, with the exception of the Moore Lake basalt, all display moderate to low REE contents with flat chondrite normalized patterns (Fig. GS-8-6).

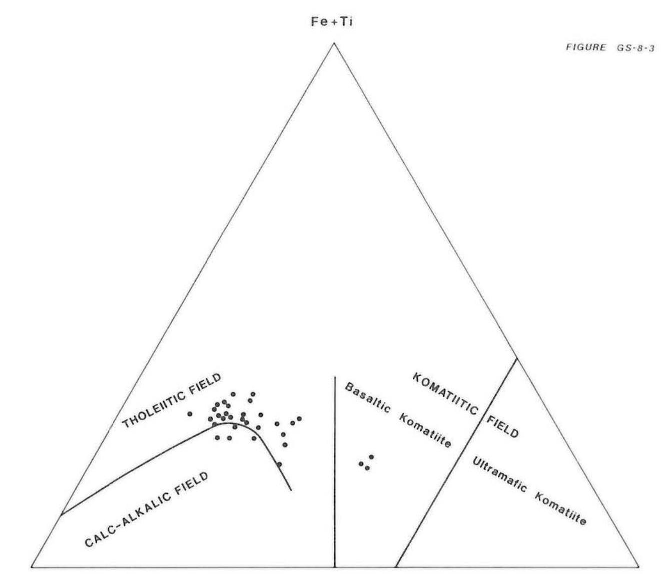

Figure GS-8-3: Chemical variation of Amisk Group basalt and basaltic andesite from Chisel-Morgan Lakes area on Jensen (1976) cation plot.

The Moore Lake basalt is distinctly different from other mafic flow units in the project area as it has high incompatible and elevated light REE abundances (Fig. GS-8-5 and -6). Combined with low Ni and Cr this identifies these rocks as fractionated. The overlying Powderhouse dacite and Ghost Lake rhyolite also display strong enrichment in thorium and uranium, and light REE (Fig. GS-8-7) indicating they too are fractionated. Based on a very preliminary examination of chemical analyses, it would appear that the Chisel-Lost-Ghost Lake base metal mineralized zone is underlain by a chemically distinct fractionated mafic to felsic sequence. The distinctive chemistry of these units should prove useful in identifying this sequence elsewhere in the Snow Lake area.

In addition to chemically characterizing supracrustal volcanic rocks, a further objective of chemically analyzing rocks is to distinguish different intrusive rocks on the basis of their trace and rare earth element contents with a view to identifying potential synvolcanic equivalents of supracrustal units. For example, Skirrow (1987) and Bailes (1987) suggested that dacite dykes in the Edwards Lake area were intrusive equivalents of the Powderhouse dacite tuff. The strong similarity of their REE patterns (Fig. GS-8-7 and -8) supports this conclusion. A surprising result arising from trace and REE analyses of intrusive rocks is the distinctly different character of the Richard and Sneath Lake plutons, despite similar major element chemistry (Table GS-8-2). These plutons are both interpreted to be synvolcanic and were expected to be similar in chemistry. However, the Richard Lake pluton, which has a syn-Amisk U-Pb zircon age of 1889 + 9/-6 Ma (Bailes et al., 1988), displays enrichment in U, Th and light REE (Fig. GS-8-8) whereas the Sneath Lake pluton displays low to moderate U, Th and REE abundances.

ECONOMIC GEOLOGY

An important objective of the Chisel-Morgan Lakes project is to establish the stratigraphy of the Amisk Group metavolcanic rocks and place volcanogenic base metal mineralization in this stratigraphic framework. In 1988, several important steps towards this objective were made:

TABLE GS-8-2
AVERAGE COMPOSITIONS OF REPRESENTATIVE METAVOLCANIC AND INTRUSIVE ROCKS, CHISEL-MORGAN LAKES AREA

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SiO_2%	54.7	54.1	57.60	53.77	54.2	51.5	48.8	53.1	50.9	72.37	74.25	70.76	73.7	68.45	71.94	74.85
Al_2O_3	15.39	16.0	14.90	15.59	14.70	16.37	14.21	16.68	17.01	12.80	13.48	13.11	12.78	13.47	13.01	12.06
Fe_2O_3	2.03	2.21	2.21	2.10	1.80	1.58	2.51	2.07	2.87	1.13	0.54	1.07	1.07	1.13	1.20	0.69
FeO	8.50	8.61	8.88	10.08	11.02	11.05	11.29	10.21	8.63	2.74	1.82	4.14	2.43	4.76	3.05	3.10
MgO	5.63	5.15	3.78	4.78	4.82	5.30	8.20	3.95	3.71	1.00	0.38	1.39	0.70	1.19	1.28	0.38
CaO	8.02	9.03	7.20	8.52	6.84	8.00	10.01	8.68	11.72	2.28	1.98	1.92	2.81	4.84	2.95	1.89
Na_2O	3.14	2.77	2.43	2.70	2.98	3.22	2.62	2.72	1.46	3.60	5.10	4.66	4.51	3.69	3.88	4.76
K_2O	0.27	0.28	0.40	0.34	0.29	0.13	0.15	0.49	0.26	1.91	0.86	1.10	0.51	0.39	0.92	0.73
MnO	0.15	0.17	0.16	0.19	0.29	0.21	0.25	0.22	0.20	0.06	0.06	0.11	0.05	0.09	0.07	0.08
TiO_2	0.55	0.55	0.71	0.48	0.82	0.51	0.38	0.56	0.51	0.33	0.19	0.37	0.27	0.55	0.25	0.20
P_2O_5	0.07	0.06	0.07	0.07	0.55	0.13	0.04	0.14	0.05	0.10	0.05	0.10	0.12	0.20	0.05	0.05
H_2O	1.13	0.99	1.05	1.05	1.10	1.09	1.41	0.86	1.27	0.73	0.48	0.68	0.40	0.50	0.73	0.39
S	0.01	0.01	0.01	0.00	0.00	0.23	0.01	0.00	0.07	0.00	0.04	0.02	0.01	0.01	0.02	0.00
CO_2	0.11	0.06	0.08	0.09	0.05	0.07	0.06	0.19	0.86	0.33	0.23	0.14	0.17	0.30	0.29	0.28
Other	0.07	0.06	0.06	0.06	0.11	0.05	0.07	0.05	0.11	0.05	0.06	0.08	0.04	0.05	0.05	0.05
Rb ppm	3	3	10	6	9	4	0	2	2	26	15	19	12	15	9	13
Ba	80	60	133	98	201	25	21	66	215	226	199	396	56	77	200	186
Sr	143	148	166	181	283	106	67	269	414	77	130	110	82	207	128	161
Ni	26	18	8	12	9	9	29	8	14	0	0	2	0	0	0	0
Cr	99	88	0	52	38	10	213	25	26	0	0	2	0	0	0	0
N	8	4	4	7	3	1	1	3	2	3	2	5	2	4	5	2

1. Welch Lake aphyric to sparsely pyroxene phyric basalt and basaltic andesite[1]
2. Welch Lake moderately to strongly pyroxene and pyroxene-plagioclase phyric basalt and basaltic andesite
3. Welch Lake aphyric basaltic andesite and andesite
4. Snell Lake basalt and basaltic andesite
5. Moore Lake basalt and basaltic andesite
6. Aphyric basalt directly overlying Chisel-Lost-Ghost zone
7. Chisel basin basalt
8. Edwards Lake mafic volcanic wacke
9. Chisel basin mafic tuff
10. Daly Lake rhyolite
11. Rhyolite fragments from Stroud Lake felsic breccia
12. Powerhouse dacite tuff
13. Ghost Lake rhyolite
14. Dacite dykes (probable subvolcanic equivalent of Powerhouse dacite tuff)
15. Sneath Lake tonalite
16. Richard Lake pluton

[1]Formation names are informal.

1. The Moore Lake basalt, Powderhouse dacite and Ghost Lake rhyolite, which underlie the Chisel-Lost-Ghost base metal mineralized zone, are now known to be from fractionated magmas with elevated dispersed trace element contents and distinctive light REE enrichment. These features will permit identification of this important sequence elsewhere in the Snow Lake area.
2. A lateral facies change is recognized in the Moore Lake basalt from flows in the east to more distal breccias in the west. Westerly thinning of the Ghost Lake rhyolite indicates a similar proximal to distal facies relationship and, together, this suggests that the volcanic centre responsible for the Moore, Powderhouse and Ghost formations is probably east of the map area. A corollary of this is that proximal volcanogenic base metal mineralization may also be located in that direction.
3. The Chisel basin mafic pyroclastic sequence, which overlies the Chisel-Lost-Ghost base metal mineralized zone, appears to correlate with mafic pyroclastic rocks belonging to the Threehouse basalt unit (Froese and Moore, 1980; Walford and Franklin, 1982). As indicated by Gale and Koo (1977), this indicates that the base of the Threehouse basalt sequence is a promising exploration target for base metal-rich sulphide mineralization.
4. Heterolithologic mafic breccia, hosting the Morgan Lake Zn-Cu massive sulphide deposit, can now be traced from Morgan Lake to Woosey Lake to Parisian Creek. Extensive hydrothermal alteration of this sequence at Parisian Creek (Preliminary Map 1988S-1) suggests they are an attractive base metal exploration target.
5. U-Pb zircon geochronology of the Richard Lake pluton (Bailes et al., 1988) yields an age of 1889 + 9/6- Ma and provides the first direct evidence supporting the widely held view that heat for hydrothermal alteration and base metal mineralization was supplied by major synvolcanic felsic plutons. The Richard Lake pluton displays the same U, Th and light REE enrichment as is displayed by the Powderhouse dacite.

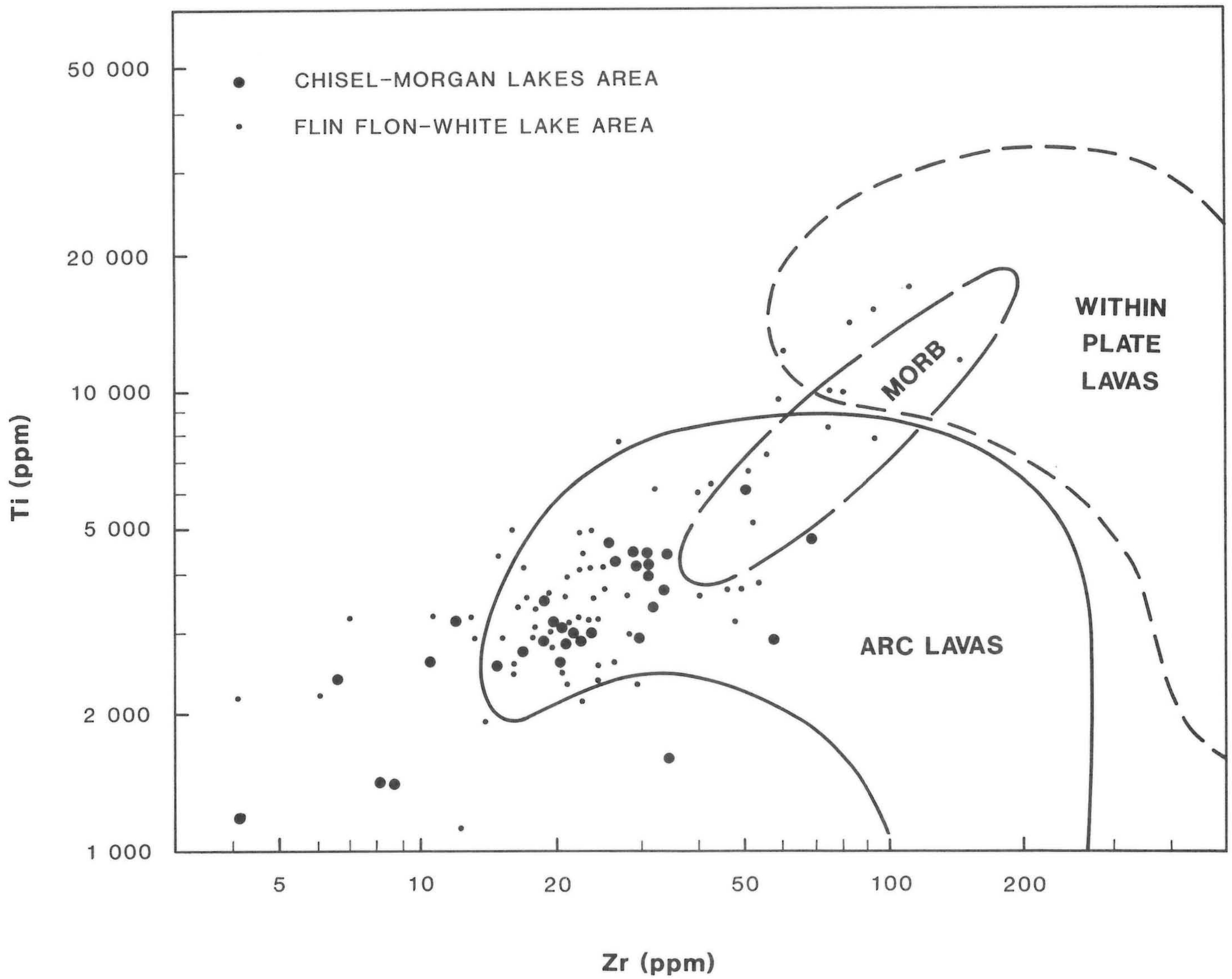

Figure GS-8-4: *Ti vs. Zr, Amisk Group basalt and basaltic andesite from Chisel-Morgan and Flin Flon-White Lake area. Fields of arc lavas, within plate lavas and MORB from Pearce et al., (1981). Low Zr content characterizes Amisk Group basalt and basaltic andesite.*

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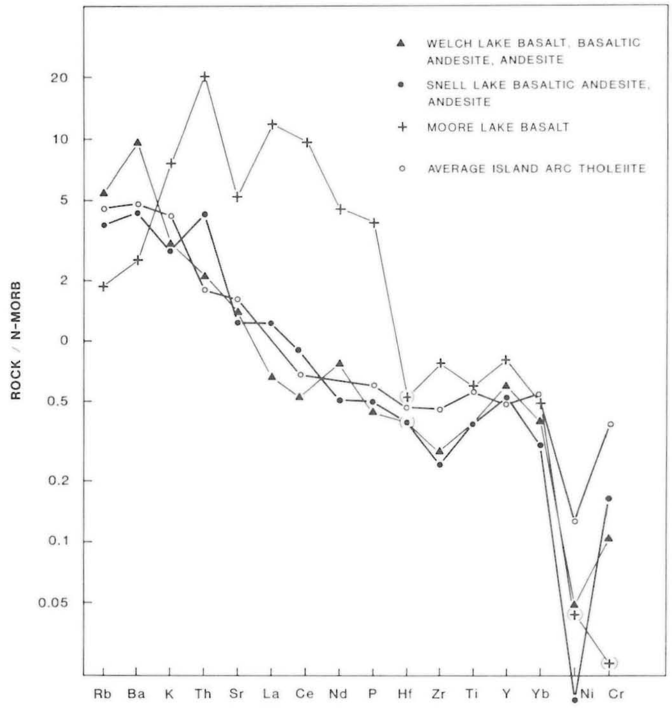

Figure GS-8-5: MORB normalized trace element patterns for representative Amisk Group basalt and basaltic andesites, with average island arc tholeiite (Pearse, 1982) for comparison. N-MORB normalizing values are from Saunders and Tarney (1984).

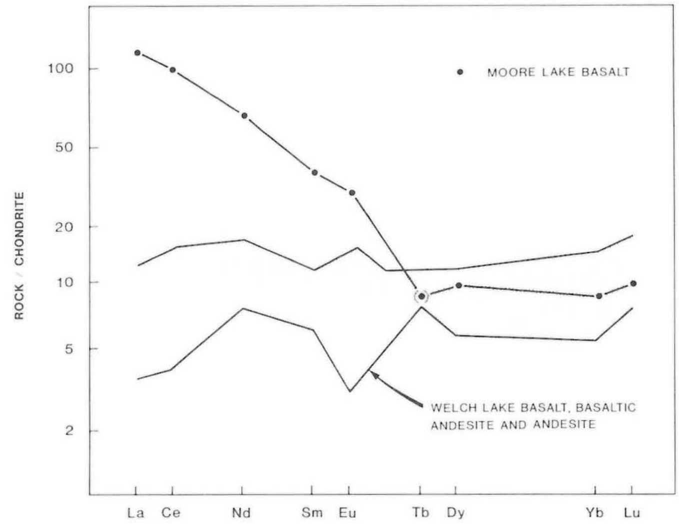

Figure GS-8-6: Chondrite normalized REE plots showing light REE enriched character of Moore Lake basalt compared to more typical flat pattern of Amisk mafic flows depicted by Welch Lake basalt, basaltic andesite and andesite. Normalizing values are those of Sun and Nesbitt (1978).

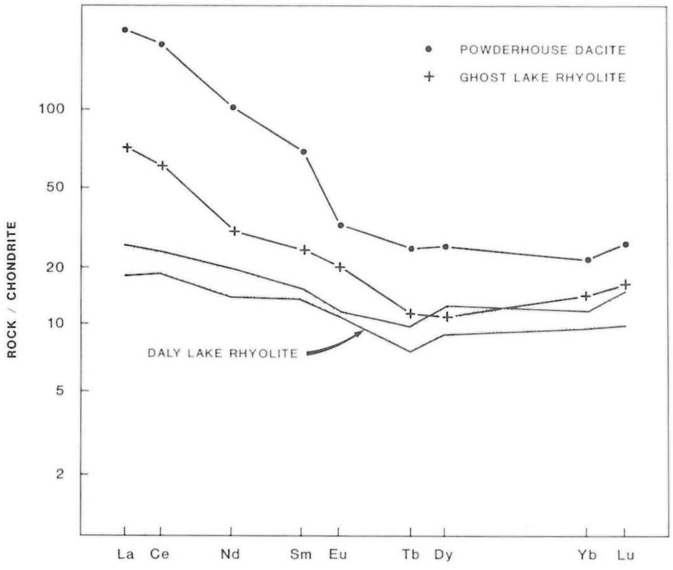

Figure GS-8-7: Chondrite normalized REE plots showing light REE enriched character of the Powderhouse dacite and Ghost Lake rhyolite compared to more typical slightly concave pattern of Amisk felsic flows depicted by Daly Lake rhyolite.

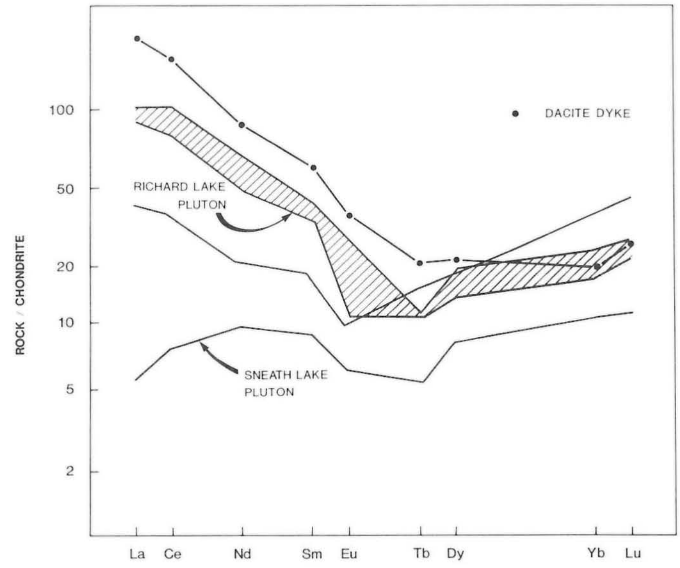

Figure GS-8-8: Chondrite normalized REE plots showing different character of Sneath Lake and Richard Lake tonalite plutons. The Richard Lake pluton is enriched in light REE. The dacite dyke has an identical REE pattern as the Powderhouse dacite and is believed to be a subvolcanic equivalent.

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GS-9 PROJECT CORMORANT: SUB-PALEOZOIC INVESTIGATIONS SOUTH OF FLIN FLON-SNOW LAKE

by W. Weber

During a winter drilling program on contract from the Geological Survey of Canada four holes were completed into the Precambrian in the southeastern corner of the project area. Results are described by J. Dugal (this volume). That paper also discusses the status of the gradiometer map series covering the project area.

Two additional vertical holes were completed by the Branch this summer in the southeastern part of the project area (see J. Dugal, this volume, for location) through 96 to 111 m of Paleozoic rocks (Table GS-9-1). Hole-9-88 is similar to several other holes in the southern part of 63K (e.g. Holes #59, 62, 65, 74, Weber and Hosain, 1987) intersecting amphibolite (metavolcanic?) granitized to a variable degree. Hole M-10-88 intersected aluminous supracrustal gneiss which may represent a sequence of hydrothermally altered mafic metavolcanic rocks. The goal and main results of Project Cormorant as of 1987 were published recently in Geoscience Canada (Blair et al., 1988).

TABLE GS-9-1 PROJECT CORMORANT PRECAMBRIAN DRILL CORE, SUMMER 1988

M-9-88

Intervals in metres	Lithologies
96.55 - 99.70	kaolinite
99.70 - 101.30	weathered felsic and mafic gneiss
101.30 - 117.90	biotite-bearing amphibolite and tonalite with
103.62 - 105.00)	
106.30 - 107.70)	pink granite
109.65 - 111.90)	
113.75 - 116.90)	

M-10-88

Intervals in metres	Lithologies
111.60 - 112.0	kaolinite
112.00 - 113.0	weathered biotite gneiss
113.00 - 115.35	intermediate-felsic biotite-garnet gneiss
115.35 - 117.90	hornblende-biotite gneiss to amphibolite
117.90 - 119.70	biotite ± hornblende gneiss, medium grained, garnet-bearing
119.70 - 128.60	garnet-porphyroblastic biotite gneiss, coarse grained
128.60 - 130.55	garnet-porphyroblastic, sillimanite-biotite gneiss, coarse grained
130.55 - 131.10	biotite hornblendite, medium- to coarse grained
131.10 - 134.26	garnet-porphyroblastic, sillimanite-biotite gneiss, coarse grained

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GS-10 U-Pb ZIRCON GEOCHRONOLOGY OF THE RICHARD LAKE TONALITE, A POSSIBLE SYNVOLCANIC PLUTON IN THE SNOW LAKE AREA

by A.H. Bailes, T.M. Gordon[1] and P.A. Hunt[2]

It has been suggested that the Richard Lake and Sneath Lake plutons (Fig. GS-10-1) are synvolcanic and were the "heat engine" that drove the hydrothermal system responsible for base metal volcanogenic sulphide deposits and associated alteration in the Snow Lake area (Walford and Franklin, 1982; Bailes, 1986, 1987a, 1987b; Bailes, et al., 1987). A U-Pb zircon geochronology program was begun in 1986 to date Amisk Group rhyolite units and potential synvolcanic plutons to test the validity of this hypothesis. The investigation has been hampered by absence of zircon in many of the submitted samples, a problem also encountered in dating Amisk Group rocks and associated plutons farther west (Syme et al., 1987). This report includes the first successful age determination of one of the possible synvolcanic plutons, the Richard Lake tonalite.

GEOLOGICAL SETTING

Early Proterozoic supracrustal rocks in the Flin Flon-Snow Lake area include both Amisk Group metavolcanic and minor metasedimentary rocks, and unconformably overlying Missi Group metaconglomerate and metasandstone (Bailes and Syme, 1987). An Amisk Group rhyolite crystal tuff from the Flin Flon area gives a U-Pb zircon age of 1886 $\pm$ 1.3 Ma (Syme et al., 1987). A rhyolite flow from the Missi Group east of Wekusko Lake gives a U-Pb zircon age of 1832 $\pm$ 2 Ma (Gordon et al., 1988). Felsic plutons in the Flin Flon-Snow Lake area typically give post-Amisk U-Pb zircon ages ranging from 1847 to 1820 Ma (Syme et al., 1987; Gordon et al., 1988) with several felsic plutons in the Snow Lake area being contemporaneous, within analytical error, with the Missi Group rhyolite flow east of Wekusko Lake.

Amisk group volcanic rocks in the Snow Lake area are extensively altered (Harrison, 1949; Bailes, 1986, 1987b). The alteration is attributed to a large-scale hydrothermal system that was active during formation of volcanogenic base metal sulphide deposits (Walford and Franklin, 1982; Bailes, 1986, 1987b). Walford and Franklin (1982) proposed that the heat source for the hydrothermal system was a large semiconformable tonalite body that underlaid the hydrothermally altered rocks and the base metal sulphide deposits. The semiconformable tonalite body is now known to comprise at least two chemically distinct intrusions (the Sneath Lake tonalite and the Richard Lake tonalite), to be multicomponent (the Sneath Lake tonalite consists of several distinct plugs with crosscutting relations), and to locally crosscut supracrustal stratigraphy at a high angle. Nevertheless, the Walford and Franklin idea, that these intrusions are synvolcanic and a heat source for hydrothermal activity, remains viable.

RICHARD LAKE PLUTON

The Richard Lake pluton (Fig. GS-10-1) is a foliated tonalite stock 1.7 x 7.3 km hosted by Amisk Group volcanic rocks. It has no thermal contact aureole. The pluton cuts across two poorly defined northeast-trending faults, on its west margin, and is cut by the late, north-trending Kobar Lake fault. The tonalite is locally cut by zones of Fe-Mg metasomatism that follow fractures (Fig. GS-10-2). This alteration, which resembles the widespread hydrothermal alteration associated with base metal mineralization in the Amisk Group volcanic rocks at Snow Lake, is most prominent on the east shore of Richard Lake (Preliminary Map 1988S-1, Bailes, 1988a, b).

The pluton varies from quartz-megacrystic medium grained tonalite in the south to a fine grained equigranular rock in the north. The tonalite displays light REE enrichment which is distinctly different than the flatter REE chrondrite-normalized pattern displayed by the Sneath Lake pluton (Fig. GS-10-3) but similar to that displayed by a package of dacite tuff (Powderhouse dacite, Bailes, 1988a) that forms the footwall to the Chisel and Ghost base metal mines.

The sample dated by the U-Pb zircon techniques comes from the narrow apophysis trending southeast of the pluton (Fig.GS-10-1). It yields an age of 1889 +8/-6 Ma (Fig. GS-10-4).

DISCUSSION

There are no U-Pb age determinations from Amisk volcanic rocks of the Snow Lake area and only one from the Flin Flon area. When compared to the 1886 Ma age of Amisk Group volcanism at Flin Flon, the Richard Lake pluton is most logically interpreted as synvolcanic.

A number of relationships that were previously noted as potentially inconsistent with a synvolcanic age for the Richard Lake pluton (Bailes, 1987) now need explanation in light of its 1889 Ma age. For example, north-northeast fold structures at Richard Lake appear to be truncated at the margin of the pluton, a feature which must now be reconciled with a synvolcanic age for the pluton. The most reasonable explanation is that the truncation of folds at the pluton margin must be a consequence of ductility contrast during deformation between the supracrustal rocks (folded) and the more rigid tonalite pluton (not folded). The other feature that requires explanation is truncation of portions of the Chisel-Lost-Ghost footwall alteration zone by the Richard Lake stock. One explanation is that the Richard Lake pluton was the heat source for the Chisel-Lost-Ghost hydrothermal system but simply continued to intrude after the hydrothermal system had collapsed, and therefore partly invaded the altered rocks.

The importance of the U-Pb zircon age for the Richard Lake pluton lies in the fact that it is the first direct evidence which supports the widely held view that hydrothermal alteration in the Snow Lake area was driven by major synvolcanic felsic plutons. U-Pb dates are now needed on the Sneath Lake pluton and on Amisk Group volcanic rocks at Snow Lake to test whether the Sneath Lake pluton is also synvolcanic and to establish that volcanism in the Snow Lake area is the same age as that at Flin Flon.

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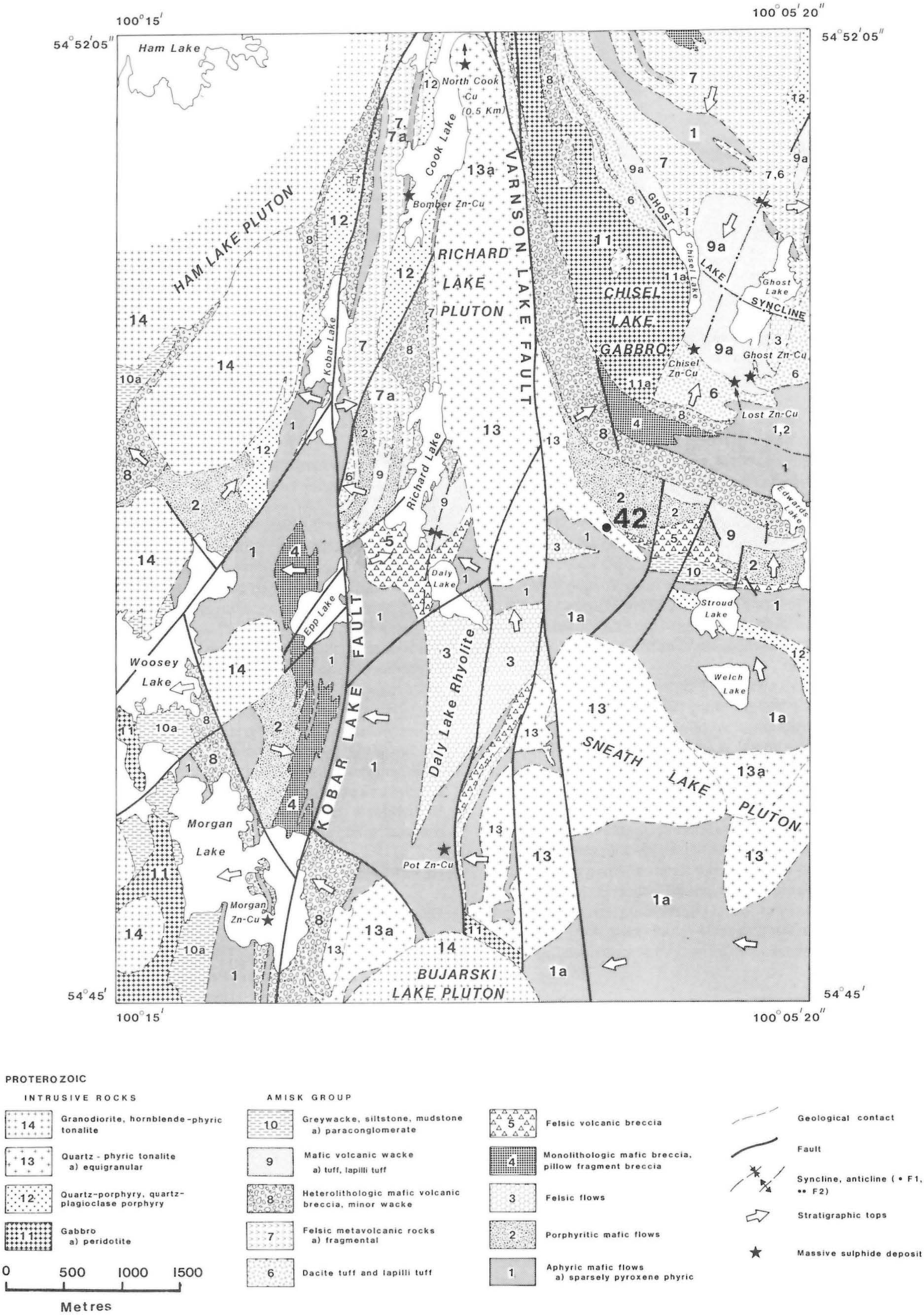

Figure GS-10-1: Simplified geological map of the Chisel-Morgan Lakes area with location of analyzed samples (42) from Richard Lake pluton.

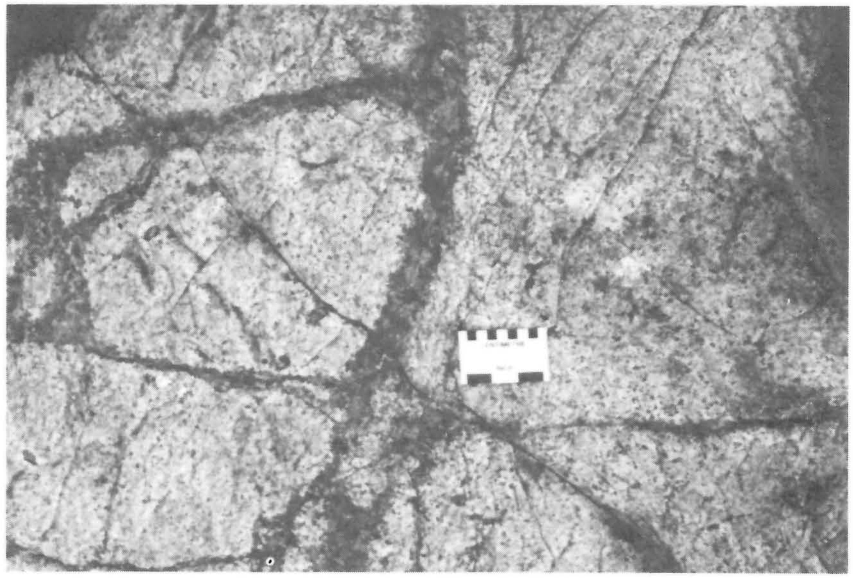

Figure GS-10-2: *Altered tonalite, Richard Lake pluton, east shore of Richard Lake. Alteration follows fractures and is metamorphically recrystallized to a mixture of garnet and biotite.*

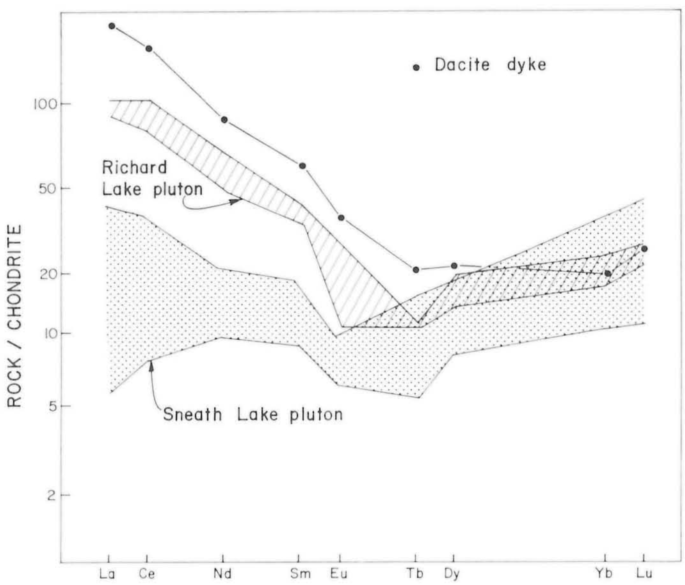

Figure GS-10-3: *Chondrite normalized REE plot showing light REE enriched character of Richard Lake pluton compared to flat pattern of Sneath Lake pluton.*

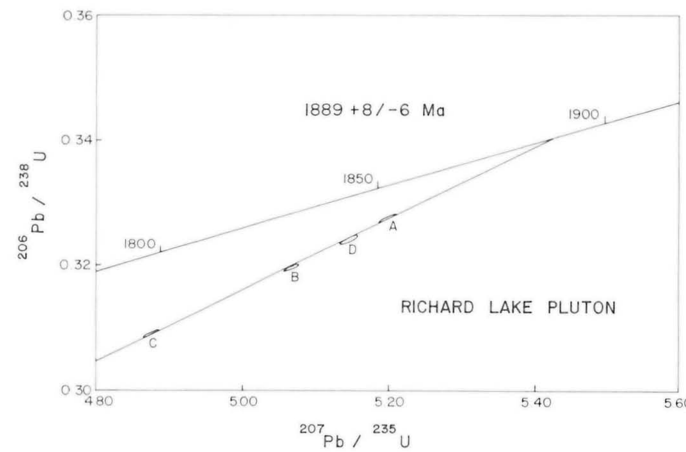

Figure GS-10-4: *Concordia diagram showing data from Richard Lake pluton (Sample 42).*

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GS-11 GEOLOGICAL SETTING OF THE BIG ISLAND ZINC PROPERTY, SHORE LAKE AREA, FLIN FLON

by K. Ferreira and G.H. Gale

INTRODUCTION

Zinc, copper and gold mineralization were intersected in drill holes by Westfield Minerals and Goldbrae Resources in 1987-88 on their Big Island property approximately 1.4 km east of Manistikwan Lake (Fig. GS-11-1). A 1:2000 scale mapping program of six weeks' duration was undertaken to define lithologic units and identify structural features in the area of the mineralized zone. The geology of the area is shown in Figure GS-11-2.

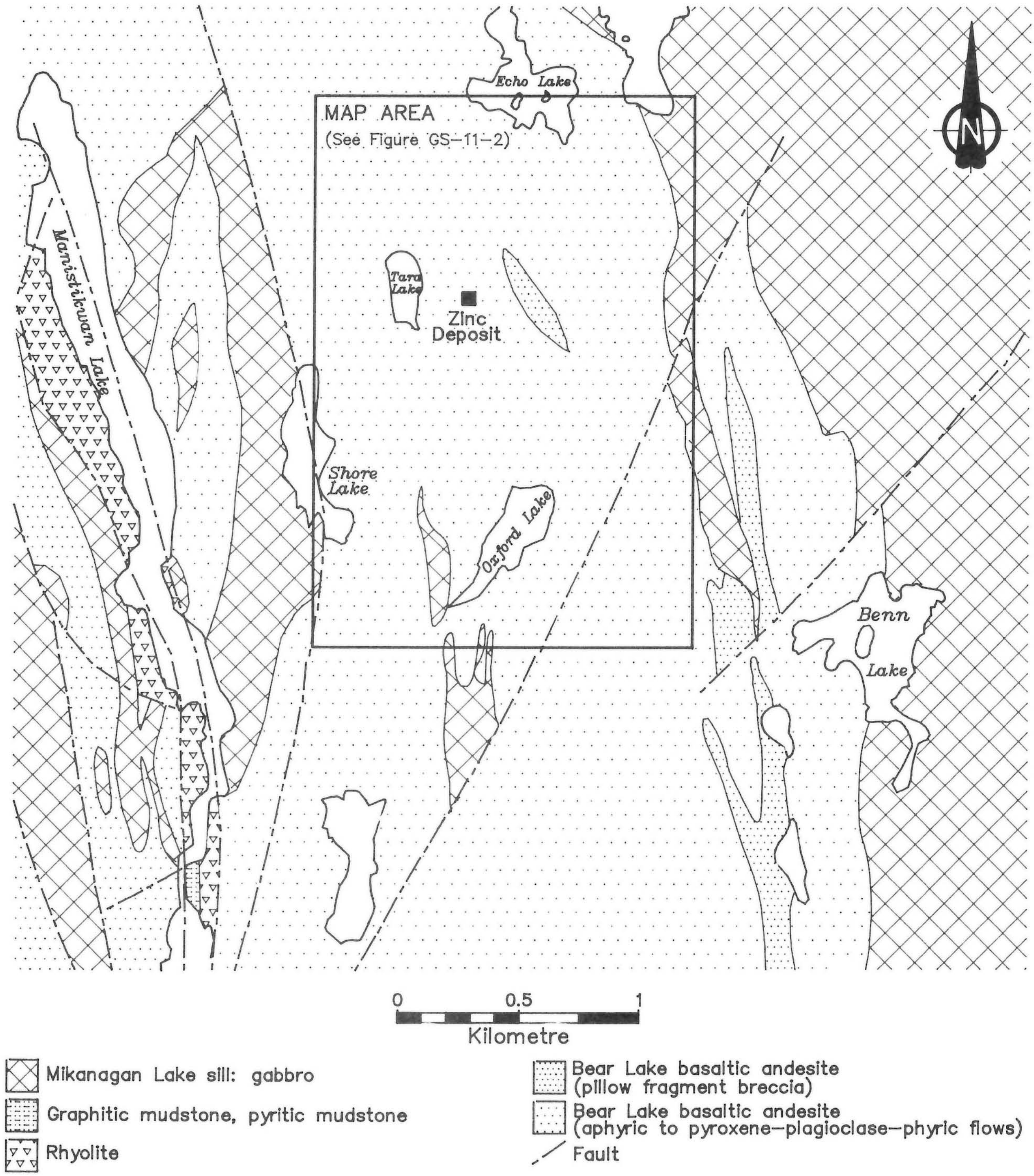

Figure GS-11-1: Regional geology (after Bailes and Syme, 1987).

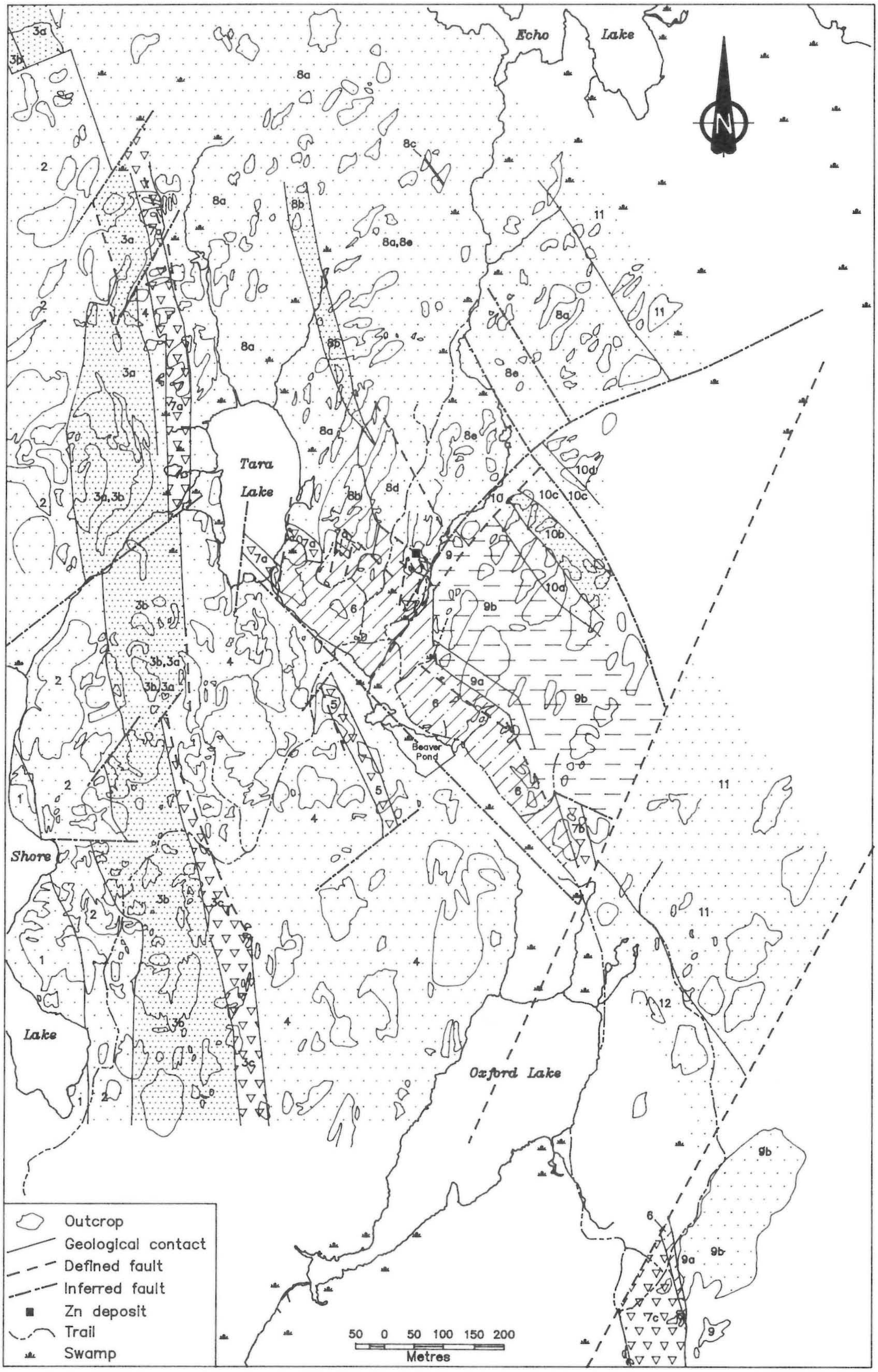

Figure GS-11-2: *Geology of the Big Island Zn property. Legend: 1) Massive mafic flows; 2) Amygdaloidal pillowed mafic flows; 3a) Heterolithic volcanic breccia, b) pillowed mafic flows, c) rhyolite; 4) Pillowed and massive mafic flows and flow breccias; 5) Altered rhyolitic rocks; 6) Tuffaceous rocks; 7a, b, c) Rhyolite flows and breccias; 8a) Pillowed mafic flows, b) heterolithic volcanic breccia, c) mafic flow breccia, d,e) carbonatized pillowed mafic flows; 9a) Miarolitic mafic flow, b) pillowed mafic flows; 10a) Mafic flow breccia, b) heterolithic mafic breccia, c) epidotized pillowed mafic flow, d) monolithic mafic flow; 11) Epidotized pillowed mafic flow; 12) Mafic flows and rhyolite dykes. Solid square east of Tara Lake indicates location of the Zn deposit.*

GENERAL STATEMENT

The area is underlain primarily by subaqueous aphyric basaltic andesite flows and related breccias of the fault-bounded Bear Lake Block (Fig. GS-11-1) defined by Bailes and Syme (1987). Lesser amounts of rhyolite, mafic tuffaceous rocks, mafic heterolithic volcanic breccias, mafic synvolcanic feeder dykes, and minor late mafic dykes are present. The sequence ranges from 140° to 180° in strike and dips steeply to the east. Numerous top determinations, including pillow stacking and amygdule distribution, indicate that the sequence youngs to the east. Overlapping flow lobes in rhyolitic and mafic flows and imbricated pillows indicate magma flowage towards the north. Mafic dykes and sills, ranging from less than 1 m to many tens of metres in thickness, commonly disrupt all units. Rocks have been metamorphosed to lower greenschist facies; original volcanic textures and structures are well preserved in unaltered areas. Numerous faults that vary from low angles to approximately normal to flow contacts have disrupted stratigraphy.

UNIT DESCRIPTIONS

MAFIC FLOWS (1)

Unit (1) comprises massive aphyric mafic flows, in places interlayered with lesser mafic volcanic breccia. The flows are thin, ribbon-like and massive, commonly containing abundant, equidistributed pinhead-sized white structures (variolites or spherulites?). Quartz amygdules are rare.

Mafic volcanic breccia layers, 1-2 m thick, contain minor felsic fragments that may have been derived from silicified mafic rocks. Crosscutting mafic dykes are common.

AMYGDALOIDAL PILLOWED MAFIC FLOWS (2)

Unit (2) is a sequence about 150 m thick of brown weathering, aphyric pillowed mafic flows. Pillows are bun-shaped, usually less than 0.5 m across, and close-packed with very little interpillow matrix.

At the base of the unit is a single non- to sparsely quartz-amygdaloidal pillowed flow. This flow is overlain by highly quartz-amygdaloidal pillowed flows that locally are topped by autoclastic flow breccias.

HETEROLITHIC VOLCANIC BRECCIA, PILLOWED MAFIC FLOWS AND RHYOLITE (3)

Unit (3) is a composite unit of mafic heterolithic volcanic breccia (3a) and mafic pillowed flows (3b) that contain blocks of rhyolite and are overlain by a rhyolite flow (3c). The unit is approximately 150 m thick in the south where it consists predominantly of aphyric pillowed mafic flows with lesser hyaloclastic flow breccia and rhyolite. At the northern limits of mapping it is only 50 m thick and consists predominantly of heterolithic breccia. Thinning of this unit is attributed to faulting at a low angle to the strike of layering. The pillowed flows decrease and heterolithic breccias increase in relative abundance from south to north in unit (3). Blocks of aquagene tuff and heterolithic breccia, several metres to tens of metres across, occur within and are surrounded by pillowed flows and hyaloclastic breccia.

Heterolithic mafic breccia (3a) is fragment-supported with about 75% fragments and 25% matrix. The fragments, 1-20 cm across, are unsorted and include: 1) subangular mafic fragments with complete and partial chilled rims, 2) angular mafic fragments that lack chilled rims, and locally, 3) rhyolite lapilli and blocks. Both quartz-amygdaloidal and nonamygdaloidal varieties of all the fragment types are present. The fine grained matrix is mafic to intermediate. Neither grading nor bedding were distinguished. Unit (3a) probably represents debris flows.

A distinctive network of siliceous material that may be described as frothy or resembling a spider web occurs: 1) in discrete clasts, 2) as the matrix, and 3) as a matrix surrounding other rock types within some fragments. The network is confined in any given place to the fragments or the matrix and does not overprint fragment boundaries. This texture probably represents extremely fluid gaseous material, perhaps collapsed pumiceous rhyolite. Silicification has not been discounted, but the non-pervasive nature of these networks make this less likely.

Unit (3b) comprises dark green to black weathering, aphyric pillowed mafic flows, several metres to tens of metres thick. Pillows are commonly loaf-shaped, with variable sizes, packing, and composition.

Rhyolitic massive flows and flow breccia (3c) form a 50 m thick sequence at the top of unit (3). Massive portions weather white, are quartz-and/or chlorite-amygdaloidal, aphyric and aphanitic. The flow breccia consists of block- to lapilli-sized rhyolite fragments in a fine grained, slightly rusty brown weathering matrix. Unit (3c) pinches out northwards against a fault. Rhyolite blocks within units (3a) and (3b) are megascopically similar to the massive flows of unit (3c).

PILLOWED AND MASSIVE MAFIC FLOWS AND FLOW BRECCIAS (4)

Unit (4) comprises a sequence at least 320 m thick of pillowed aphyric mafic flows and lesser mafic autoclastic flow breccia, and massive and lobate aphyric mafic flows. Pillows are generally quartz-amygdaloidal, close-packed, well formed bun and loaf shapes with only a small amount of interpillow matrix. Unit (4) is characterized by inhomogeneity in amygdule abundance, selvage thickness, pillow size, and flow thickness among individual flows. Flow base and flow top breccias are commonly distinguishable in individual flows. Individual flows are commonly traceable over several hundred metres, but are not continuous across the entire sequence.

ALTERED RHYOLITIC ROCKS (5)

Unit (5) comprises a 25 m thick unit of rhyolitic rocks exposed west of a beaver pond between Tara and Oxford lakes. The unit consists of 2-3 m long, aphyric, pumiceous(?) rhyolite lenses, and 1-2 m blocks of rhyolite and epidotized rhyolite. The rocks have been dissected by quartz-chlorite alteration veins.

TUFFACEOUS ROCKS (6)

Unit (6) consists of tuffaceous rocks at least 60 m thick, which are well exposed in washed areas at the Zn deposit and in several trenches east of the beaver pond. The rock is light to medium grey weathering and dense.

The upper part of the unit consists predominantly of ash-sized material, with lapilli occurring locally towards the central and lower parts of the unit. Clusters of quartz amygdules, 1-2 mm, occur in irregularly shaped areas without discrete boundaries in the ash-sized material. Weathered-out pits, probably previously carbonate-filled amygdules, up to 1 cm, are also concentrated in irregularly shaped, randomly distributed areas up to several metres across in ash- and lapilli-sized material. The lower part of the unit contains pillowed mafic flow rocks that are probably large blocks. Unit (6) may represent an ignimbrite.

Unit (6) forms the footwall of the Zn deposit. Similar rocks along strike to the east of Oxford Lake are tentatively correlated with rocks east of the beaver pond.

RHYOLITE FLOWS, BRECCIAS AND DYKES (7)

Unit (7) consists of discontinuous rhyolite lenses that are traceable from north to south across the map area. The unit has been divided into three rhyolite breccia subunits that also contain sections of rhyolite flows. North of Tara Lake, unit (7a) consists of a 30 m thick rhyolite flow; southeast of Oxford Lake, unit (7c) is 90 m thick.

Unit (7a) consists predominantly of brown weathering, pumiceous rhyolite breccia. 10-20% of the unit consists of white weathering, massive rhyolite lobes with 1-10 mm weathered-out amygdules.

Unit (7b) is a rhyolite flow breccia with weathered-out amygdules.

Unit (7c) consists of rhyolite flow breccia, massive aphyric rhyolite, and one exposure of quartz-phyric rhyolite that may be a flow or a dyke. Rhyolites in this unit are locally quartz-amygdaloidal, contain some breccia that is probably reworked, and are intensely altered in places.

The lack of pumiceous rhyolite in unit (3) precludes correlation between unit (3) and unit (7). Unit (5) may represent the intensely altered equivalent of unit (7a), but the two units have not been positively correlated.

PILLOWED MAFIC FLOWS, VOLCANIC BRECCIAS AND CARBONATIZED FLOWS (8)

Unit (8) consists of a sequence at least 400 m thick of pillowed mafic flows and lesser volcanic breccias. Five subunits are defined: pillowed mafic flows (8a), heterolithic volcanic breccia (8b), monolithic mafic volcanic breccia (8c), and carbonatized pillowed mafic flows (8d and 8e).

Unit (8a) comprises dark green weathering pillowed aphyric mafic flows, related hyaloclastic breccias, and lesser mafic feeder dykes/sills. Pillows are loaf-shaped, close-packed, and locally quartz-amygdaloidal. Individual flow thicknesses were not determined, but several accompanying hyaloclastic breccias are 2-10 m thick.

Unit (8b) consists of several 5-10 m thick heterolithic volcanic breccias that contain both isolated pillows and pillow fragments. These breccias are probably debris flows.

A mafic flow breccia (8c), 2 m thick, contains fine grained, matrix-supported, monolithic mafic fragments, 1-30 cm, in a fine grained mafic matrix.

Carbonatized pillowed mafic flows (8d) contain 25-50 cm, poorly formed, close-packed pillows that have pale green and dark green weathering interiors and dark green chloritic selvages. The pillows contain common, irregularly shaped cavities up to 10 cm that were originally filled with carbonate. Unit (8d) also includes several exposures containing ash- to lapilli-sized material that is similar to the fine grained parts of unit (6).

Carbonatized pillowed mafic flows (8e) contain 0.5-1.0 m, locally variolitic, well formed pillows that have yellow interiors and beige to straw yellow selvages. Free calcite is disseminated throughout unit (8e).

Units (8d) and (8e) are variably carbonatized and were identified only north of the Zn deposit. Units (8d) and (8e) are separated by a vertical fault.

PILLOWED AND MIAROLITIC MAFIC FLOWS (9)

Unit (9) is a 200 m thick sequence of relatively unaltered mafic flows that occurs directly east of the Zn deposit and as an isolated mass east of the south end of Oxford Lake. The unit comprises pillowed and lesser massive mafic flows, including a miarolitic massive mafic flow, and numerous mafic dykes/sills.

The miarolitic mafic flow (9a) occurs at the base of the sequence and is 50 m thick. It is characterized by abundant ovoid miarolitic cavities up to 20 cm long, spaced decimetres apart, and commonly lined with quartz crystals. Round to ovoid structures, 30-50 cm, composed of medium- to coarse-grained quartz and feldspar are common throughout unit (9a). These ovoid structures resemble granitic cobbles upon cursory examination, but their boundaries are gradational and miarolitic cavities extend into these structures from the enclosing flow. These quartz- and feldspar-rich areas probably result from streaming of internal gases.

Pillowed mafic flows (9b) overlying the miarolitic flow contain well formed, close-packed, loaf-shaped pillows up to several metres long with selvages about 1 cm thick and only minor interpillow matrix. Quartz amygdules are common. Pea-sized variolites are abundant, especially in flows near the base of unit (9b), where entire pillow interiors are filled with coalescing variolites.

A distinctive spherical to colloform texture occurs in some mafic synvolcanic dykes, and less commonly in the mafic flows. Buff coloured areas with diameters of approximately 2 cm surround spheres and partial spheres of the brownish weathering mafic rocks, creating a colloform texture. The origin of this texture is unknown; alteration and immiscibility have been suggested.

MAFIC VOLCANIC BRECCIA (10)

Unit (10) is a sequence more than 150 m thick of various volcanic breccias and an epidotized pillowed mafic flow. Four stratigraphically sequential subunits have been distinguished: a highly amygdaloidal mafic flow breccia (10a), heterolithic mafic volcanic breccia (10b), epidotized pillowed mafic flows (10c), and a monolithic volcanic breccia (10d).

Unit (10a), 20-25 m thick, consists of a mafic flow breccia with subangular to rounded basalt fragments that contain more than 50% quartz amygdules. The fragments are supported by a fine grained mafic matrix.

Unit (10b) comprises at least four layers of heterolithic mafic breccia that contain 1-30 cm, angular fragments of variably textured mafic volcanic rocks and locally, 2 x 10 m blocks of overturned pillowed flows. The breccia is fragment-supported with a fine grained mafic matrix. The larger fragments occur towards the centres of the layers; individual layers are graded towards both the top and the base. These rocks are considered to be debris flows.

UNIT (10c) at least 30 m thick, is an aphyric pillowed mafic flow with epidotized rims and centres.

Unit (10d) is composed of 50%, quartz-amygdaloidal (30-40%), monolithic mafic fragments supported by a fine grained mafic matrix. Unit (10d) probably represents a hyaloclastic flow.

EPIDOTIZED PILLOWED MAFIC FLOWS (11)

Unit (11) comprises a 50-100 m thick sequence of pillowed mafic flows. Well formed, close-packed, bun- and loaf-shaped pillows several metres long have highly epidotized, commonly scimitar-shaped, central and upper parts. Free carbonate occurs as lenses and disseminations.

Pillowed mafic flows in the large fault-bounded block centred on Oxford Lake have undergone similar alteration and may be stratigraphically equivalent to unit (11) in the northeasternmost part of the map area.

MAFIC FLOWS AND RHYOLITE DYKES (12)

Unit (12) comprises a 100-150 m thick sequence of massive and pillowed mafic flows confined to the fault block centred on Oxford Lake. A cursory examination indicates that they do not resemble mafic flows observed elsewhere in the map area. Rhyolite dykes crosscut several exposures of mafic flows.

STRUCTURE

Major lithologic and individual flow contacts indicate a strike of generally 180° for rocks west of Oxford Lake and Tara Lake, but 140° to 160° northeast of the Zn deposit and east of Oxford Lake.

The area has been dissected by a plethora of early and late faults. Major faults are shown in Figure GS-11-3. One of the more significant sets of faults displaces unit (7a) and the mineralized zone (Fig. GS-11-3). The fault zone directly north of the beaver pond near the top of unit (6) apparently displaces the rhyolites of units (7a) and (7b). A detailed structural analysis of this area is anticipated.

MINERALIZATION

The Zn deposit consists of 1) a lens of solid sulphide that is composed of sphalerite, pyrite, chalcopyrite and gold, and 2) a zone of post-deformation sulphide veins and veinlets containing sphalerite, pyrrhotite, pyrite, chalcopyrite and gold. It is hosted by altered rhyolite and mafic to intermediate tuffaceous rocks.

The Zn deposit is underlain by unit (6). Several small exposures of pumiceous rhyolite and massive rhyolite breccia in outcrops of the Zn deposit indicate that it occurs either at the contact between units (6) and (7c), or within unit (7a).

Disseminated and veinlet sulphides are present at several other localities of unit (7) rhyolites. In addition, sulphide impregnations and vein systems typical of volcanic hydrothermal systems associated with massive sulphide deposits were noted in several places in units (3) and (4). The significance of the extensive carbonatization north of the Zn deposit is not known.

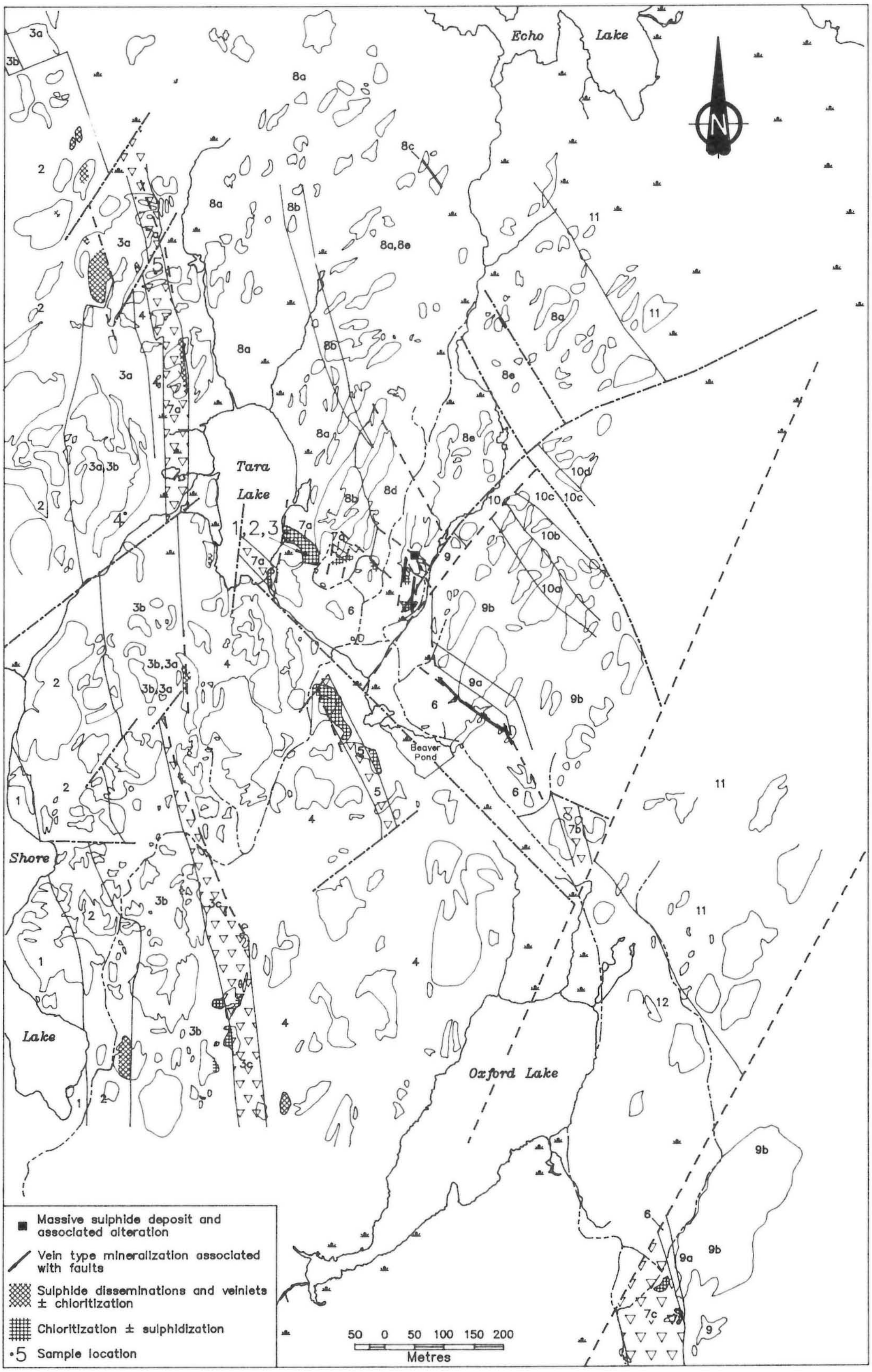

Figure GS-11-3: Mineralization and associated alteration in the vicinity of the Big Island Zn deposit. Lithologic units and symbols as shown in Figure GS-11-2.

The altered host rocks in the footwall of the Zn deposit can be traced southwards along strike for at least 300 m. Altered rocks are also present 200 m west of the Zn deposit in units (4) and (5) west of the beaver dam. However, there are no geochemical or field data to establish that this alteration is contiguous with the Zn deposit.

Pumiceous rhyolite breccia (7a) near the southeast shore of Tara Lake has been chloritized and pyritized along veins, but the massive lobes are not altered.

The solid sulphide lens and its associated alteration zone are typical of volcanogenic massive sulphide deposits. The vein sulphide occurrences are typical of mobilized sulphides in deformation zones; in these occurrences, the sulphides and gold are envisaged to have been mobilized primarily from the surrounding alteration zone.

GEOCHEMISTRY

Silicate whole rock analyses of rhyolite analyzed during the initial stages of the project are presented in Table GS-11-1. The analyses confirm that the massive unaltered-appearing rhyolites have rhyolitic compositions (76.03-78.86% SiO_2) and are not depleted in Na (2.53-3.65% Na_2O); this suggests that hydrothermal fluids have not affected these rocks. Rhyolites that were identified as being altered from field observations are depleted in Si (59.29 and 67.55% SiO_2) and Na (0.05% Na_2O), and are enriched in Mg and Fe relative to unaltered rhyolites (range of 1.56-3.10% MgO vs. 0.01-0.46% MgO; 8.74-11.40% FeO vs. 2.22-5.85% FeO; altered vs. unaltered, respectively). Additional geochemical studies are in progress.

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TABLE GS-11-1
SILICATE WHOLE ROCK ANALYSES OF RHYOLITIC ROCKS NEAR 'TARA' LAKE
(See Figure GS-11-3 for sample locations)

Sample No.	WF-1	WF-2	WF-3	WF-4	WF-5
SiO_2%	67.55	77.28	59.29	78.86	76.03
Al_2O_3	11.53	10.76	14.03	10.62	9.94
FeOt	8.74	3.01	11.40	2.22	5.85
CaO	6.82	2.62	6.72	2.35	2.55
MgO	1.56	0.46	3.10	0.01	0.39
Na_2O	0.05	3.36	0.05	3.65	2.53
K_2O	0.21	0.68	0.76	0.86	0.09
TiO_2	0.49	0.43	0.54	0.44	0.59
P_2O_5	0.07	0.10	0.07	0.01	0.15
MnO	0.13	0.04	0.20	0.03	0.08
Total	97.14	99.73	96.15	99.05	98.20

WF-1: 'Frothy' rhyolite flow; unit 7a
WF-2: Quartz-amygdaloidal massive rhyolite flow, unaltered; unit 7a
WF-3: Chloritized pyritized rock; unit 7a
WF-4: Rhyolite flow, unaltered; unit 3b
WF-5: Rhyolite flow, unaltered; unit 7a

GS-12 GEOLOGY OF THE LEO LAKE AREA

by K. Ferreira

INTRODUCTION

The Leo Lake project is part of a program to investigate mineralization associated with the Baker Patton felsic complex in the Flin Flon area. Mapping at a scale of 1:2400 commenced in 1987 between Flintoba and Leo (a.k.a. Mud) lakes (Ferreira, 1987a and 1987b) (Fig. GS-12-1). Continuation of the field work in 1988 was directed towards 1) increasing the areal extent of map coverage to the north towards Alberts Lake, and 2) re-examining numerous selected areas of outcrop that had been bleached or stripped during 1987.

LITHOLOGY

Major lithologic units are shown in Figure GS-12-2; copies of the 1:2400 map are available upon request. Rhyolitic to rhyodacitic volcanic fragmental rocks are dominant with lesser quartz-feldspar porphyry and gabbro. Fragmental rocks are differentiated by the type, abundance and distribution of fragments and crystals. Well developed cleavage, the fine grain size of the matrix and lichen cover hamper detailed outcrop examinations of the felsic rocks.

Rhyolitic tuff to lapilli tuff (unit 1) consists of lensoidal subangular rhyolitic fragments in a beige to rusty weathering very fine grained matrix. Fragments are dominantly lapilli- and ash-sized, but block-sized fragments also are present. All fragments were derived from felsic volcanic rocks, but vary in texture and composition. The dominant fragment type is beige weathering, aphyric, aphanitic to very fine grained, lensoidal and generally 1-5 cm long. Other fragments include reddish brown weathering, subangular to irregularly shaped, very fine grained chloritic lapilli that are usually less than 2 cm across and contain minor, less than 1 mm, quartz crystals. The fragments are unsorted and lack internal stratification. Less than 2% quartz crystals, smaller than 2 mm, are commonly enclosed in lapilli and are comparatively rare as free crystals in the matrix.

Rhyolitic ash-flow tuff (unit 1a) is beige to light brown weathering with ash- and lapilli-sized fragments in a dense, very fine grained, tuffaceous matrix. Unit 1a is distinguished from the rest of unit 1 by the presence of abundant lithophysae, which indicate welding in a pyroclastic flow. A brown weathering tuff layer, about 0.5 m thick, at the western contact also contains lithophysae.

'Two-quartz' rhyodacitic tuff-breccia (unit 2) weathers creamy white to light beige with tuff- to breccia-sized felsic clasts and up to 20% quartz crystals in an aphanitic matrix. The clasts are heterolithic, angular to rounded and unsorted. The most prevalent species of clasts are: 1) lensoid lapilli and blocks composed of felsic finer grained fragments and quartz crystals of variable size and abundance, 2) lensoid, quartz-poor, aphanitic lapilli and 3) subangular to rounded, very fine grained, reddish brown weathering chloritic clasts with fine grained quartz. Quartz crystals, 15-20%, are bimodally distributed, 1-3 mm and 5-14 mm. Some 'two-quartz' (i.e., with bimodal-sized quartz) fragments with a clastic internal texture indicate an earlier pyroclastic event involving the 'two-quartz' magma. The aphanitic to very fine grained, creamy white weathering matrix is commonly difficult to distinguish from fragments.

Rhyolitic to rhyodacitic tuff to lapilli-tuff (unit 3) with up to 10%, unimodally distributed quartz crystals (up to 5 mm), occurs in the southern and northern parts of the map area. Fragment size, abundance, type, matrix size and composition are similar to unit 2.

Rhyolitic fragmental rocks (unit 4) that contain very few quartz crystals are similar to rocks in unit 1, except that unit 4 tuffs lack the intense rusty weathering that is characteristic of unit 1.

'Two-quartz' porphyry (unit 5) at the shore of Leo Lake is similar in composition, quartz crystal size and abundance to 'two-quartz' fragmental rocks, but fragmental textures have not been observed on outcrop nor etched slab. If this rock is indeed intrusive, it probably represents the source magma from which the 'two quartz' fragmental rocks were derived in the Leo-Flintoba lakes area and at the Baker Patton deposit 3 km to the southwest (Tannahill and Gale, 1986; Gale and Foote, 1988).

Medium grained granodiorite (6) occurs in several small areas near gabbro contacts in the northern part of the map area. Gabbro (unit 7) is brown weathering, medium to fine grained and massive.

ALTERATION

Chloritization and sericitization have affected units 1-4 in varying degrees, from imparting a slight greenish or yellowish hue to the rock to virtual total replacement of original mineralogy and texture. Discontinuous, mm- to cm-wide, irregularly oriented quartz-carbonate-(chlorite) veinlets accompany chloritization and sericitization in variable amounts. Intense pyritization, associated with chlorite, has affected unit 1, but pyrite occurs only in minor amounts (generally less than 2%) in units 2, 3 and 4. The comparative lack of sulphide mineralization in unit 2 indicates that sulphidization was essentially complete before unit 2 was deposited and that unit 2 postdates unit 1. This age relationship is further supported by the presence of metre-sized angular blocks of unit 1 enclosed within unit 2 west of Baseline 150E.

STRUCTURE

Layering attitudes are inconsistent within the map area, and traces of bedding surfaces have irregular outlines and are folded. These irregularities are due to non-horizontal depositional surfaces and later folding that has locally displaced bedding along axial cleavage planes.

Early foliation (S1) apparently parallels bedding and commonly reflects minor fold patterns. A chloritic fracture cleavage, marked by brownish to light green recessive weathering lines spaced 2-10 cm apart, parallels S1 in the eastern part of the map area (Fig. GS-12-3, GS-12-4). Minor fold patterns resulting from a folding event (D2) are best developed in the central part of the map area, and a late, steep, north-northeast-trending axial planar cleavage (S2) is superimposed on the folded surfaces (Fig. GS-12-5). Chloritization (+ /- pyritization) is commonly focussed into small (0.5-2 cm long) tectonic lenses parallel to S2. Minor shearing occurs in cm-wide zones (Fig. GS-12-6) that are curvilinear, more commonly subparallel, but also crosscut S2, and locally are accompanied by irregular veinlets or pods of quartz-carbonate-(chlorite)-(pyrite). A late north-northeast-trending fault extends from Sourdough Bay (Lake Athapapuskow) south of the project area through Flintoba Lake and north to Alberts Lake (Fig. GS-12-1).

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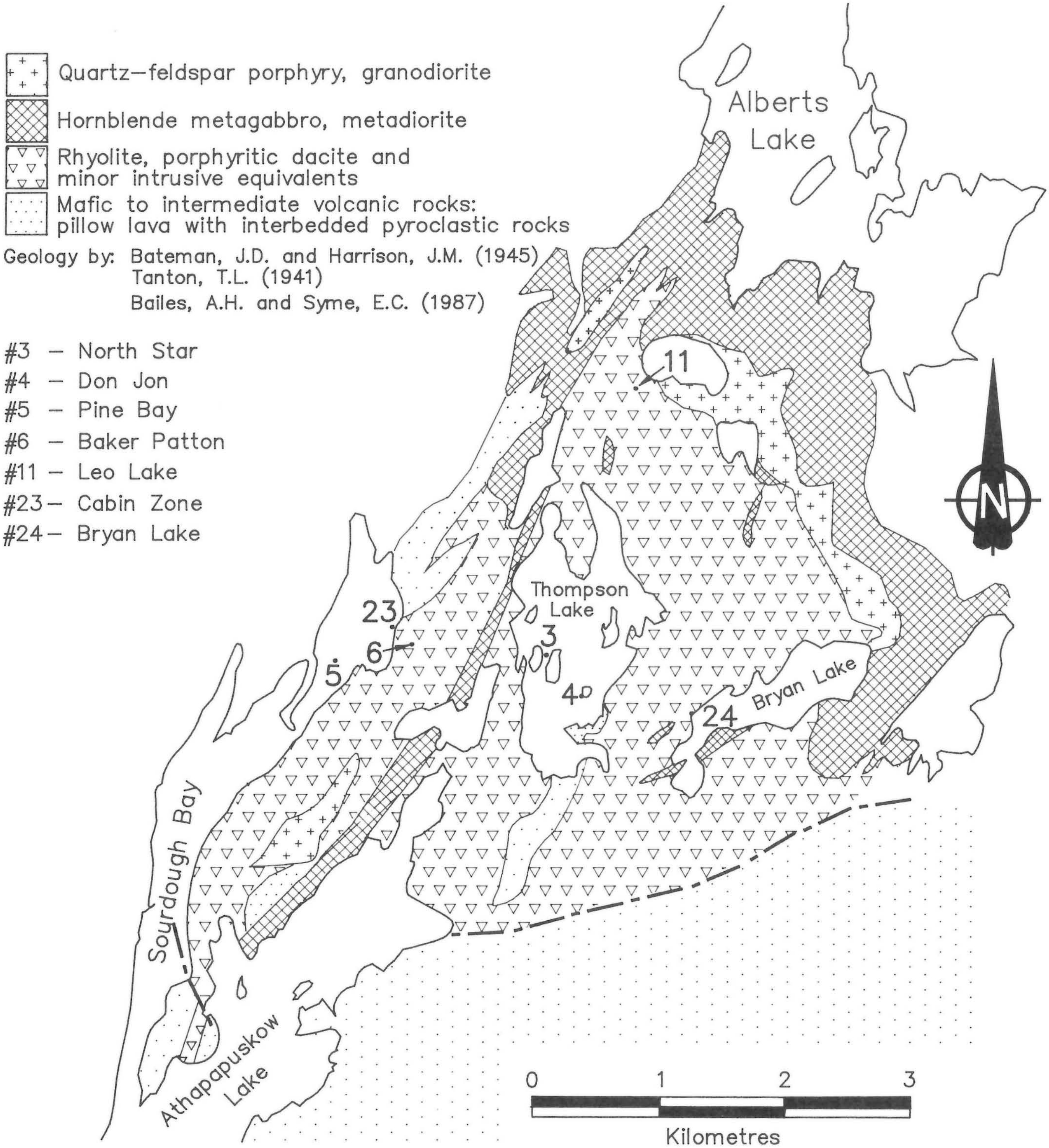


Figure GS-12-1: Distribution of mineral occurrences in the Baker Patton felsic complex.

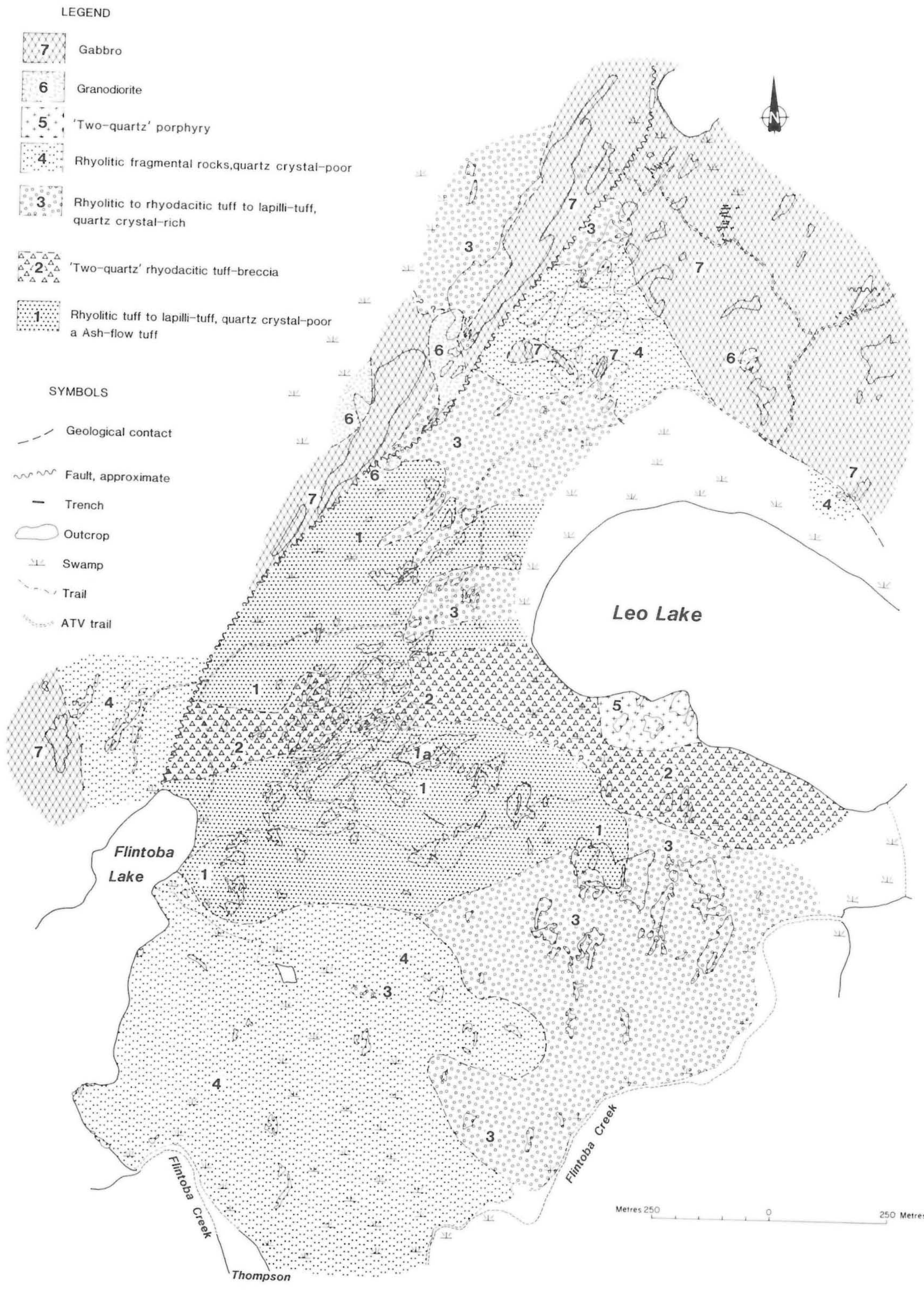
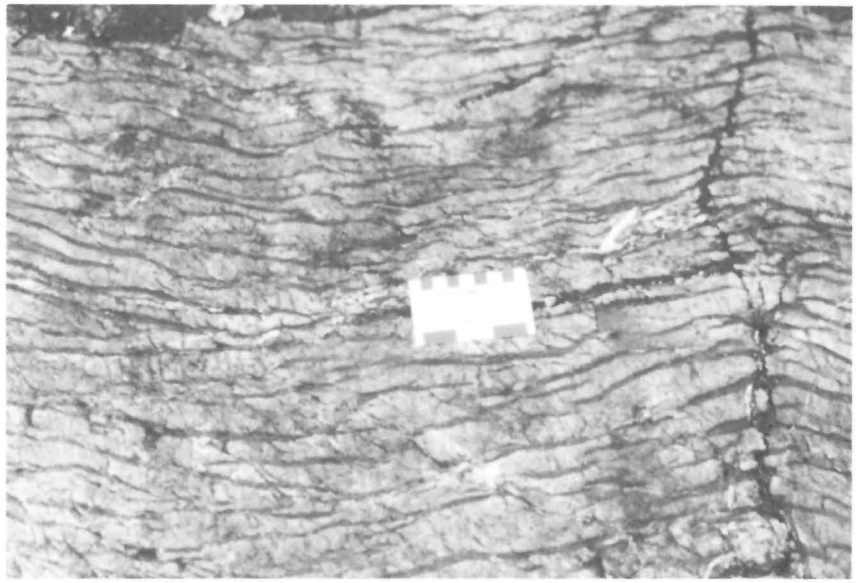


Figure GS-12-2: *Geology of the Leo Lake area.*

Figure GS-12-3: Chloritic fracture cleavage.



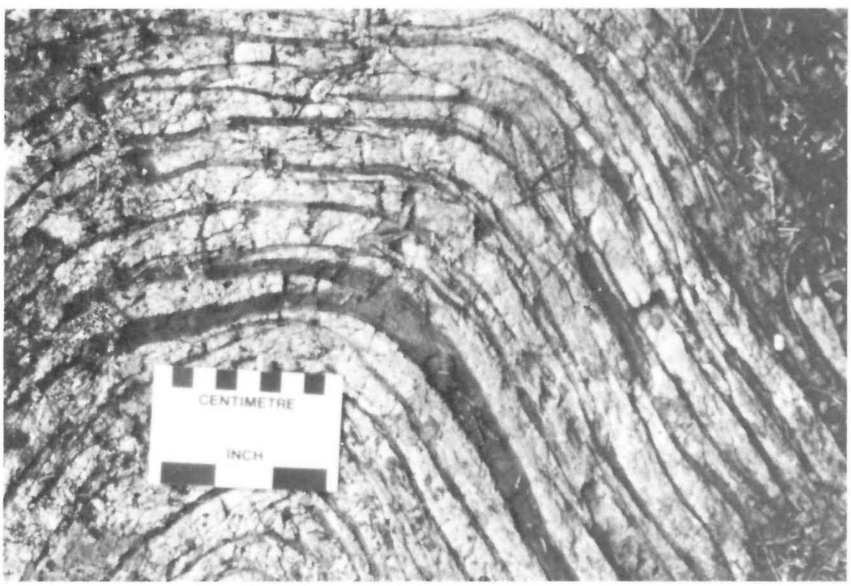


Figure GS-12-4: Chloritic fracture cleavage.

Figure GS-12-5: Axial planar cleavage (trending upper left to lower right) superimposed on fragmental rhyolite. The prominent centre fragment is the brownish chloritic lapilli.

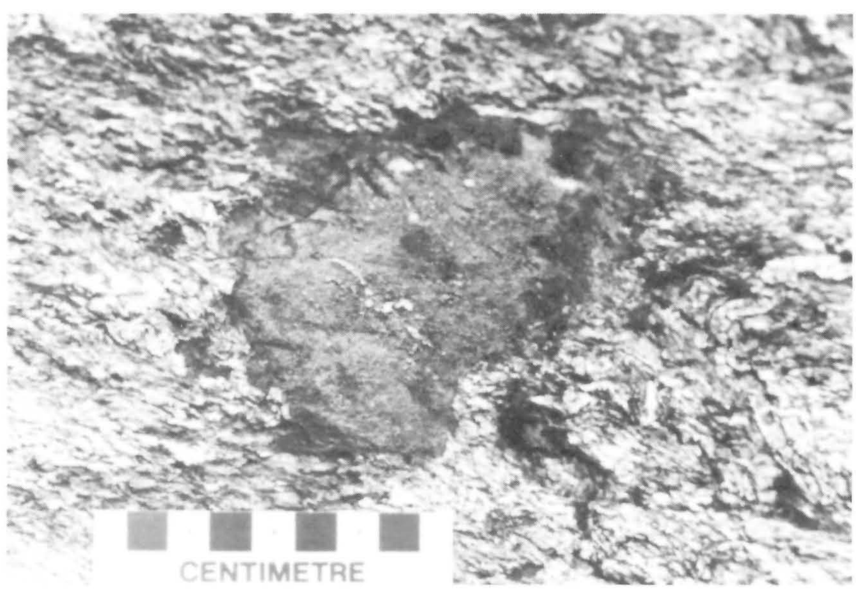


Figure GS-12-6: *Minor shear zone.*

GS-13 GEOLOGICAL SETTING OF THE BAKER PATTON ALTERATION ZONE

by G.H. Gale and G. Foote

The Baker Patton deposit is one of several small volcanogenic massive sulphide deposits within the Baker Patton felsic complex (see Ferreira, 1988, this volume, Fig. GS-12-1).

A six week program of geological mapping at 1:1000 scale was conducted in the general vicinity of the Baker Patton shaft. This mapping, initiated by Hayden-Luck and Gale (1985) and continued by Tannahill and Gale (1986) provides an updated map of the Baker Patton alteration zone and a geological framework for an evaluation of geochemical data.

The major rock units are shown on Figure GS-13-1. Lithologic descriptions provided by Tannahill and Gale (1986) for the northern part of the area are adequate for this account. Units not previously described include unit 8a, a sequence of white weathering amygdaloidal massive rhyolite flow lobes, flow breccia and pumiceous flows, and pale green andesitic flows and breccias, and unit 9, a diatreme breccia.

Several outcrops lying between the diatreme and the 'two quartz' rhyolite breccia (unit 2) south of Murray Lake could not be positively correlated visually as part of unit 6. These rocks are tentatively considered to be unit 6 that has undergone chloritization, in part during emplacement of the diatreme.

Outcrop preparation (bleaching) undertaken in 1986 was instrumental in establishing that the volcanic sequence youngs westward since it revealed scour channels, flame structures and graded beds in unit 6. The overturned westward tops are supported by the presence of a number of blocks of older 'two quartz' rhyolite (unit 2) in the unit 6 amygdaloidal flow.

Detailed mapping has revealed a number of faults not previously recognized that appear to have a direct bearing on the interpretation of sulphide intersections from previous drill programs. In a number of places lithologic contacts appear to be fault controlled (Fig. GS-13-1) or partly fault controlled where they are subparallel to layers in a unit.

The more commonly observed and inferred faults are late north- and east-striking faults, but it is not readily apparent if these are strike-slip or dip-slip faults. Early east-striking faults produced graben-like structures and may be related to caldera formation.

A regional fault along Flintoba Creek separates unaltered andesite to the north from altered rhyodacitic rocks to the south. The abrupt termination of altered unit 7, 4b and 2 rocks near the diatreme south of Murray Lake infers the presence of a late(?) fault that should be approximately parallel to the long axis of the diatreme.

Geochemical studies of the major alteration zone, initiated in 1980 and postponed awaiting completion of a geological base, will be continued in the near future. Visual examination of the data (Fig. GS-13-2, -3) confirms field observations that: (1) the alteration zone extends from Flintoba Creek in the north to immediately south of Murray Lake, in that chem-

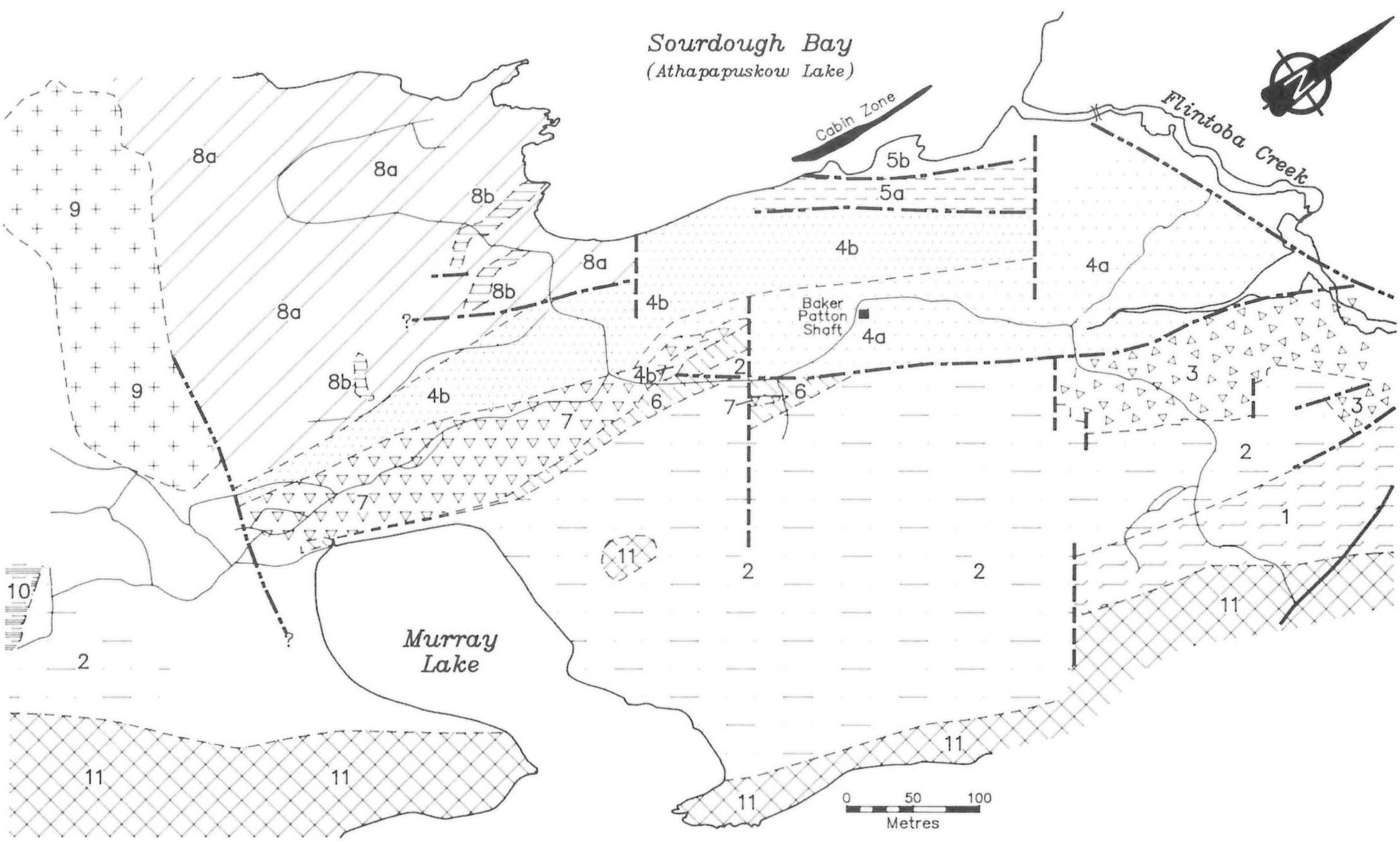


Figure GS-13-1: Geology of the Baker Patton area. Legend: 1) aphyric rhyolite flows; 2) 'Two-quartz' rhyolite breccia; 3) aphyric rhyolite breccia; 4a) rhyodacitic flows, 4b) rhyolitic and rhyodacitic flows; 5a) rhyolite breccia, 5b) massive rhyolite flows; 6) amygdaloidal rhyolitic flow and sedimentary rocks; 7) heterolithic rhyolite breccia; 8a) rhyolitic and andesitic flows, 8b) quartz-feldspar dyke(?); 9) diatreme; 10) aphyric rhyolite breccia; 11) gabbro. Thick broken lines represent faults.

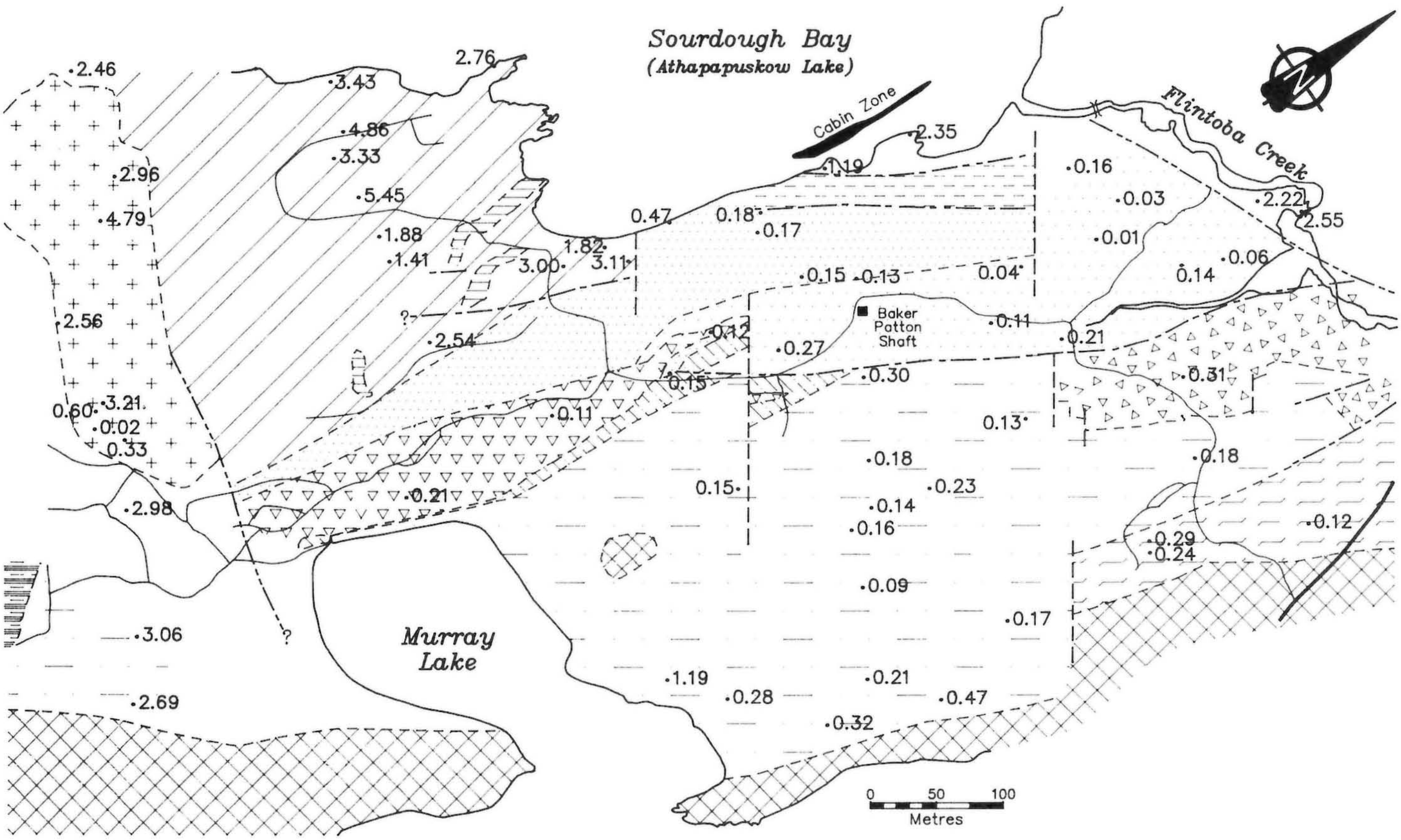


Figure GS-13-2: *Sodium (Na_2O) contents of volcanic rocks in the Baker Patton area.*

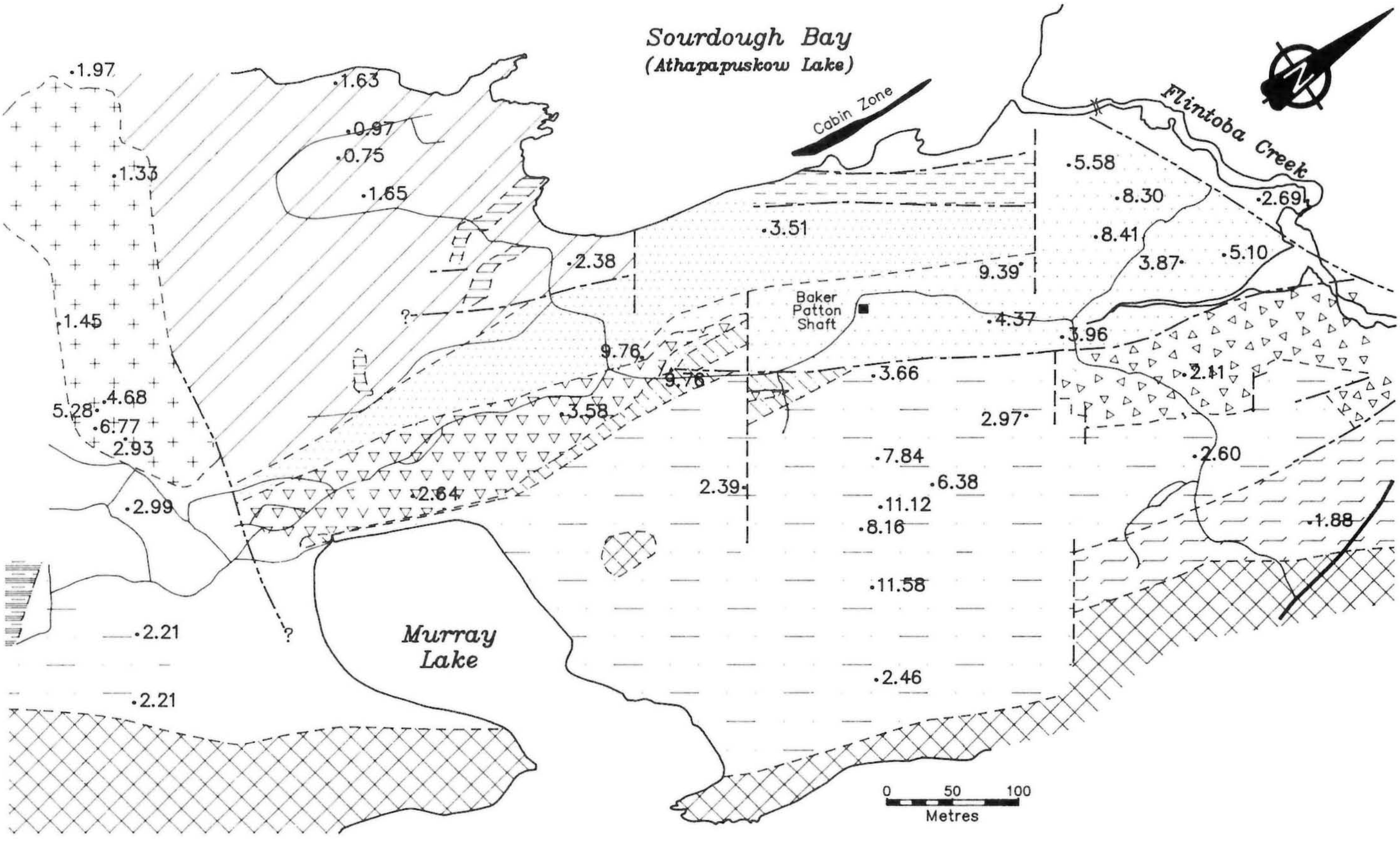


Figure GS-13-3: *Magnesium (MgO) content of volcanic rocks in the Baker Patton area.*

ically these rocks are depleted in sodium; and (2) the fault block containing the Baker Patton and Cabin zone mineralization represents the most intensely altered, central portion(?) of the alteration zone, since these rocks are extremely depleted in sodium and enriched in MgO relative to the same rock types that occur to the north and south of this central area.

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GS-14 MINERAL INVESTIGATIONS IN THE KISSEYNEW GNEISS TERRAIN

by G. Ostry

INTRODUCTION

Mapping projects at 1:5000 were completed in the Puffy Lake area and initiated at Squall Lake.

PUFFY LAKE

Surface geological mapping at 1:5000 was continued adjacent to the areas mapped previously (Ostry, 1986, 1987). Interpretation of lithologic and stratigraphic relationships remains essentially unchanged.

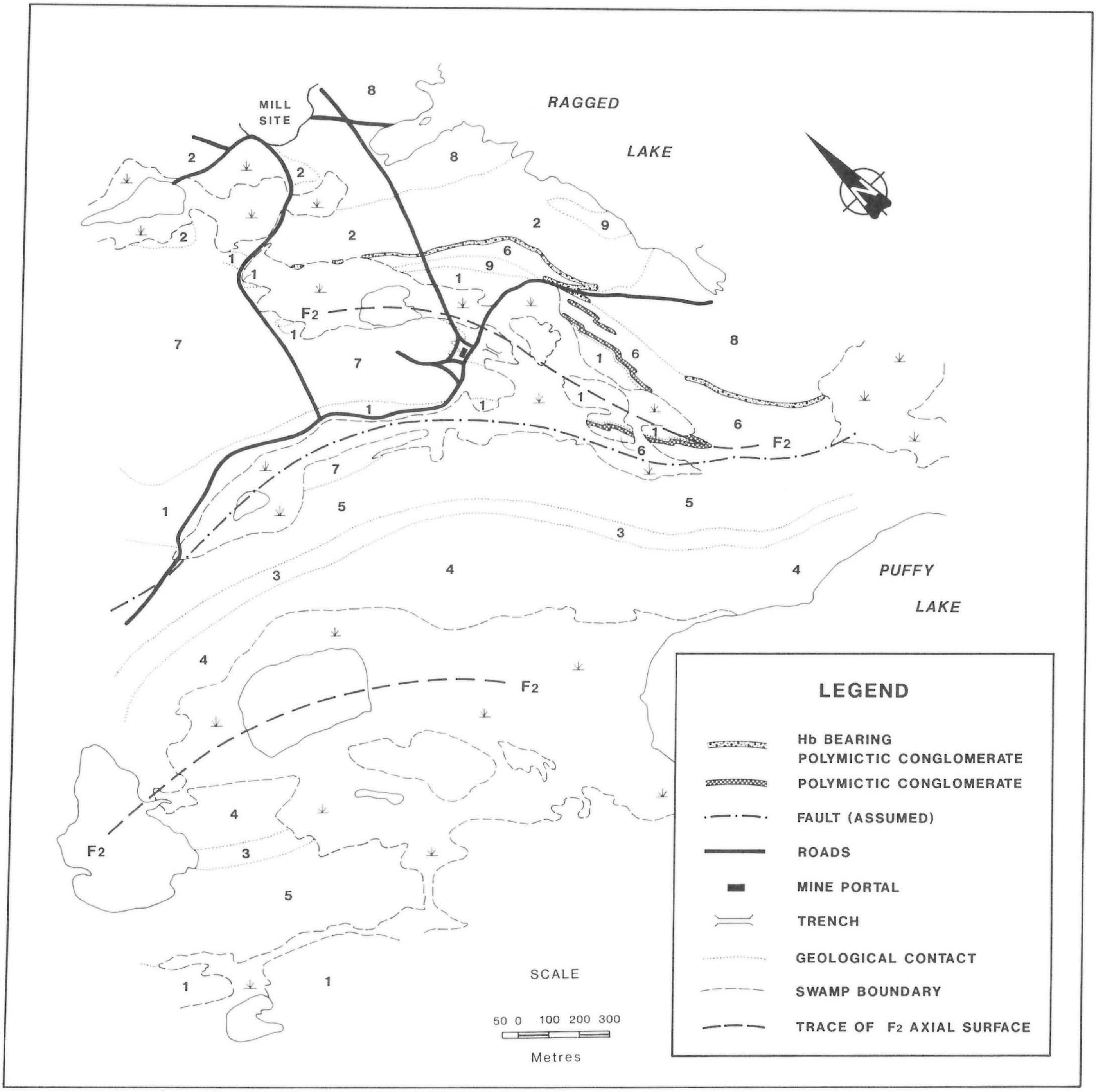

Figure GS-14-1: Geology in the vicinity of the Puffy Lake gold deposit, Puffy Lake. Unit descriptions in text.

UNIT DESCRIPTIONS

Amphibolitic and biotite-rich gneiss (Units 1 and 2)

The intermediate — mafic amphibole-bearing and/or biotite-bearing gneisses are divided into units 1 and 2. Exposures of unit 1 occur in the southwest corner of the map area, trend easterly from the west boundary of the map along the south margin of the tonalite gneiss (unit 7), and occupy the core of a major F_2 fold in the east portion of the map area (Fig. GS-14-1). In the northwest corner of the map, unit 1 rocks terminate within the tonalite gneiss. Unit 1 exposures are interpreted to be part of one continuous stratigraphic unit (Zwanzig, 1984). Lithologically, unit 1 rocks range from layered fine grained massive, garnet- and amphibole-bearing mafic gneisses in the southwest corner to dominantly fine- to medium-grained intermediate biotite-rich ± garnet gneiss with amphibolite (± garnet) interlayers in the core area of the fold.

Four major lithologic types were observed within the layered intermediate — mafic rocks of unit 2, in decreasing order of abundance:

1) fine grained, variably garnetiferous amphibolite ± biotite with numerous calc-silicate rich pods (up to 10 x 30 cm) and abundant feldspar-hornblende ± quartz ± garnet vein/lens mobilizate. Layering on the order of cms to tens of cms is defined by garnet content;
2) fine grained, grey — dark grey weathering, massive quartz-feldspar-hornblende ± biotite ± garnet gneiss;
3) fine grained, cream weathering, feldspar-quartz-biotite felsic gneiss that comprises up to approximately 5% of unit 2; layers range from 1-10 m thick; and
4) a 1-3 m hornblende-bearing conglomeratic layer, with up to 40-50% fragments, that occurs exclusively at the unit 2/unit 6 contact and along the granite (unit 8)/unit 6 contact. Fragments, in decreasing order of abundance, include weakly to moderately magnetic fine- to very fine-grained, pink to pale pink weathering felsic rock, mafic amphibolite, epidote-rich rock (altered amphibolite clasts?), white quartz, moderately to strongly magnetic grey quartz and aphanitic pale pink to white weathering felsic rock.

Biotite-rich gneiss (Unit 3)

Unit 3 is a fine grained, grey weathering, quartz-feldspar-biotite-garnet gneiss that is similar to the greywacke-derived gneisses mapped by Robertson (1953) east of Nokomis Lake.

Fine grained quartzofeldspathic gneiss (Units 4 to 6)

The fine grained felsic quartzofeldspathic gneisses are divided into units 4, 5 and 6, based on spatial distribution and lithologic dissimilarities. These well layered units commonly have 2-3 m thick layers, but massive — banded intermediate hornblende-feldspar gneisses and amphibolite layers are up to 10-20 m thick, particularly in unit 5. Calc-silicate layers/boudins up to 1 m wide (more commonly on the order of centimetres) occur within all three units. The predominant rock types within unit 4 are massive and banded (bands up to 5 cm) pink weathering siliceous quartz-feldspar-biotite ± magnetite gneiss that contains up to a few per cent potassium feldspar-quartz segregation clots 3 cm or less in diameter. Within approximately 50 m of the unit 4/unit 3 contact up to 14 m thick hornblende-feldspar ± biotite ± quartz gneiss units are interlayered with the pink weathering gneiss.

Unit 5 consists of a wide variety of fine grained, felsic, biotite- and/or hornblende-bearing quartzofeldspathic gneisses. The quartzofeldspathic rocks are variably magnetic and weather white, pink, green or gray. Up to 5 cm calc-silicate layers/boudins are common and locally form up to 10% of an individual exposure. Fine grained, intermediate, hornblende-feldspar ± quartz gneiss and amphibolite layers that range from centimetres to 10 m in thickness constitute approximately 10-20% of unit 5. A 10-20 m wide zone of interlayered massive and garnetiferous amphibolite occurs at the unit 5/unit 3 contact.

Unit 6 comprises a sequence of variably magnetic, fine- to medium-grained, white-grey and pale green weathering, biotite-bearing quartzofeldspathic gneiss that contains up to 30% fragmental rock layers. The fragmental rocks include polymictic conglomerates with up to 50-60% clasts in a quartz-feldspar-biotite ± magnetite matrix, and pebbly felsic quartz-feldspar-biotite ± magnetite gneiss (metasandstone) with up to 10% clasts. Both the conglomerates and pebbly layers have very fine grained pink weathering felsic rock fragments, the predominant clast type in both units, and grey quartz clasts that are moderately to strongly magnetic. Other clasts within the conglomerates include pale grey weathering very fine grained felsic rock, white and clear quartz, and very minor intermediate to mafic fine grained rock.

Intrusive rocks (Units 7 to 9)

A white weathering lineated and variably magnetic coarse- to medium-grained tonalitic gneiss (unit 7) and a medium- to coarse-grained pink weathered lineated granite (unit 8) form two major intrusive rock units within the map area (Fig. GS-14-1). Within the tonalitic gneiss a vague 'relic' layering was observed locally that indicates incorporated rafts of fine grained quartzofeldspathic gneiss or vestiges of an anatectic melt. Both rafts and areas of hybridized unit 1 rocks were observed within the tonalite, particularly in the northwest corner of the map within the unit 7/unit 1 contact zone. The granite (unit 8) is massive and apparently devoid of incorporated wall rock. Smaller ellipsoidal medium grained tonalite/granodiorite bodies (unit 9), possibly related to unit 8, intrude unit 2 and at the unit 1/unit 6 contact east of the mine portal. Numerous thin (up to 4 m) sill-like felsic intrusive rocks and pegmatites intrude the quartzofeldspathic gneisses of units 4 and 6.

STRUCTURE

At least three and possibly four periods of deformation have affected the rocks in the vicinity of the Puffy Lake Mine. The earliest deformation recognized (D_1) produced a well developed foliation (S_1) defined by biotite and /or hornblende alignment parallel to compositional layering. Large-scale folds related to D_1 were not identified. Small-scale intrafolial folds within unit 6 (Fig. GS-14-2) display an axial plane foliation (S_1) and may have been produced during D_1 deformation. The second deformation (D_2) produced the most conspicuous macroscopic structures within the map area (Fig. GS-14-1), i.e., two large-scale reclined flexural folds (F_2) that fold the S_1 foliation. Small-scale 'S' asymmetry (Fig. GS-14-3) and 'Z' asymmetry (Fig. GS-14-4) folds are well developed on the limbs of the large fold that occupies the eastern portion of the map area, particularly within unit 6. A well developed mineral lineation that plunges approximately 20-30° at 030-060° and is parallel or close to parallel with F_2 fold axes was generated during D_2. A possible shear foliation or cleavage parallel to the F_2 axial surface is developed locally and appears to be best developed within the biotite- and amphibole-rich rocks of unit 1 that occupy the hinge zone of the east fold.

D_3 deformation has produced local small-scale folds that deform F_2 minor folds (Fig. GS-14-5) about axes with shallow plunges to the east and steeply dipping axial planes. Both the fold axes and the trace of the axial planes trend approximately 070-080°. Quartz rods that are parallel or close to parallel to the F_3 fold axes are well developed in the hinges of F_3 folds. One of the latest deformational events in the map area has gently warped F_2 axial planes and produced local boudinage structures within quartz veins and competent lithologic layers, particularly on the limbs of the F_2 folds. It is unclear whether the warping is a late D_2 feature, related to D_3 deformation or was produced by an even later deformation.

Evidence of faulting within the map area is limited. The fault indicated on Figure GS-14-1 is based on a tentative interpretation from observations that include 1) a geographical linear; 2) discordance of foliations within unit 5 near the western boudary of the map; 3) the possibility that the lens of tonalite (unit 7) gneiss south of the road is displaced; and 4) the presence of increased quartzofeldspathic mobilizate within unit 6 rocks on either side of the geographical linear.

MINERALIZATION

The quartz-sulphide mineralization was described by Ostry (1986). The main zone of mineralization now appears to be contiguous or close to contiguous with the trace of the axial surface of the east F_2 fold.

Figure GS-14-2: Possible D_1 intrafolial folds within layered quartz-rich paragneiss of unit 6. Hinge areas below and to right of scale.

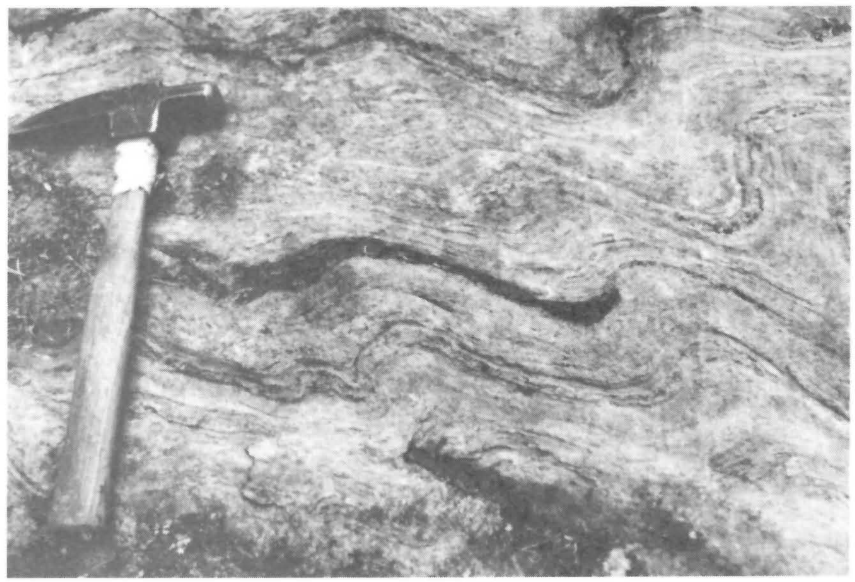

Figure GS-14-3: Minor D_2 S folds within pebbly felsic paragneiss of unit 5.

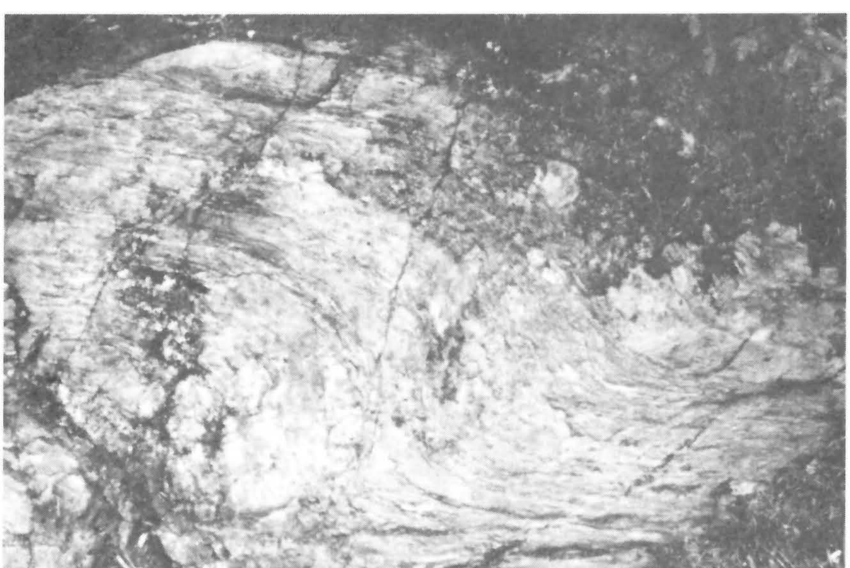

Figure GS-14-4: Minor D_2 S folds within pebbly felsic paragneiss of unit 6.

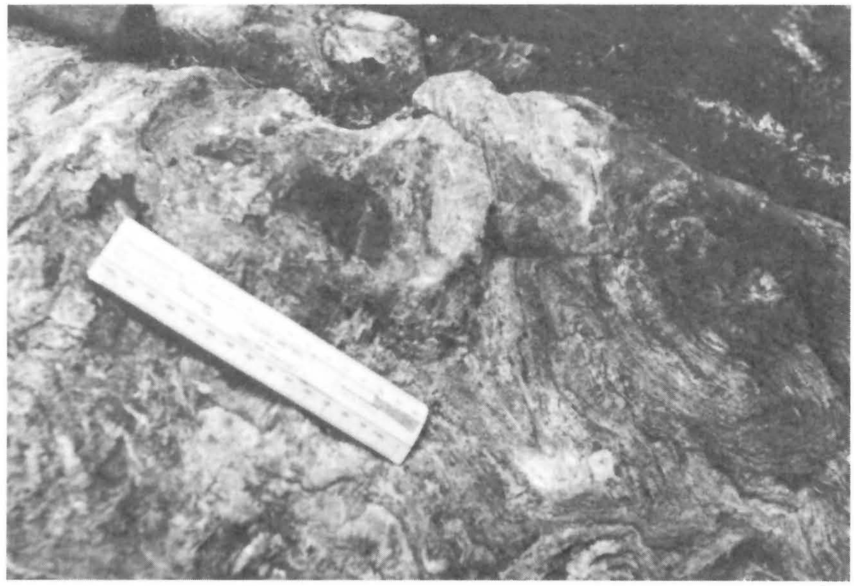

Figure GS-14-5: Small-scale D_3 folds within felsic paragneiss of unit 6.

SQUALL LAKE

Approximately two weeks were spent in the Squall Lake — McLeod Lake area north of the town of Snow lake. Outcrop and geological mapping at 1:5000 was initiated in the vicinity of the gold mineralization south of Squall Lake noted by Harrison (1949).

ACKNOWLEDGEMENTS

Rolf Pippert and Gordon Dorby are thanked for their assistance during the course of the field season. Pioneer Metals Corporation is thanked for their hospitality at the Puffy Lake Mine site during the mapping project.

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GS-15 MINERAL OCCURRENCE DOCUMENTATION — HERBLET AND PULVER GNEISS DOMES AND WEKUSKO LAKE AREA

by M.A.F. Fedikow and C. Malis

Field activities in 1988 were directed towards the completion of mineral occurrence documentation in NTS areas 63J/13, 63J/12, 63K/16 and 63-O/4. Additionally, 1:5000 scale mapping was commenced in the Squall Lake-McCleod Lake area and is described by G. Ostry (GS-14, this volume). A 1:2500 mapping project at Puella Bay, Wekusko Lake, centred on Zn-Pb-Cu-Au-Ag mineralization (Fedikow and Malis, 1987) was completed and included the collection of 1-2 m continuous chip samples from 33 trenches on the property. Outcrop and geology maps were prepared for the vicinity of the Zona occurrence, southeast shore of Wekusko Lake, as well as a number of other scattered mineral occurrences, in order to complete mineral documentation for the NTS areas mentioned above. As in previous years, the analysis of samples collected from this year's mineral occurrence documentation will be available for viewing in a mineral deposit open file as results are received.

I. PUELLA BAY, WEKUSKO LAKE

Geological mapping at 1:2500 scale was completed at Puella Bay and indicates that the Zn-Pb-Cu-Au-Ag mineralization documented in 1987 represents mobilizate related to an intensely foliated zone trending approximately 170°. The development of this zone can be traced from relatively unaltered and non-foliated Missi Group sedimentary rocks; quartz, quartz-feldspar and feldspar-quartz porphryies; and gabbros; to intensely foliated, aphyric, fine grained, equigranular felsic and mafic rocks. The foliation is defined in most places by biotite in both mafic and felsic units and additionally by quartz-carbonate-iron sulphide-biotite streaks in the mafic rocks. Locally, remnant quartz phenocrysts are visible in foliated, equigranular felsic units and can be traced back into undeformed porphyritic intrusions. A second occurrence of polymetallic sulphide mineralization (sphalerite-galena-chalcopyrite-pyrite) was detected on this property and contains a higher concentration of galena than in the mineralized zone discovered in 1987. Pb-isotope ratios will be otained for this mineralization to determine if any relationship can be ascertained between the timing of formation of massive sulphide deposits in the Snow Lake area and this occurrence.

The predominant alteration in the area is carbonatization with lesser amounts of silicification; intense to patchy rusty weathered rocks and fuchsite are common.

II. ZONA OCCURRENCE

The Zona occurrence, located approximately 1.5 km southeast of Broad Bay and 3 km south of Puella Bay on Wekusko Lake, is characterized by relatively narrow (0.5-3 cm) vertically dipping pyritic quartz veins trending 320° that are hosted within a granodiorite intrusion. A shaft and a number of trenches were examined and sampled; the results will be reported in a mineral deposit open file describing mineral occurrences in NTS 63J/12. Although other quartz veins were observed in proximity to the Zone shaft, many appear to be "bull" quartz and vertical whereas others are horizontal in outcrop. Numerous pods or folded lenses of unmineralized white quartz occur in the intrusion and attest to a multiple deformational history in the area. Adjacent to the pyritic quartz veins near the Zona shaft the granodiorite is biotite-rich, silicified and contains disseminated grains of pyrite and deformed pyrite veinlets. This visible alteration extends 5-6 cm from the vein/wallrock contact. Wallrock fragments are observed locally within the quartz veins. Figure GS-15-1 summarizes the geological observations and sample locations around the Zona shaft.

III. GNEISS DOMES

As part of the examination of mineral deposit depositional environments in the Snow Lake area, and stimulated by the occurrence of polymetallic volcanogenic massive sulphide-type deposits (Wim, B Zone) and related alteration zones in felsic metavolcanic rocks at their periphery, the Herblet and Pulver gneiss domes were examined for three weeks. Gossans and gossanous zones mapped by Bailes (1975) at Dowling Lake, Chartier Lake, Stack Lake and Pulver Lake were examined in detail to determine their mineralization and alteration style. Additionally, samples were collected for thin section studies to ascertain whether the gneisses contained zircon suitable for age determinations. Based on preliminary field observations the occurrences are ranked on the basis of mineralogy and alteration as described below.

Herblet Lake Gneiss Dome

DOWLING LAKE

A total of 12 mineral occurrences were examined at Dowling Lake and in the surrrounding gneisses. The locations of these occurrences are illustrated with respect to local geology in Figure GS-15-2. All occurrences are characterized by variable amounts of iron oxide staining and only a few contain visible disseminated sulphide mineralization since surface leaching has commonly reduced the host rocks to a rotten, crumbling, rusty weathered granitoid gneiss. Mineral occurrence characteristics are described below.

Mineral Occurrence #3

This occurrence is characterized by an intensely altered melanocratic hornblende-plagioclase gneiss exposed at the back of a bay on the northern shore in the western part of Dowling Lake. The unit contains 2-3% finely disseminated chalcopyrite in an altered coarse grained matrix of garnet-amphibole(anthophyllite?)-quartz-magnetite. This occurrence was traced across to the western side of the bay where a rusty weathered, locally malachite stained, intensely foliated hornblende-plagioclase gneiss is exposed. Local disseminated chalcopyrite was observed in these rocks in addition to rusty weathered quartz veins without visible sulphides.

Mineral Occurrence #1

This mineral occurrence is exposed for a distance of 2.5 km from the eastern end of Dowling Lake through a large island in the east end of the lake to the mouth of the narrows. This rusty weathered mineralized zone is apparently discordant to stratigraphy since it crosscuts units C1 and C2 (Fig. GS-15-2) and ranges greatly in exposed width from approximately 100 m at its eastern extremity to 1 m at the western end; however, the western part lies under the lake and may be appreciably thicker. Rusty weathered, pyritic quartz veins occur within rusty, garnetiferous, magnetite-bearing C1 granitoid gneiss. Locally 2-5% disseminated pyrrhotite is observed to be accompanied by silicification of the granitoid gneiss. At the western end of the zone disseminated chalcopyrite predominates over pyrrhotite in a silicified zone at the water's edge. The rocks hosting the mineralization are more intensely foliated than the surrounding wallrock. This zone may represent a silicified shear zone with accompanying pyrrhotite-chalcopyrite mineralization.

Mineral Occurrence #2

This mineral occurrence is similar in extent to occurrence #1 and is also marked by rusty weathering, C1 granitoid gneiss. Visible sulphides were observed at only one location along this zone where pyrite was observed in association with a thin zone of silicification. White and rusty weathered quartz veins without visible sulphides were observed at many localities within and along this zone.

Other Occurrences

The remainder of the mineral occurrences examined at Dowling Lake are commonly characterized by rusty weathered C1, C2 or C3 gneisses. Many are fracture controlled, of limited extent, without visible sulphides in outcrop and commonly accompanied by rusty red stained quartz veins. One exception is mineral occurrence #4. This occurrence

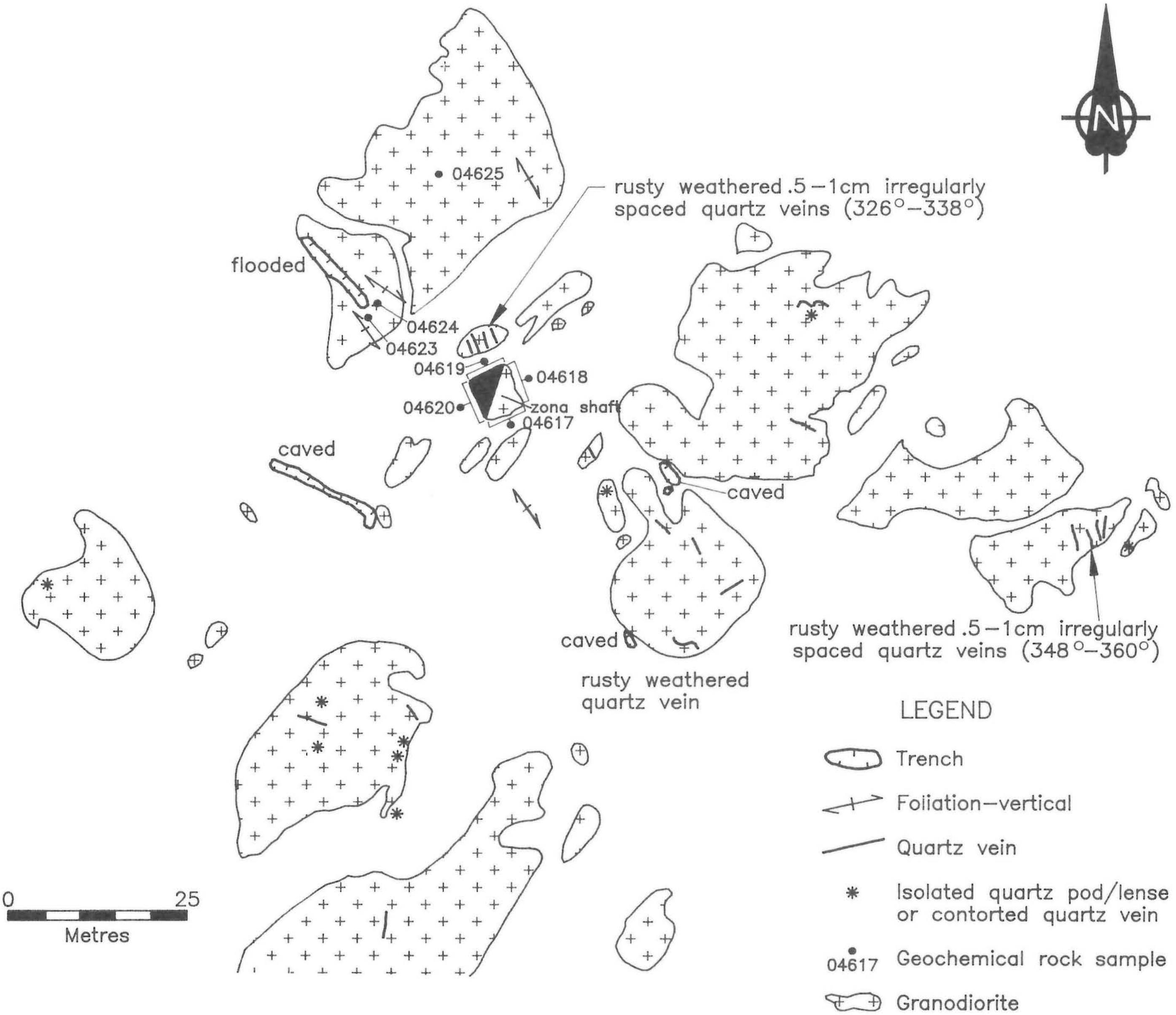

Figure GS-15-1: Geology, shaft and trench locations at the Zona occurrence.

is mapped within a hornblende-plagioclase gneiss; however, it appears to represent a sheared or faulted C1 gneiss. The area is rusty weathered and contains 0.5-1 cm red garnets, 1-3 cm long, bladed amphibole (anthophyllite?), black biotite, and quartz. Visible sulphides were not observed.

CHARTIER LAKE

Mineral occurrences examined in the Chartier Lake area are similar, for the most part, to those at Dowling Lake with respect to mineralization and alteration mineral assemblages. Generally, the occurrences are marked by disseminated (less than 10%) sulphide minerals that are accompanied by patchy rusty weathering of variable extent and intensity. Mineral occurrences examined on Chartier Lake and local geology are shown in Figure GS-15-3.

Mineral Occurrence #13

This occurrence, marked as gossan by Bailes (1975), comprises 8 mm-1 cm red garnet and bladed amphibole (anthophyllite?) in a rusty weathering plagioclase-quartz matrix. Due to lichen and moss covered outcrop it is difficult to determine whether or not this zone is part of a much more extensive and intensive alteration system developed along the southwestern shore of Sheps Lake at the eastern end of a portage from Chartier Lake. This alteration system is developed in C2 hornblende-plagioclase gneiss and at the Sheps Lake portion of the occurrence the alteration is characterized by the assemblages:

1. relatively unaltered hornblende-plagioclase C2 gneiss
2. hornblende-plagioclase gneiss with red, uniformly distributed, 1-3 mm euhedral to subhedral garnets
3. coarse grained mineral assemblage of 4 mm to 3 cm red garnets, 3 mm-1 cm bladed and blocky amphiboles, black and brown biotite and minor disseminated pyrite
4. intensely silicified hornblende-plagioclase C2 gneiss with subhedral to euhedral, 2-7 mm red garnets, local remnants of the hornblende-plagioclase precursor, and 2-5% disseminated pyrite and chalcopyrite.

This zone is traceable for more than 100 m along the narrow strip of land separating Chartier Lake from Sheps Lake and its full extent is unknown owing to the paucity of exposure in this area.

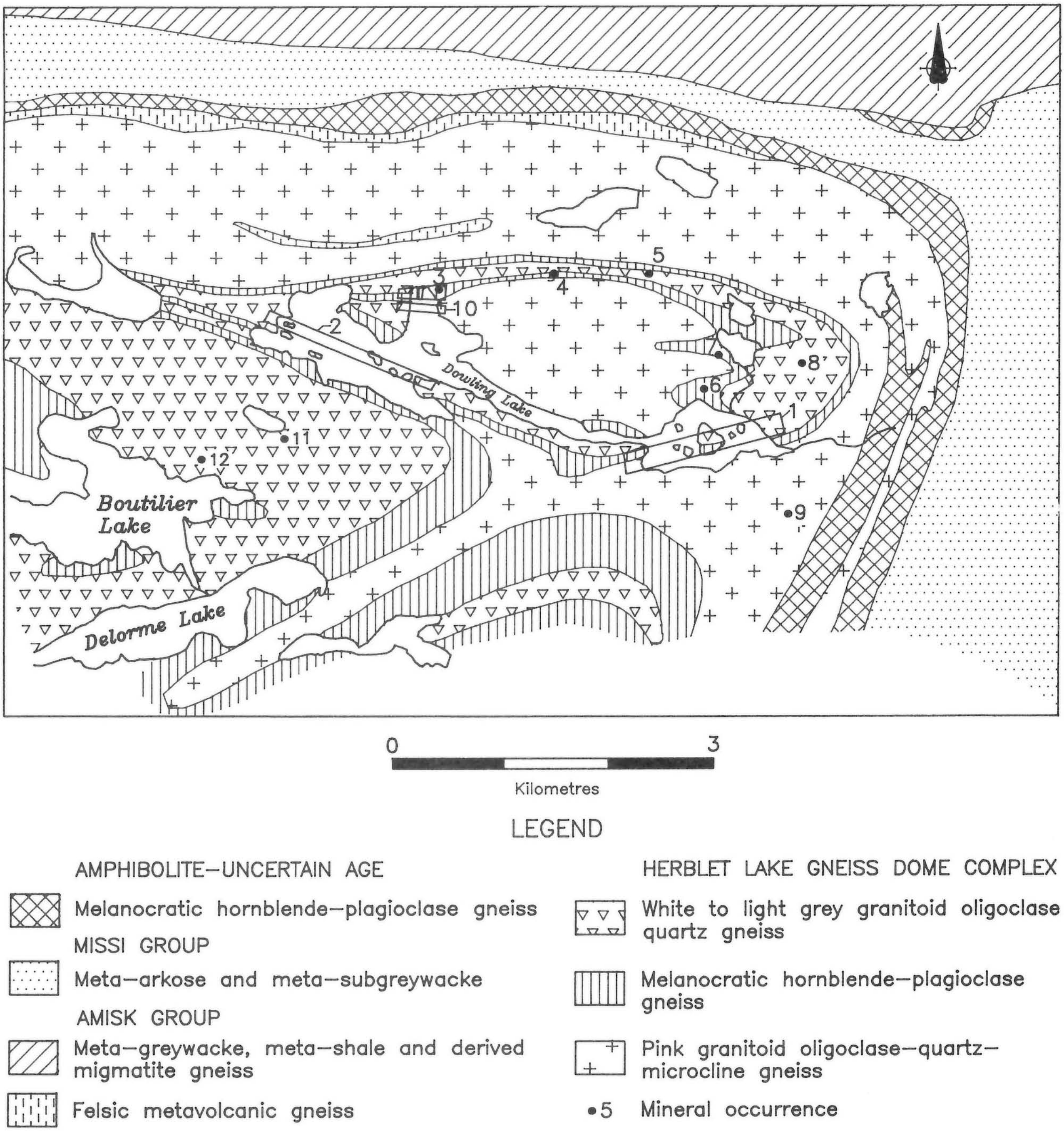

Figure GS-15-2: General geology (after Bailes, 1975) and mineral locations, Dowling Lake, Herblet Lake Gneiss Dome Complex.

Mineral Occurrence #4

This occurrence is located at the western end of Chartier Lake in association with two en echelon ground electromagnetic anomalies defined by Hudson Bay Exploration and Development Ltd. between 1957-1972. Three drill holes tested these anomalies and from available information (Bailes, 1975) the holes intersected 5-15 feet (1.5-4.5 m) of graphite and pyrite-pyrrhotite mineralization. The gossanous zone representing occurrence #16 may be associated with this type of mineralization. The gossan occurs as an intermittent zone of intensely foliated, rusty weathered gneiss containing less than 1% disseminated pyrite in wallrock and thin reddish quartz veins within a felsic pegmatite (C2 raft?). This zone continues westward and becomes wider and more intense within C2 hornblende-plagioclase gneiss. The C2 gossan zone comprises intensely silicified and rusty weathered rocks containing 1-2% disseminated pyrrhotite, pyrite and chalcopyrite.

Other Occurrences

Mineral occurrences #14, #15, #16, #17 and #18 are characterized by the development of limited alteration and mineralization. Occurrences #14 and #17 comprise rusty-weathered C2 hornblende-plagioclase gneiss with a few grains of pyrite close to the contact with C3 oligoclase-quartz-microcline granitoid gneiss. Occurrence #15 represents an isolated rusty weathered zone of coarse grained amphibole-biotite gneiss without visible sulphides flanked by salmon pink C3 granitoid gneiss. Patchy rusty weathering was observed in C3 gneisses in proximity to the occurrence. Occurrence #18 is hosted by rusty weathered C3 gneiss with a few grains of pyrite and pyrrhotite.

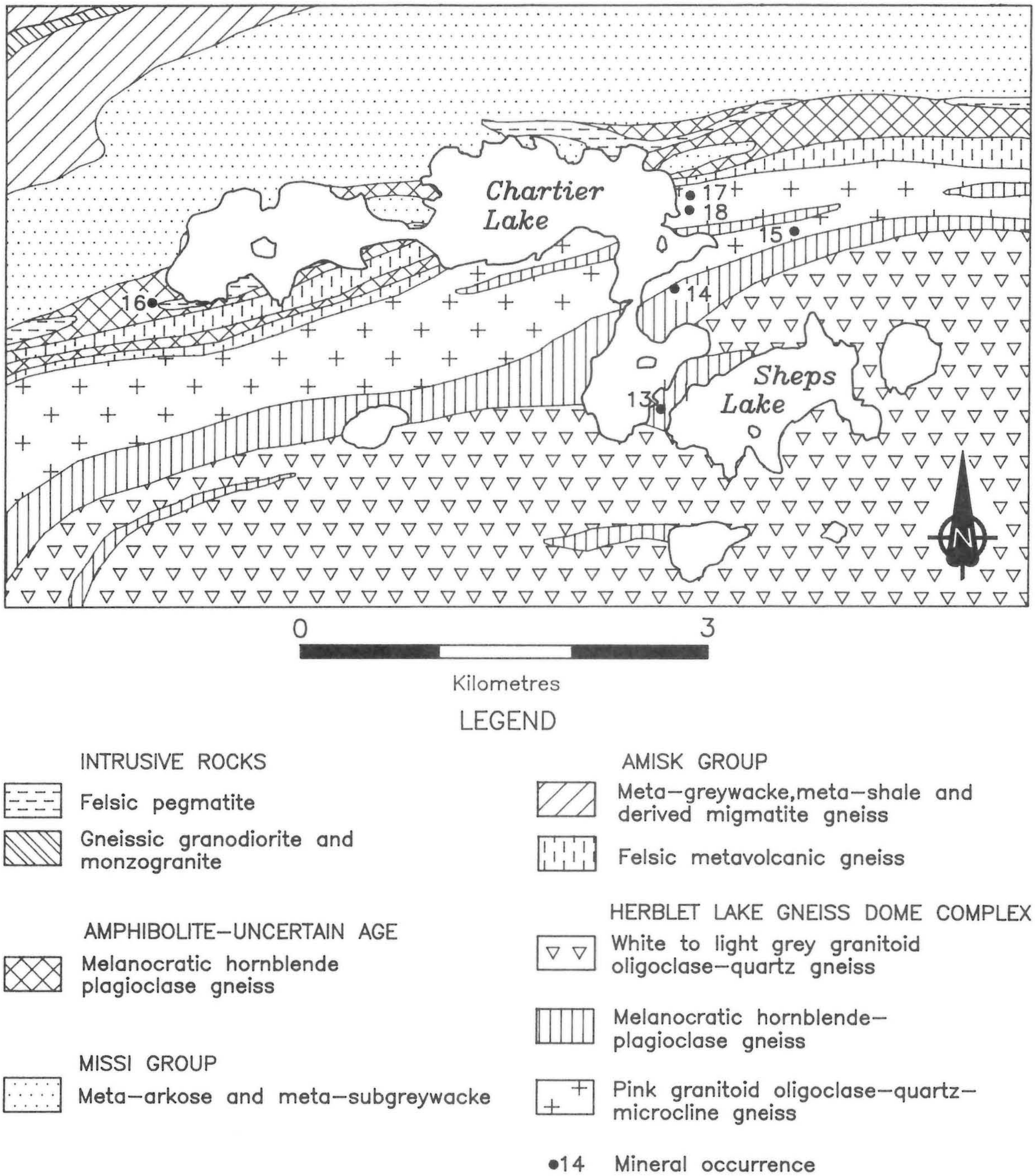

Figure GS-15-3: General geology (after Bailes, 1975) and mineral occurrence locations, Chartier Lake, Herblet Lake Gneiss Dome Complex.

STACK LAKE

Two mineral occurrences were examined on the east shore of Stack Lake (Fig. GS-15-4). Occurrence #19 is a rusty weathered quartz vein with 1% disseminated pyrite hosted by a rusty weathered white to light grey oligoclase-quartz granitoid gneiss. Occurrence #20 is located at the tip of a short peninsula and comprises rusty weathered melanocratic hornblende-plagioclase gneiss. This gneiss has been altered to a coarse grained assemblage of garnet (5 mm-2 cm)-amphibole(anthophyllite?, 5 mm-1 cm)-black biotite set in a rusty weathering matrix of quartz and plagioclase. Approximately 1-2% finely disseminated pyrrhotite and chalcopyrite occur in the matrix and at the boundaries and cores of the garnets.

Pulver Lake Gneiss Dome

The Pulver Lake gneiss dome, east and adjacent to the Herblet Lake gneiss dome, is characterized by numerous, extensive zones of alteration and mineralization associated with: (1) white to light grey granitoid oligoclase-quartz veins; (2) melanocratic hornblende-plagioclase gneiss; and (3) pink granitoid oligoclase-quartz-microcline gneiss (Bailes, 1975). These gneisses are the same rock units that host the mineralization examined in the Herblet Lake gneiss dome. The occurrences examined within the Pulver Lake gneiss dome and their relationship to the individual gneiss units are illustrated in Figure GS-15-5. Mineral occurrence characteristics are described individually below.

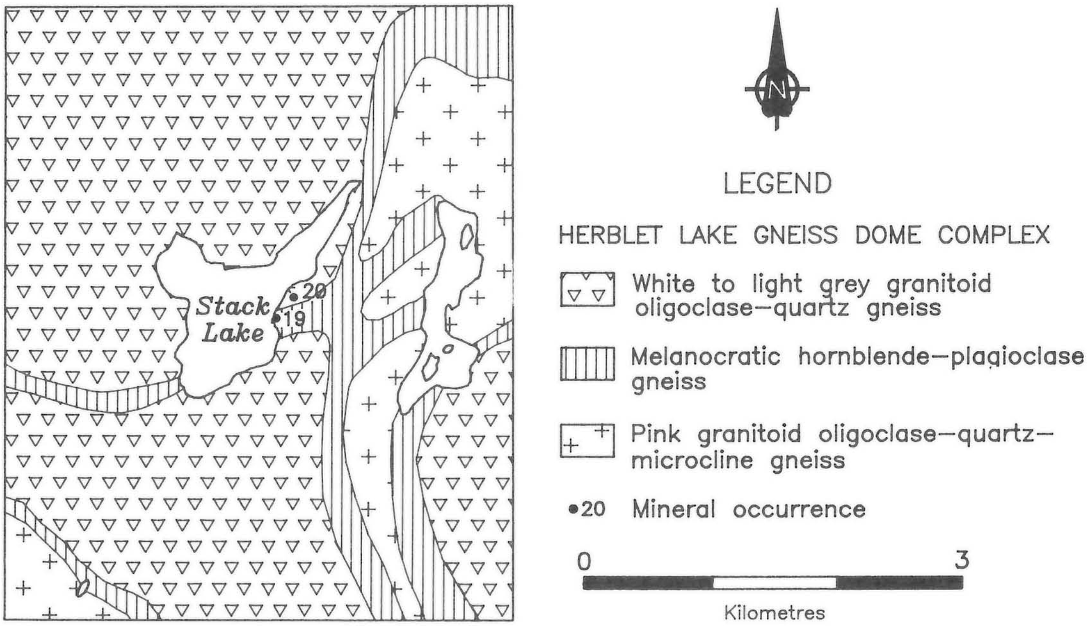

Figure GS-15-4: General geology (after Bailes, 1975) and mineral locations, Stack Lake, Herblet Lake Gneiss Dome Complex.

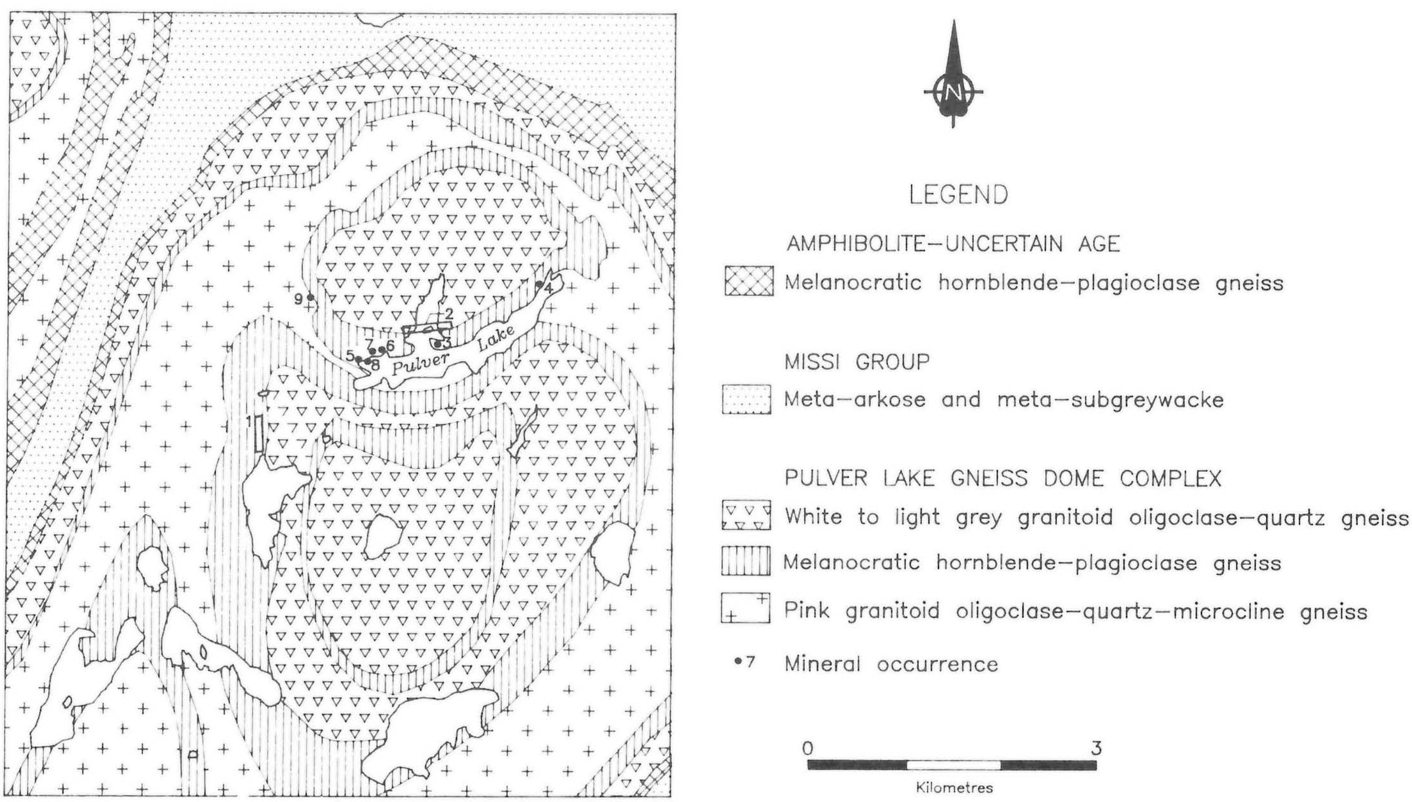

Figure GS-15-5: General geology (after Bailes, 1975) and mineral occurrence locations, Pulver Lake, Pulver Lake Gneiss Dome Complex.

Occurrence #1

An extensive, approximately 0.5 km zone of patchy and intensive rusty weathered C2 amphibolite gneiss is exposed on the northern shore of an unnamed lake southwest of Pulver Lake. At this locality the C2 gneiss comprises alternating 5-20 cm layers of medium grained amphibolite-biotite-garnet with plagioclase-potash feldspar-quartz-biotite layers of equivalent thickness. Mineralization is characterized by 3-5% disseminated pyrrhotite and rare chalcopyrite. Unmineralized white quartz veins occur in the amphibolite and parallel the foliation in the rocks.

Occurrence #2

This occurrence is exposed on a small island in the northern arm of Pulver Lake and for a distance of approximately 300 m east of the island on the mainland. A zone of rusty weathered and silicified garnetiferous C1 granitoid gniess with 1-5% disseminated pyrrhotite and subhedral to euhedral magnetite characterizes this occurrence. White, 4-8 cm thick rusty weathering quartz veins occur throughout this alteration zone and contain 1% disseminated pyrite. At many locations the outcrop is rotten as a result of sulphide weathering. Unmineralized white quartz veins are also present in association with this zone. Three samples were collected for geochemical analysis, two representing mineralized quartz veins and one representing the silicified pyrrhotite-bearing C1 gneiss.

Occurrences #3 to #8

These mineral occurrences are described together since they are spatially related to shoreline exposures of silicified and rusty weathered C2 amphibole-plagioclase gneiss.

Occurrence #3 is situated at the east end of Pulver Lake adjacent to a pink pegmatite intrusion. At that location 1-5% disseminated pyrrhotite occurs in silicified rusty weathered C2 gneiss. A second mineralized zone, 5-7 m from the pegmatite-C2 gneiss contact, contains 1-5% disseminated pyrite. Mineral occurrences #3 and #5-#8 all occur at the west end of Pulver Lake within silicified and rusty weathered C2 gneiss and contain a maximum of 5% disseminated pyrite $\pm$ pyrrhotite and chalcopyrite. Occurrence #3 contains 1-3% disseminated pyrite hosted by weathered to rotten C2 gneiss. Occurrences #6 and #7 are characterized by 1-3% disseminated pyrite and pyrrhotite along biotite-rich foliation planes with an exposed width of 0.5 m. Occurrence #5 is situated near the contact between salmon pink granitoid C3 gneiss and C2 amphibole-plagioclase gneiss. The occurrence comprises two quartz veins each with a distinctly different character which appears to be directly related to the nature of the host rocks. One quartz vein that occurs within C3 gneiss is white and contains a few rusty areas and 1% disseminated pyrite within the vein. The wallrock is visually unaltered. The other quartz vein occurs within C1 gniess, but is rusty weathered and vuggy from the solution of sulphide minerals; it still contains 1-3% disseminated pyrite. The wallrocks of this quartz vein are intensely rusty weathered. Both quartz veins were sampled for geochemical analysis.

Occurrence #8 is the most intensely altered of the Pulver Lake occurrences and can be traced from a shoreline exposure for 100 m in a northwest direction. The zone is 50 m wide and contains 5% disseminated pyrite as well as pyrite blebs and veinlets. This C2 gneiss has been silicified and intensely altered to a quartz-muscovite rock. Occurrence #9 consists of rusty-weathered C3 pink granitoid gneiss with 1-5 cm thick unmineralized white quartz veins and approximately 2% disseminated pyrite adjacent to the quartz veins in the wallrock. A single sample was collected for analysis.

A large number of variably mineralized and altered occurrences have been given cursory examination in the Herblet and Pulver gneiss domes. Although a much broader perspective is required to shed light on the origin of these gneisses, the similarities in alteration styles of gneiss hosted mineralization to mineral deposits examined in Amisk volcanic rocks in the Snow Lake area indicates the need for a more detailed examination of these domains. Accordingly, 1:5000 scale mapping projects will be commenced in 1989 to elucidate details of some of the more extensive alteration zones encountered this summer.

IV. MINERAL OCCURRENCES — 63J/13

OSBORNE MINE ROAD OCCURRENCES — HL-150 AND HL-151

Two spatially related mineral occurrences were examined along the Osborne Mine road close to the Herblet Lake access road. Both mineral occurrences are situated within felsic pyroclastic and/or volcaniclastic rocks (Froese and Moore, 1980) and comprise patchy to intensely rusty-weathered and silicified felsic and mafic volcanic and volcaniclastic rocks containing 1-5% disseminated pyrrhotite, pyrite and rare chalcopyrite. Mineral occurrence HL-150 (Fig. GS-15-6) is characterized by interbedded mafic volcaniclastic and fragmental rocks containing disseminated iron sulphides and fragmental (fine to medium grained siliceous fragments with red garnet and magnetite rimmed by 0.5 cm amphibole-biotite rinds) and aphyric, massive felsic volcanic rocks. Pyroxene-phyric mafic dykes intrude the mafic volcaniclastic and fragmental rocks. West of this occurrence alteration assemblages of (1) garnet-kyanite-biotite and (2) garnet-cordierite-anthophyllite-biotite were observed in rusty weathered felsic volcanic rocks. Mineral occurrence HL-151 (Fig. GS-15-7) consists of patchy to intensely rusty weathered silicified felsic volcanic rocks containing 1-5% disseminated pyrrhotite and pyrite. Red-brown garnets (1-4 mm) have irregular distribution in outcrop. Abundant, very fine grained, siliceous quartz-phyric felsic units occur throughout the outcrop area. These units are generally not rusty weathered although they may contain less than 1% disseminated pyrrhotite. At one locality these units truncate an earlier foliation developed in biotite-garnet rusty weathered rhyolite and accordingly may be rhyolite dykes.

YUKON LAKE OCCURRENCES

Three mineral occurrences were examined along the west and north shore of Yukon Lake, a small north-south oriented lake southwest of Roberts Lake. The area of the occurrences is mapped as greywacke and derived schists and gneisses by Frarey (1950; Map 987A). The occurrences appear as small X's on map 987A along the west and north shores of Yukon Lake (Fig. GS-15-8). Occurrence #1 contains 1-2% fine grained, white pyrrhotite, pyrite, and very minor chalcopyrite in foliated (027°, vertical dip) medium grained, locally silicified gabbro. Calcite veinlets are present in the gabbro; rotten, rusty weathered intensely foliated and silicified float was observed adjacent to the outcrop. Two chip samples were collected for analysis. Trenches were not observed at this locality.

Occurrence #2 consists of 1-5% disseminated pyrrhotite exposed in two trenches approximately 25 m west of occurrence #1. Detailed mapping in proximity to the mineralization (Fig. GS-15-9) indicates the mineralization and intensely foliated, rusty weathered and silicified wallrocks occur at or near the contact between interbedded greywacke and arkose and medium grained gabbro. The actual host rocks to the mineralization cannot be ascertained due to the intense alteration. A 40 cm thick, white quartz vein with scattered pyrite and rusty areas occurs in association with this mineralized zone and can be traced along strike from trench #1 to trench #2 and also in broken and rubbly outcrop north of trench #2. Carbonate blebs and veinlets and needles of tourmaline are also present in the quartz vein and the wallrocks. The zone of alteration has an approximate thickness of 15 m at surface. A total of six chip samples of the mineralized wallrocks and quartz vein were collected for analysis.

Occurrence #3 is exposed in a few outcrops in low ground approximately 825 m north of occurrence #2. At this locality a 15 m wide mineralized zone is situated in a gully at or near the contact of medium grained gabbro and bedded greywacke. Wallrocks are intensely foliated and silicified and are mineralized with 1-2% disseminated pyrrhotite and trace chalcopyrite. The intensely foliated but non-silicified wallrocks that occur on the western edge of the occurrence comprise rusty weathered to rotten chlorite-sericite schists, with veinlets and disseminations of carbonate and tourmaline. Barren thin white quartz veins are also present. The foliation at this locality is 021° and, because of the disrupted nature of the outcrop, the dip is uncertain but is suspected to be near vertical. Two chip samples were collected for analysis.

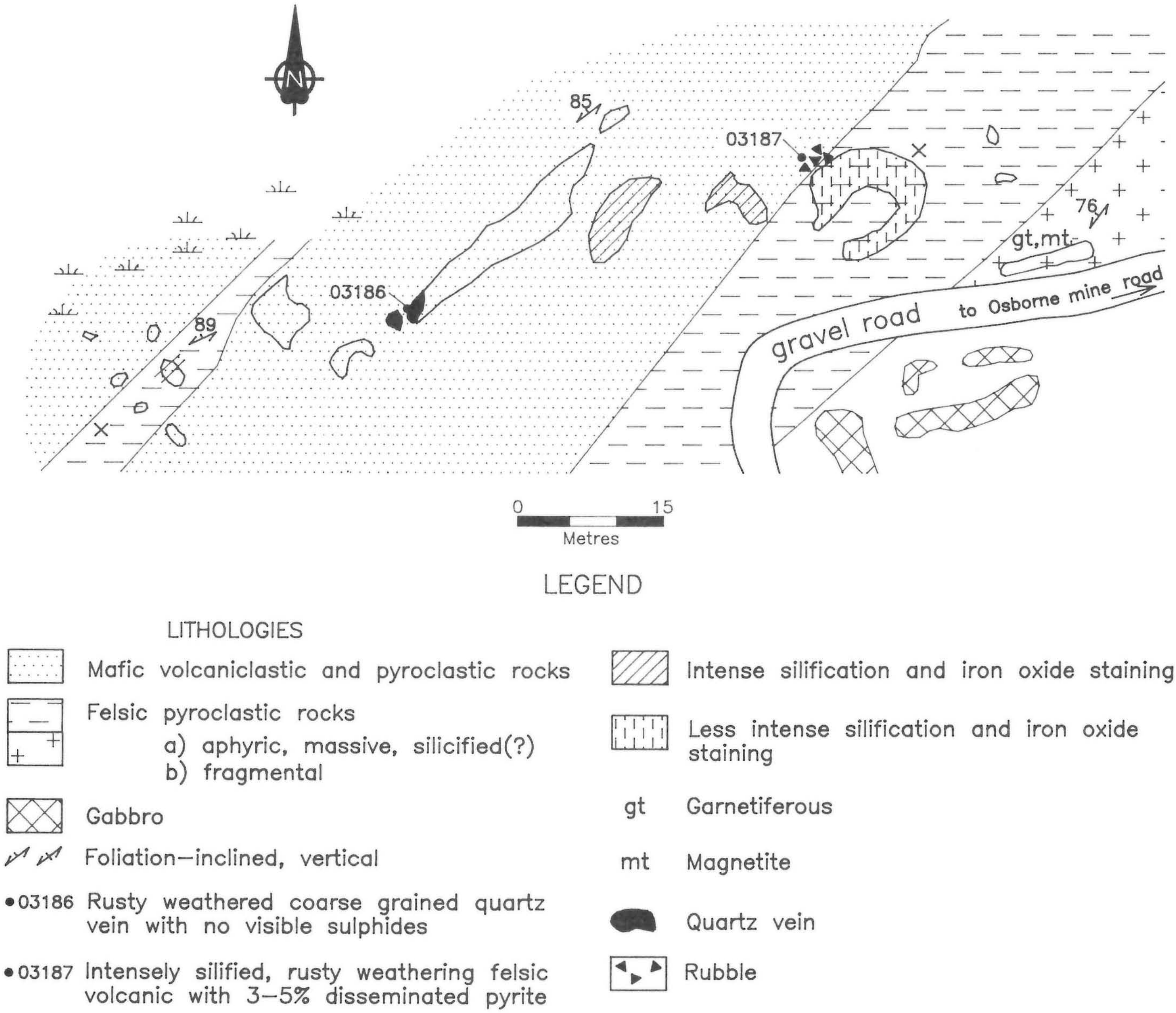

Figure GS-15-6: Geology and sample location map for mineral occurrence HL-150 (63J13-150).

All three mineral occurrences in the Yukon Lake area have similarities with respect to mineralization, alteration and geological setting. These occurrences appear to be restricted to the contact zones of gabbro and greywacke where the contrast in competence between two lithologies acted as a deformational focus. Accordingly, fluid flow would be directed along the intensely foliated contacts resulting in the silicification and mineralization observed. Occurrences #2 and #3 appear to lie along the eastern side of an extensive fault mapped by Farey (1946) which separates massive, fine grained and porphyritic basalt from epiclastic sedimentary rocks in the Yukon Lake area. This fault is indicated by elongate curvilinear swamps on airphotos.

V. MINERAL OCCURRENCES — 63J/12

WATTS RIVER Au OCCURRENCE

This mineral occurrence was located approximately 4 km southwest of Watch Lake and 1 km north of the Watts River in an area of little geological information (cf. Map 987A, Frarey, 1950). The occurrence consists of two main sets of mineralized quartz veins within a fine- to medium-grained mafic rock that is interpreted to be a gabbro. These two vein systems have attitudes of 015° and 050° and contain mainly pyrite with lesser chalcopyrite and rare sphalerite. A total of 44 trenches and one flooded shaft of undetermined depth were located on the property. Visible gold (0.5-2.0 mm) was observed within gabbroic wallrock adjacent to or within the quartz veins in samples of muck around the shaft. The quartz vein system has an approximate strike length of 520 m. Some diamond drilling has been undertaken on the property as evidenced by several unlabelled boxes of drill core observed within derelict cabins adjacent to the shaft. The drill core is medium grained gabbro with rusty-weathered quartz veins. Generally, alteration is restricted to about 6 cm from the vein-wallrock contact although bleached and silicified gabbro was observed up to 1 m away from the vein. Extensive lichen cover of the outcrop in the area and slumped, overgrown trenches on the property makes geological assessment of this Au occurrence difficult. A program of outcrop cleaning, trench mucking and 1:5000 scale mapping is required in the area before a proper evaluation can be undertaken. A total of 17 chip samples representing vein material, wallrock and muck from around the shaft were collected. The sample and trench locations and a preliminary outcrop and geology map are presented in Figure GS-15-10.

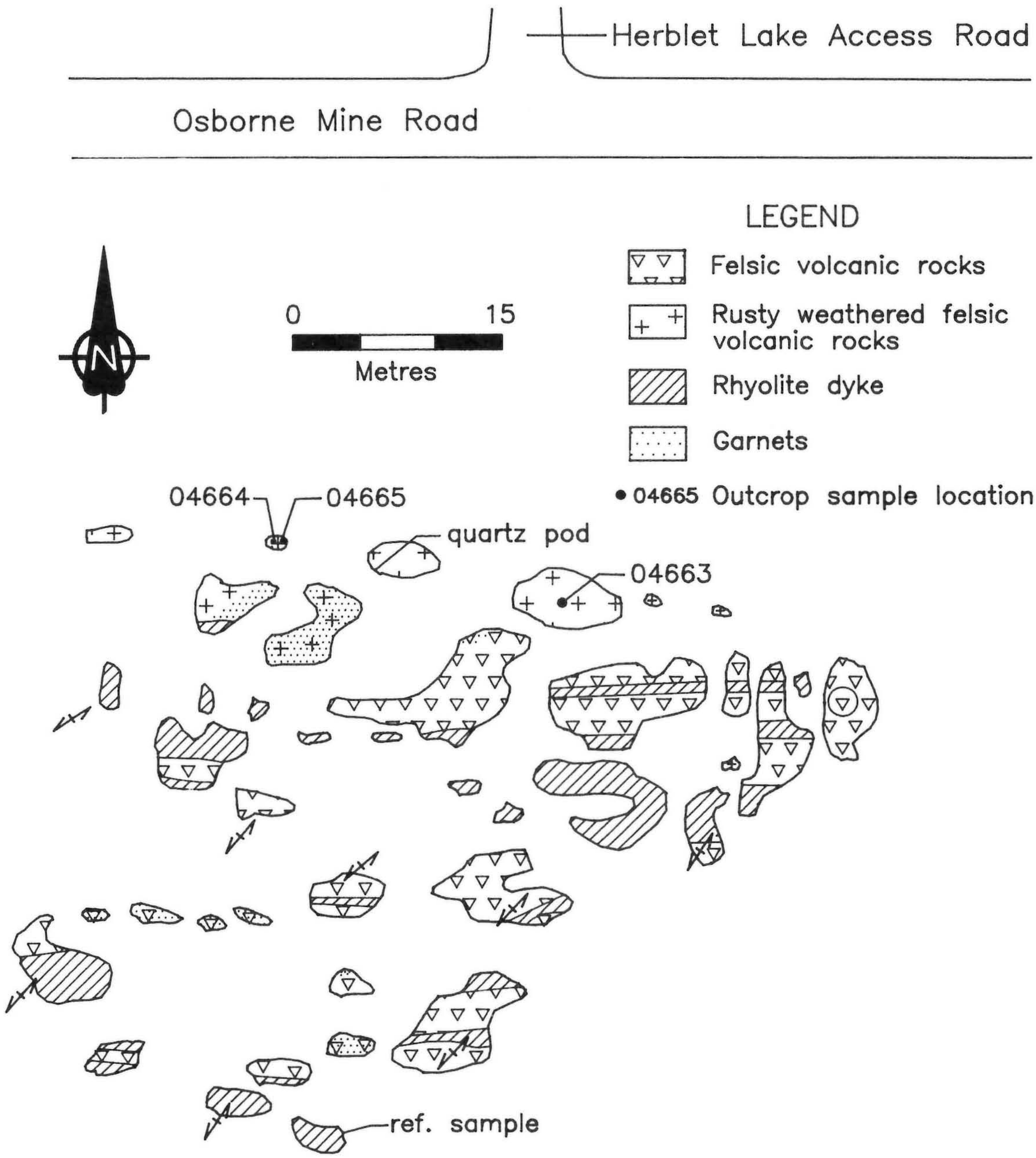

Figure GS-15-7: Geology and sample location map for mineral occurrence HL-151 (63J13-151).

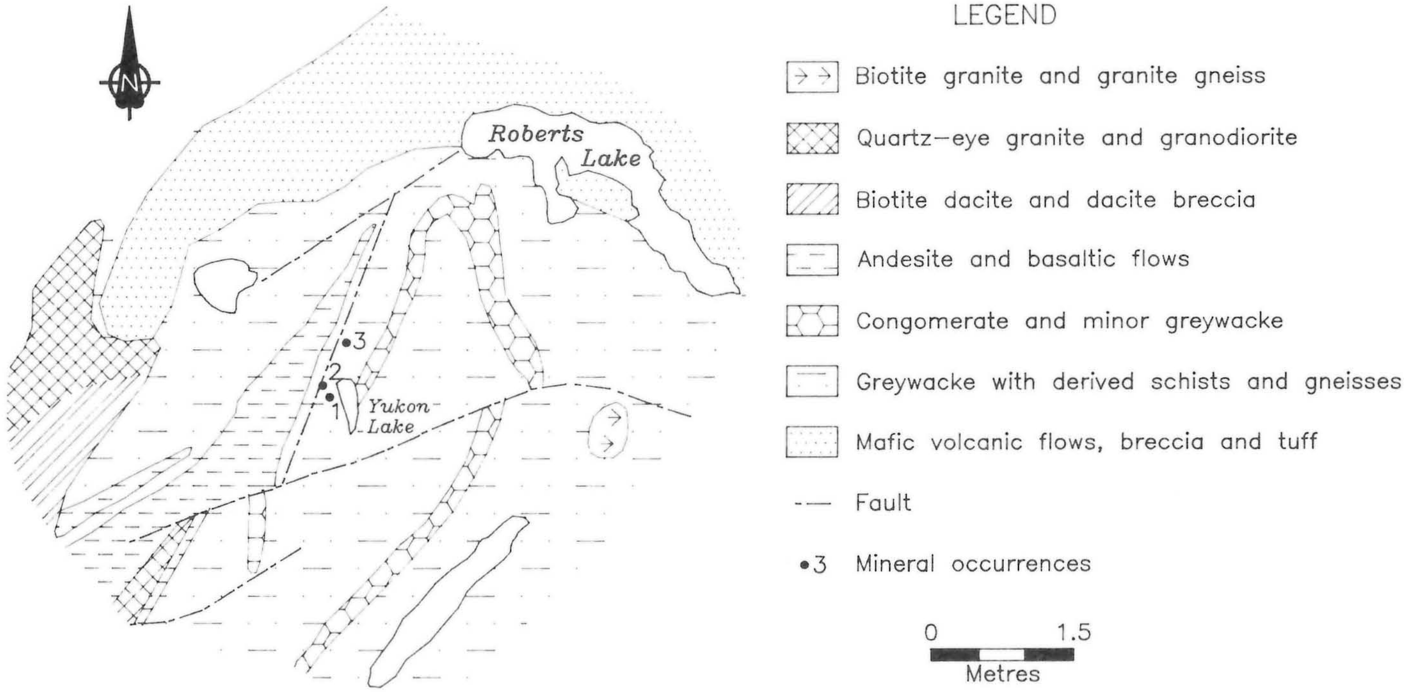

Figure GS-15-8: Local geology (after Frarey, 1950; Map 987A) around the Yukon Lake mineral occurrence.

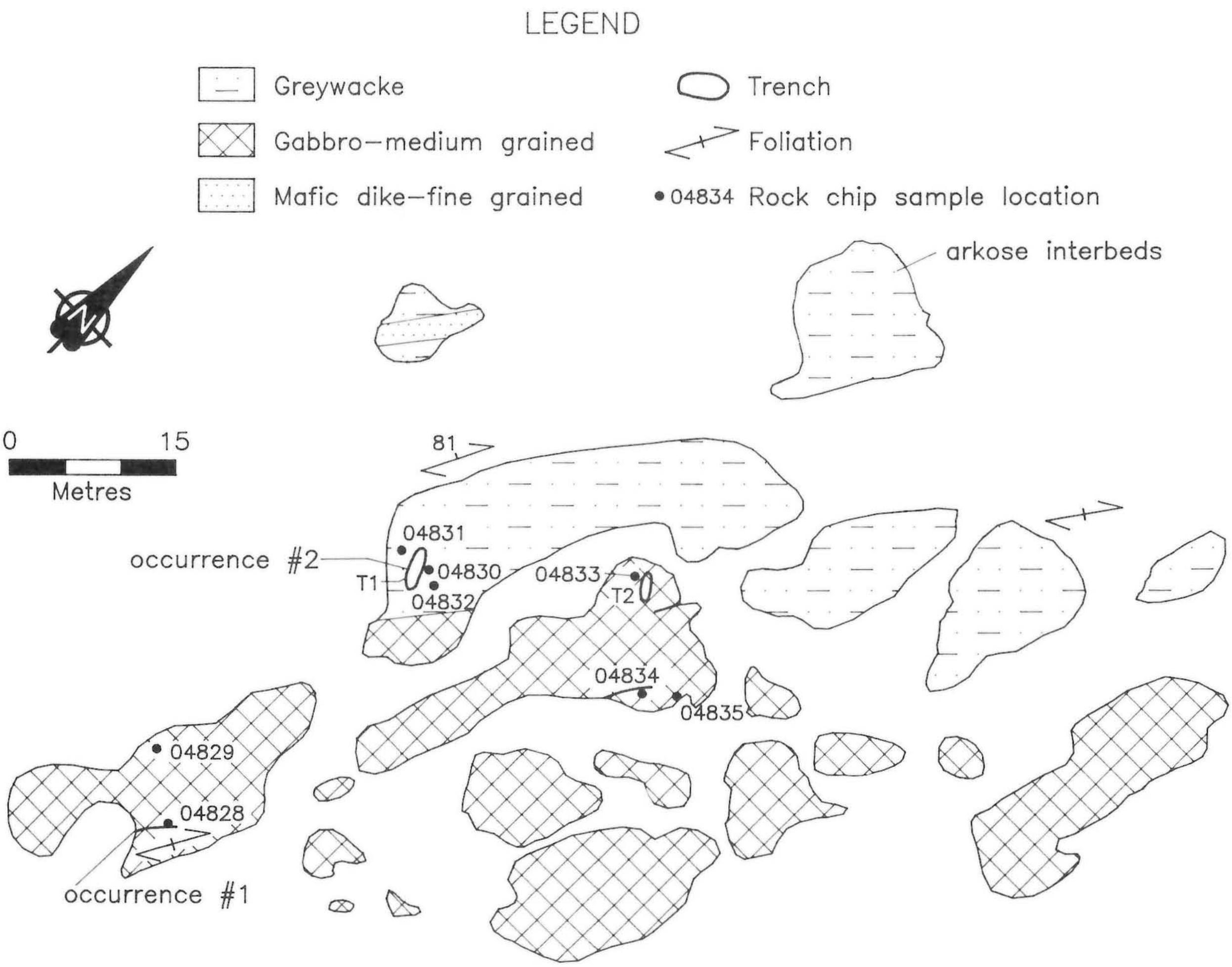

Figure GS-15-9: Geology, trench location and sample location map for Yukon Lake mineral occurrences 1 and 2.

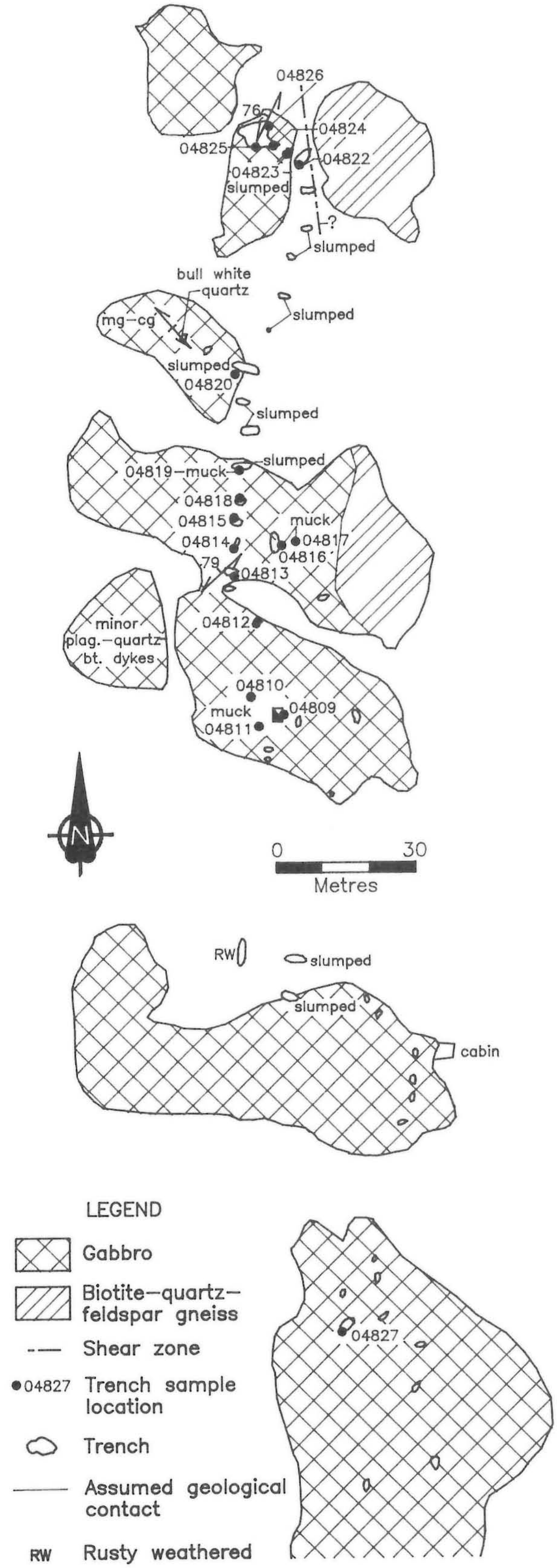

Figure GS-15-10: Geology and trench location map for the Watts River Au occurrence.

VI. MINERAL OCCURRENCE — 63-O/4

NORTH CABIN VEIN OCCURRENCE

A sparsely mineralized quartz vein system outcrops on a north-south oriented island at the northern end of the northeast arm of Herblet Lake. The vein system is hosted by garnetiferous amphibolite mapped as massive basalt by Froese and Moore (1980). The amphibolite is intensely silicified for 1 m on either side of the veins which lie within the plane of foliation of the amphibolite. Scattered grains of pyrite are observed within the quartz veins; the wallrocks are not mineralized. The geology of this occurrence and the locations of samples collected from the property are illustrated in Figure GS-15-11.

ACKNOWLEDGEMENTS

We acknowledge the assistance of Dan Ziehlke (Pro Roc Explorations Inc.) and Jim Corman (Snow Lake) during visits to the Yukon Lake and Watts Creek occurrences. Al Johnston (Granges Exploration Ltd.) is thanked for discussions regarding the Zona Au occurrence.

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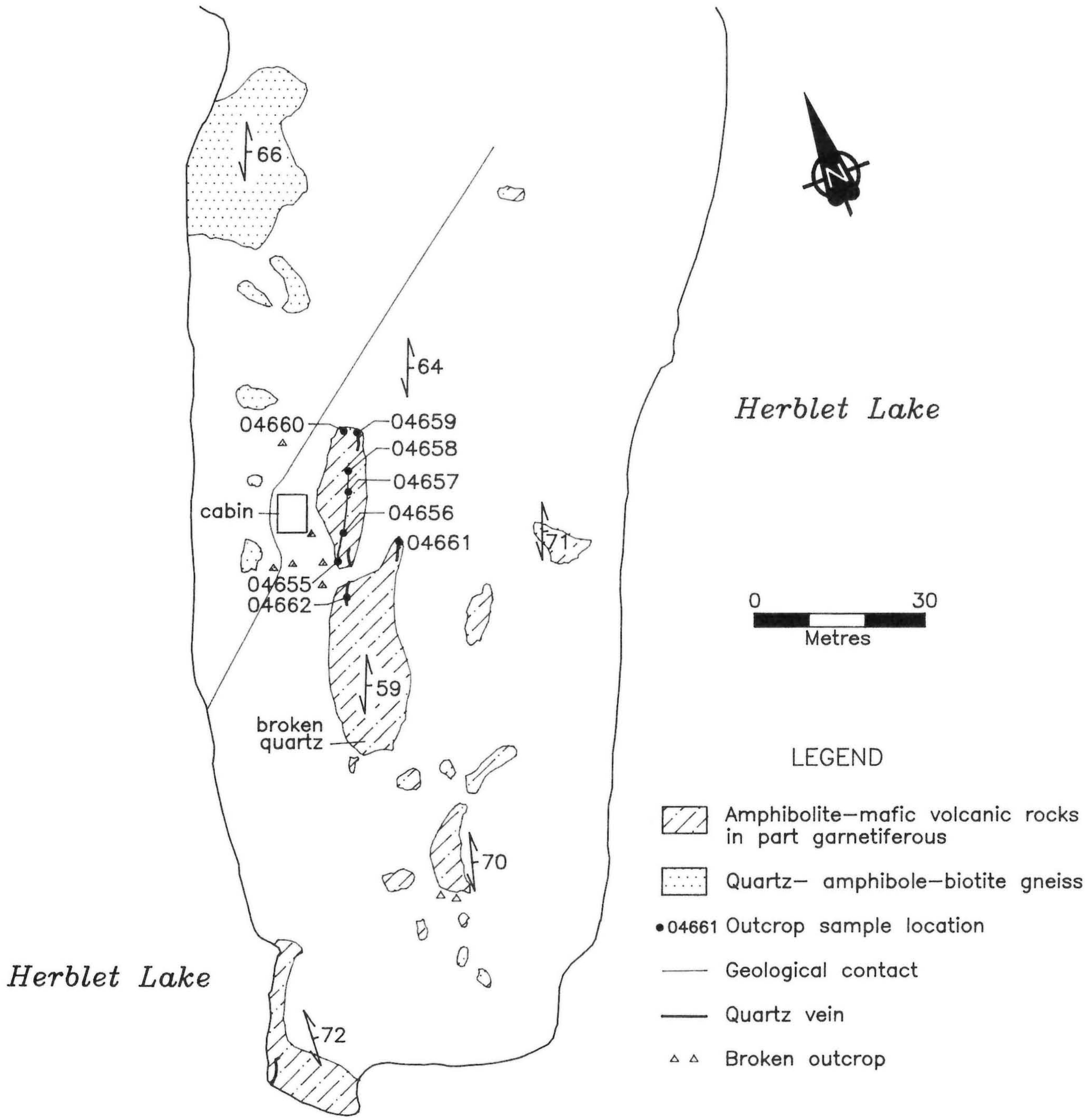

Figure GS-15-11: Geology and sample locations for the North Cabin vein occurrence.

GS-16 MICROPROBE ANALYSIS OF PYROXENES IN THE AMISK GROUP, FLIN FLON

by A.C. Turnock[1] and E.C. Syme

The tectonic affinity of Early Proterozoic metavolcanic rocks in Manitoba is of considerable importance in reconstructing the tectonic evolution of the Trans-Hudson orogen. Recent detailed mapping of Amisk Group metavolcanic rocks near Flin Flon has defined their range of composition, environment of deposition and stratigraphic relationships (Bailes and Syme, 1987). The major- and trace-element geochemistry of Amisk Group rocks suggests that they were emplaced in an oceanic island arc (Syme, in press). All of the metavolcanic rocks are to some extent altered from pristine original compositions, however, so it is important to analyze some component of the rock that has remained totally unaltered. To that end, fresh pyroxene phenocrysts in volcanic rocks within the subgreenschist (prehnite-pumpellyite) zone of metamorphism have been analyzed by electron microprobe at the University of Manitoba. The minor element compositions and Mg/Fe ratios of the pyroxenes can be compared to pyroxene compositions in volcanic suites of known tectonic affinity and stage of differentiation.

Samples were obtained from the Hook Lake block, 10 km southeast of Flin Flon; lithologies include mafic flows and pyroclastic tuff and tuff breccia. Of 25 samples, 19 were found suitable for analysis. Subgreenschist metamorphic conditions have produced dominantly hydrous metamorphic assemblages replacing the fine grained groundmass and plagioclase phenocrysts in the rocks. Pyroxenes, however, appear fresh with no sign of oxide pigmentation that would indicate alteration. In the 19 samples, 3 or 4 point analyses were done on each of 3 or 4 crystals per sample, for a total of 190 analyses.

A preliminary assessment of the results shows that the pyroxenes are augites, 95% or more made up of the Ca-Mg-Fe components. The remainder comprises Al_2O_3 (2-5%), Cr_2O_3 (0.1-0.6%), TiO_2 (0.1-0.4%) and MnO (0.1-0.3%). Fe/Mg ratios (Fe/(Fe + Mg)) are low, with values ranging from 0.1 to 0.2. The rather low concentrations of minor elements and low Fe/Mg ratios suggest that the primary magmas were subalkaline, and may have originated by extensive melting of a depleted source. These preliminary findings are consistent with the whole rock geochemical data, suggesting that the Amisk Group was emplaced in a tectonic environment similar to that of modern island arcs.

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GS-17 INDUSTRIAL MINERAL OCCURRENCES IN THE FLIN FLON AND THOMPSON AREAS

By W.R. Gunter

During the 1988 field season, the following industrial mineral occurrences in the Flin Flon and Thompson areas (Fig. GS-17-1) were investigated:

1. Payuk Lake granodiorite;
2. Iskwasum Lake talc;
3. Pegmatites and pegmatitic granite near Manasan quarry;
4. Marble at Manasan quarry.

PAYUK LAKE GRANODIORITE

An occurrence of orange-white weathering, coarse- to medium-grained granodiorite was mapped by Syme (1988) as the Mink Narrows granodiorite. The granodiorite intrudes both basalts and volcanic sediments of the Flin Flon greenstone belt. The granodiorite on the south side of the pluton (Fig. GS-17-2) retains an unaltered appearance and has a limited number of fractures. Portions of this area were relatively fracture-free and therefore were mapped in detail (Fig. GS-17-3).

In the northern part of the intrusion the Mistik Creek Fault system has caused abundant fractures in the granodiorite. These fractures are commonly lined with epidote and thus the granodiorite in that area is unsuitable for the quarrying of dimension stone.

Samples removed from the southern part of the pluton are stored in Winnipeg and will be cut and polished to determine their colour and texture.

ISKWASUM LAKE TALC

In order to give an indication of the talc potential of the Iskwasum Lake area, a sampling and detailed mapping project was undertaken on occurrence 4 of Gunter and Yamada (1986). An investigation subsequent to that report (C. McGregor, pers. comm., 1986) indicated the presence of considerable magnesium chlorite, in addition to talc and carbonate.

The talc-rich rock has a buff to brown weathering surface. The fresh surface is very fine grained, white to grey, and has distinct, 1 mm mottles

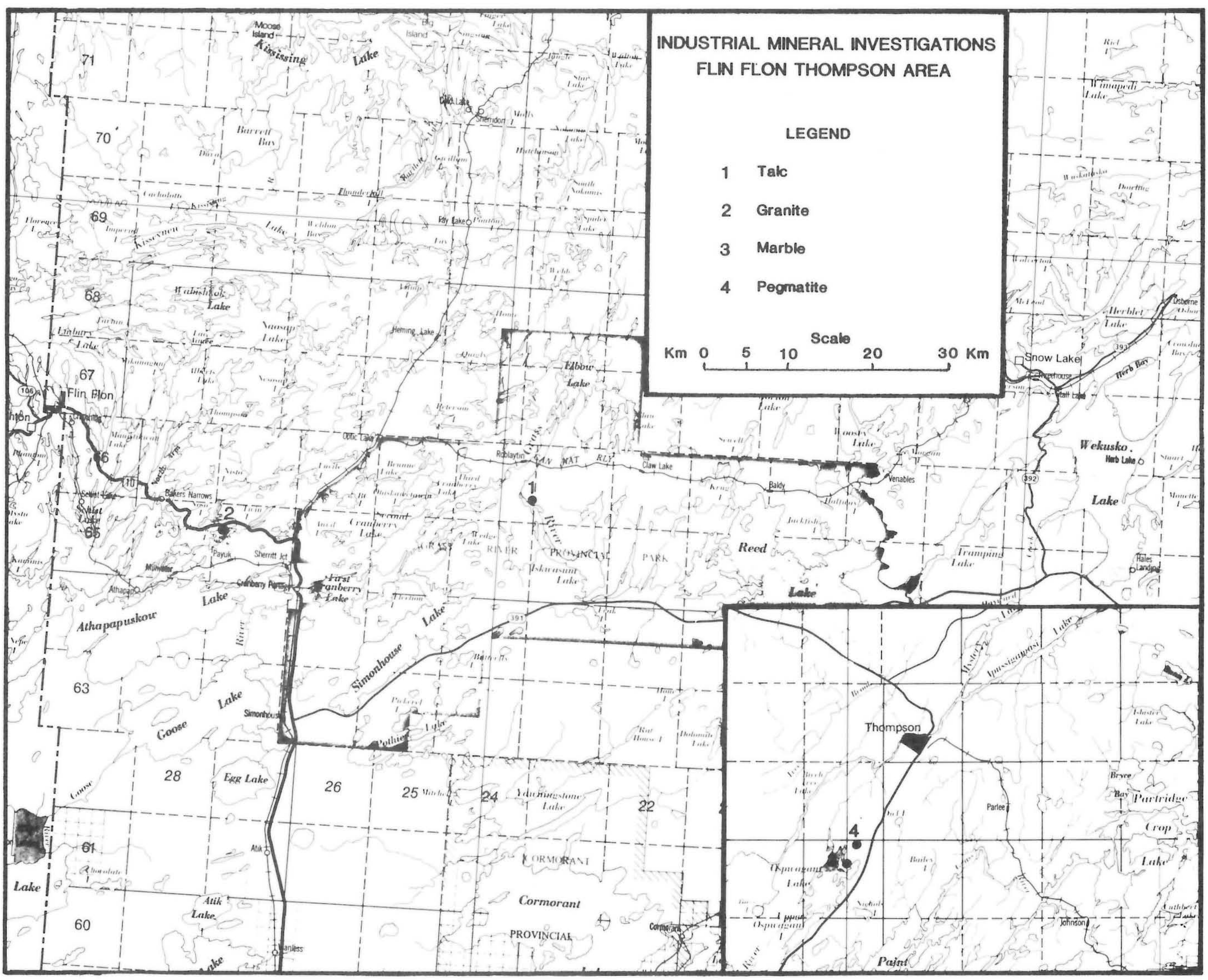

Figure GS-17-1: Location map: Industrial Minerals of the Flin Flon-Thompson area.

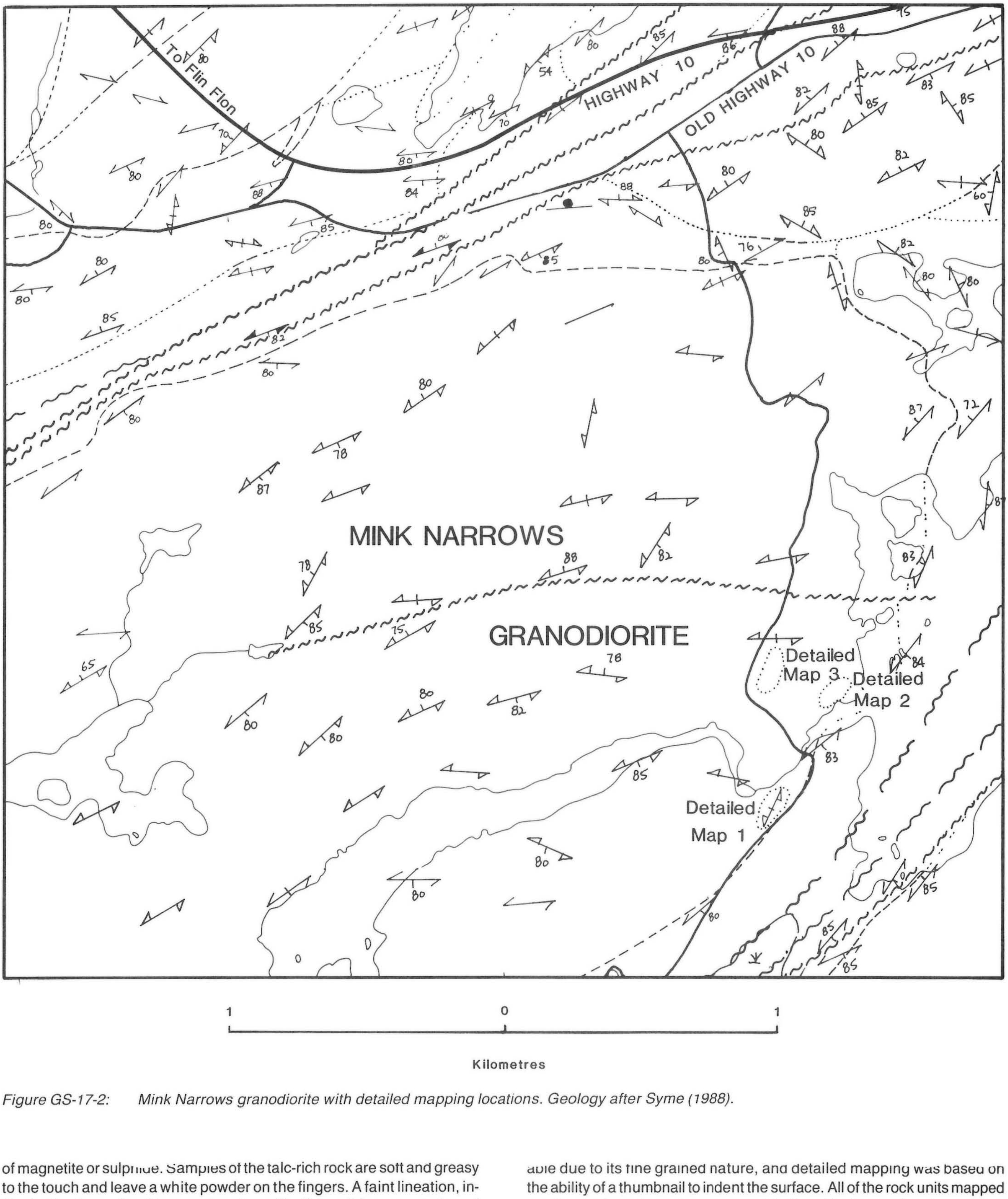

Figure GS-17-2: Mink Narrows granodiorite with detailed mapping locations. Geology after Syme (1988).

of magnetite or sulphide. Samples of the talc-rich rock are soft and greasy to the touch and leave a white powder on the fingers. A faint lineation, indicated by the mottled texture, is not readily discernible on a weathered surface.

Stripping of a 30 x 50 m area revealed several occurrences of the talc-rich rock adjacent to a chlorite-magnetite rock. The textural features are similar in both rock types. The quantity of talc was not readily identifiable due to its fine grained nature, and detailed mapping was based on the ability of a thumbnail to indent the surface. All of the rock units mapped can be easily indented, as opposed to the chlorite-dominant rocks that cannot be scratched without a hammer. The soft and very soft areas of the talc-rich unit can be carved with a knife.

Contacts were exposed with neither the chlorite rock nor an outcrop of serpentinized, coarse grained, pyroxenite adjacent to the north-

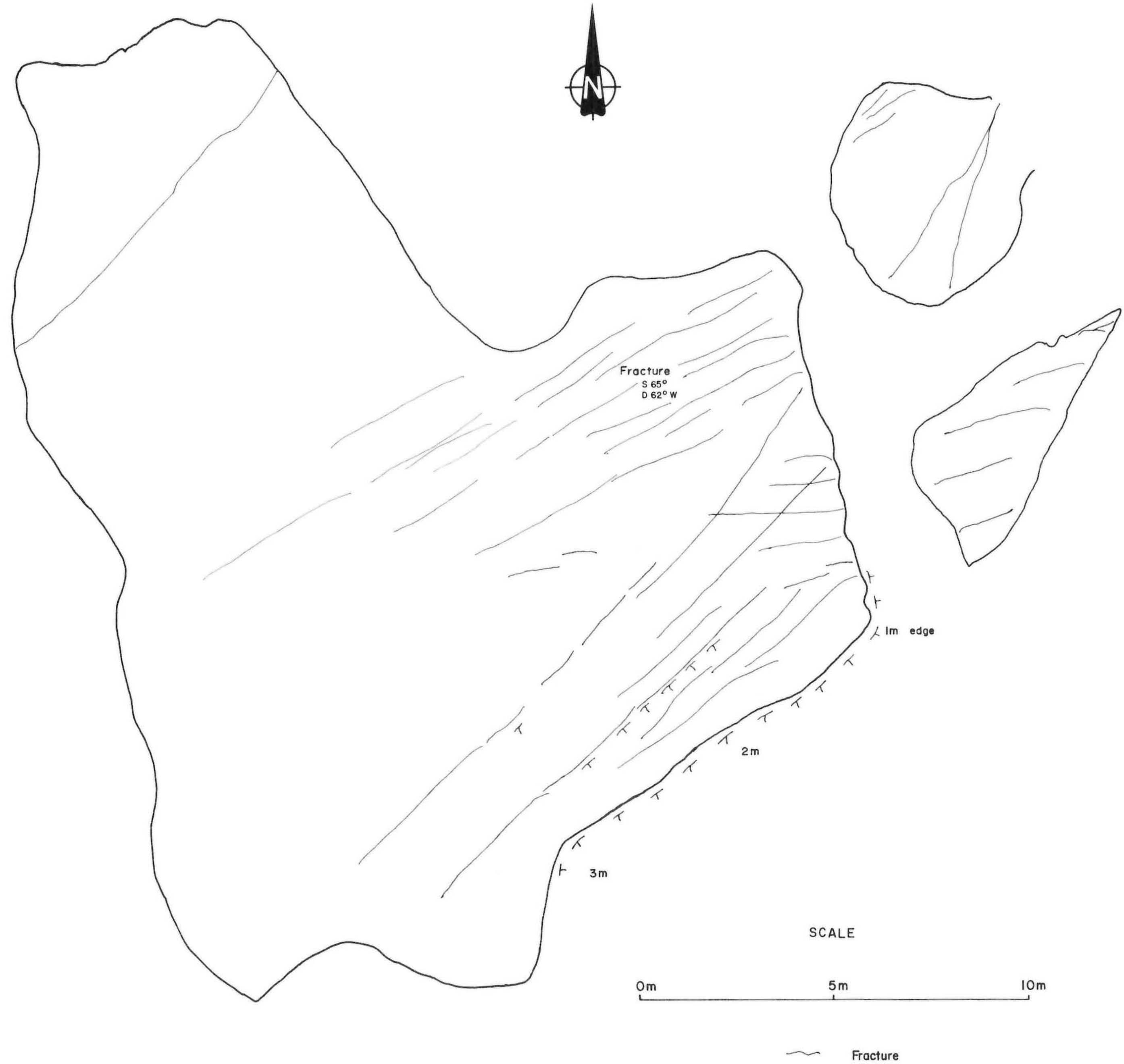

Figure GS-17-3: Detailed map of Area 2.

ern edge of the map area, but both rock types were exposed to within 2 m of the talc-rich rock. A small 1 x 3 cm fragment of serpentine found in the talc was characteristically highly weathered.

Ten samples of talc and one of chlorite, each weighing approximately two to three kilograms, were collected from the mapped area (Fig. GS-17-4). These will be analyzed for percentage talc, heavy metal content and reflectance to determine their suitability for use in either commercial or cosmetic products.

PEGMATITES AND PEGMATITIC GRANITE NEAR MANASAN QUARRY

During the investigation of the building stone potential of the Ospwagan granite (Gunter and Yamada, 1987) several samples of fluorite, plumose muscovite and a single sample of beryl were recovered and confirmed by X-ray analysis. A pegmatitic dyke containing conspicuously banded aplite, also found during that investigation, was stripped, mapped and sampled (Fig. GS-17-5). Several other promising-looking pegmatites in the area also were sampled to determine if there was an enrichment of rare elements in either the Ospwagan granite or its pegmatitic offshoots.

Figure GS-17-4: Detailed map of talc-rich area, Iskwasum Lake, occurrence 4.

The pegmatite dyke (Fig. GS-17-5) consisted primarily of two units, with minor amounts of a coarse grained unit at the boundary between the other units.

Unit 1: Banded Aplite. This unit is fine to very fine grained, and is grey-white. The banding is caused by concentrations of garnet and muscovite. In places the muscovite is coarser in grain size and occurs in "Christmas tree" skeletal aggregates. The contact between units 1 and 2 is gradational over 50 cm unless separated by unit 3. Locally, the banding takes the form of shells that are concave inward. The material between the shells is a coarse grained, Unit 3 type aggregate, that locally disrupts the banding.

Unit 2: Plumose Muscovite. This unit is coarse to very coarse grained, and grey-white. It is characterized by 20-30 cm club-shaped graphic feldspar crystals and medium grained plumose muscovite. The plumose aggregates are oriented with their axes perpendicular to the walls of the dyke, an orientation that is similar to the long direction of the club-shaped feldspar crystals.

Unit 3: (not shown) Areas of very coarse grained (20 to 30 cm or more) pegmatite composed of quartz, euhedral muscovite, feldspar, tourmaline, garnet and apatite occur at the boundary of Units 1 and 2. The edges of these areas are sharp without any evidence of growth from the crystals of either of the surrounding units.

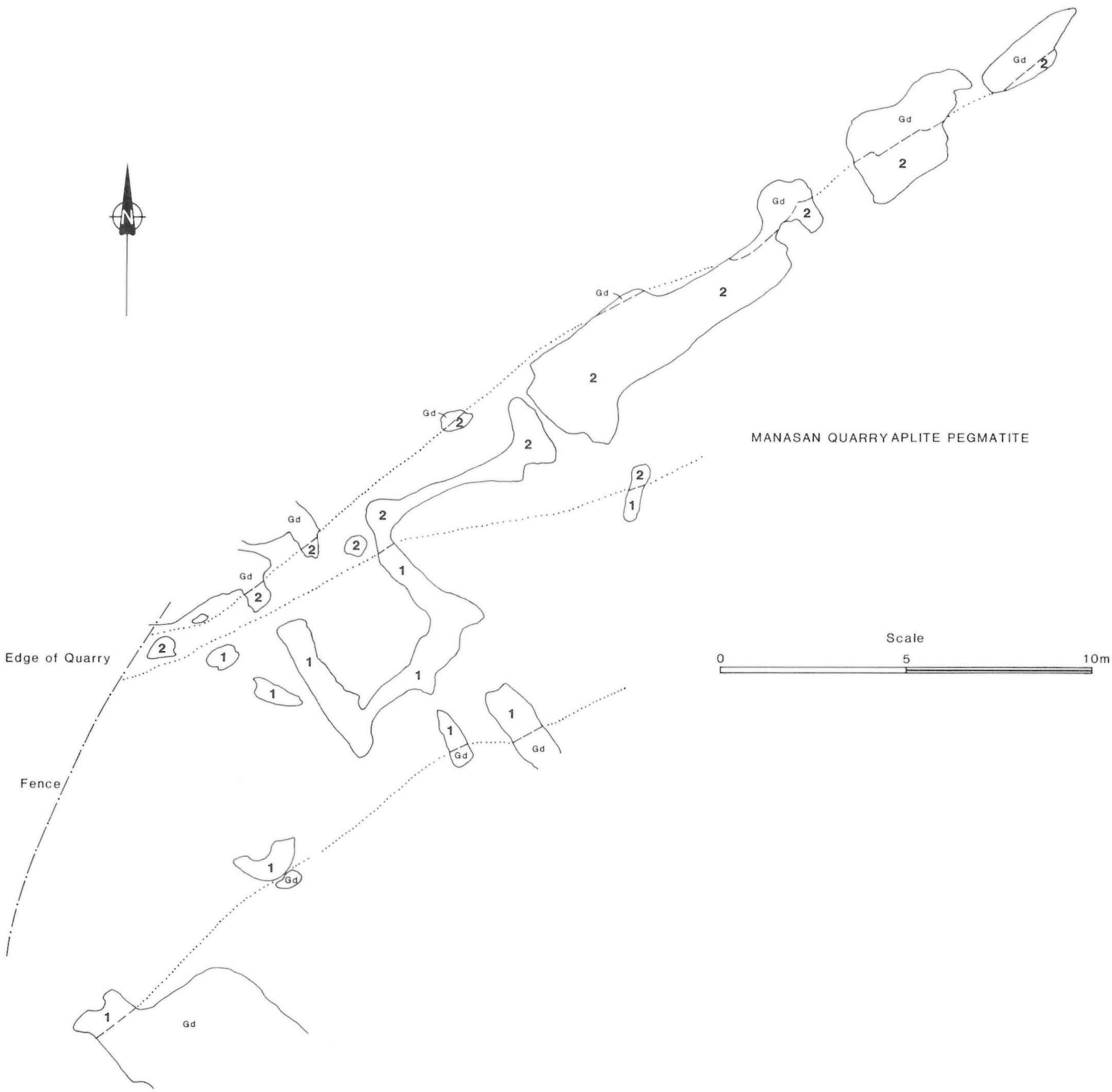

Figure GS-17-5: Detailed map of aplite-muscovite pegmatite near Manasan Quarry: Unit 1, banded aplite; Unit 2, plumose muscovite.

The pegmatite dyke has been folded with the enclosing biotite gneiss, and does not cut the gneiss as do most of the other pegmatites. This pegmatite shows no signs of later tectonic disturbance but most of the other pegmatites show zones of mylonitization and dolomite-filled shear zones.

In the Red Sucker Lake area a similar plumose muscovite pegmatite, that contains only traces of rare element mineralization, occurs within several hundred metres of three Li-Be-Ta-Sn-rich pegmatites (Chackowsky, 1987). A comparison of the Ospwagan Lake granite with the Greer Lake pegmatite-pegmatitic granite complex in the more thoroughly documented Winnipeg River area (Davies, 1957; Cerny et al., 1981; Bannatyne, 1985) reveals several similarities. Mineralization in the pegmatitic granites, as outlined by Cerny et al. (1981, p. 63) shows that most of the major minerals occurring in the Greer Lake pegmatitic granite are also found in the Ospawgan occurrence. The major exception to this is that no lithium minerals were noted in the latter. Columbite-tantalite has not been recorded from the Ospwagan area, but this may be a function of the sample density.

The similarities in texture and mineralogy of the Ospwagan Lake granite to mineralized granite pegmatites and pegmatitic granites elsewhere in the province indicates that the rare-element potential of the Thompson area should be investigated.

MARBLE AT MANASAN QUARRY

A comprehensive map of the marble occurrence in the Manasan quarry was completed to enable better definition of rock units (Fig. GS-17-6). Existing exposures were enlarged, with the aid of a Wajax pump, and mapped at approximately the same scale as the skarn shown in Map #1 of Gunter and Yamada (1986).

Four units are outlined on the map.

Figure GS-17-6: *Detailed map of stripped area, Manasan Quarry: Unit 1, amphibolite-rich calc-silicate; Unit 2, carbonate phlogopite; Unit 3, phlogopite-serpentine; Unit 4, serpentine marble.*

Unit 1: Amphibole-rich calc-silicate. A thinly laminated, fine grained, dark green to black rock. The contact with Unit 2 is sharp with laminations parallel to the contact.

Unit 2: Carbonate-Phlogopite. A white weathering friable rock with 2-3 mm thick interlaminations of white carbonate and brown, medium grained phlogopite.

Unit 3: Phlogopite-Serpentine. A transitional unit between Units 2 and 4. The top of the unit is placed at the disappearance of the phlogopite-carbonate interlaminations. The unit is marked by interbands of very thinly laminated, phyllitic, recessive weathering Unit 2 and the thicker bands of Unit 4. The base of this unit is transitional over 5 m with the disappearance of Unit 2 layers.

Unit 4: Serpentine Marble. This unit is green to light green on a fresh surface and weathers buff. Laminations, 5-10 cm thick, and a rounded, almost waxy surface, indicate that this rock is not brittle and is capable of producing large blocks of marble. The base of this unit is not exposed and its western edge is bordered by a swamp.

Although somehwat different in appearance due to their higher silica and magnesian contents, the Thompson marbles could become a competitor to some of the coloured Italian marbles, e.g. those from the Carrara region.

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GS-18 GEOLOGICAL INVESTIGATIONS IN THE RICE LAKE AREA

by W. Weber

A short field program was conducted in the Bissett region to plan future survey projects in the Rice Lake greenstone belt in support of exploration activity and to upgrade the geological data base of Manitoba Superior greenstone belts. Of particular interest are the areas burnt over during 1983 and 1987 forest fires between Wallace Lake and Flintstone Lake. The most promising area for future work appears to be between Stormy Lake and Garner Lake, from the major anticlinal structure passing through Gunnar Mine (presently being investigated by R. Brumbecker as part of a Master's thesis under the auspices of Geological Survey of Canada, Mineral Resources Division) and D. Seneshen's (1986) thesis area, south of the Manigotagan River, to the granitoid rocks northeast of the Garner Lake ultramafic body.

Another potential project is a more detailed investigation of supracrustal rocks north of the Wanipigow River fault and their relationship to greenstones south of the fault (see below).

A re-examination of the recently burnt area around Conley shaft at Wallace Lake demonstrates clearly that the Conley Formation (McRitchie, 1971) is a unique stratigraphic succession of units (Table GS-18-1) representing shallow water deposition during the rise and erosion of a granitoid hinterland, as already suggested by McRitchie (op. cit.).

The questions remaining to be answered are:

— Is the Conley Formation part of an Early Archean (pre-rifting?) depositional event, as described from northwestern Ontario (Thurston et al., 1987), predating the typical (arc-type?) greenstones in the Rice Lake belt? U-Pb zircon data indicate the presence of 2.9-3.0 Ga old granitoid crust north of the Wanipigow fault between Wallace Lake and Black Island (Ermanovics and Wanless, 1983; Turek et al., in press) but supracrustals have not been dated yet.

— Are metabasalts, e.g., Big Island Formation (McRitchie, op. cit.) part of this (Early Archean?) cycle? What is their chemical composition compared to the basalts in the greenstone belt proper? Is there a stratigraphic or possibly a tectonic break (thrust?) between Big Island Formation and Conley Formation?

— Is there a facies changes within the Conley Formation from west to east as suggested by McRitchie (op. cit.) and do these units extend across the Wanipigow fault toward Beresford Lake?

— Are supracrustals north of the Wanipigow fault, e.g., north of Bissett, north of Wanipigow Lake and in the Aikens Lake area part of, or an extension of, the Conley or Big Island Formation and (associated?) ultramafic rocks?

This association of a number of compositionally highly variable greenstones, including iron formation, mafic and ultramafic rocks and felsic dykes which are all sheared along a major fault zone such as the Wanipigow fault, represents a little explored environment for a new gold deposit type for the belt, which is characterized mainly by lode gold deposits.

It is unlikely that the arenaceous rocks of the Conley Formation are correlative with the San Antonio Formation. Although lithologically similar, these are more commonly crossbedded, are generally less quartzitic and have not been observed to be intruded by gabbro nor quartz-feldspar porphyry, as is the case in the area of the Conley shaft.

TABLE GS-18-1
Table of Formations, Conley Bay, Wallace Lake

Intrusive Rocks

Quartz-feldspar porphyry
Gabbro-diorite

Conley Formation[1]

4	Parallel bedded (0.3-0.5 m) quartz arenite, in part pebbly, grading into thin (1-10 cm), greenish argillite bed tops which are commonly scoured; intraformational argillite rip-ups and breccias, occasional matrix supported trondhjemite pebble conglomerate
3	Thin bedded, white, massive quartzite, 1-3 m, grading into unit 4
2	Brown dolomitic limestone-marble with thin (5-20 cm), discontinuous, generally laminated quartzite beds (in part silicified stromatolite?), 2-8 m
1	Black graphitic shale-argillite with thin sulphide facies iron formation[2] and carbonate beds, 2-3 m(?)

Metabasalt and ultramafic rocks appear to be stratigraphically(?) below this type section elsewhere, e.g. in northwestern part of Wallace Lake (McRitchie, 1971).

[1]Conley Formation originally described by McRitchie (1971).

[2]West and north of Conley Bay oxide facies iron formation is the facies equivalent.

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Figure GS-18-1: *Dolomitic limestone interbedded with laminated quartzite; unit 2 of the Conley Formation, Conley Bay.*

GS-19 INDUSTRIAL MINERALS INVESTIGATIONS IN SOUTHEAST MANITOBA

by B.E. Schmidtke

During the summer of 1988, a three-day inventory of potential dimension stone sites on the east shore of Lake Winnipeg was carried out in cooperation with the Manitoba Department of Northern Affairs. Granitic outcrops were examined near the town of Berens River and along the Pigeon River. None of the outcrops examined have the wide fracture spacing required in a dimension stone quarry. The youngest intrusion, a pale pink granite, has an average fracture spacing of less than one metre. The colour is bland and would not compete with the pink-red granites quarried in southeast Mantiboa. The older intrusions are gneissic, closely fractured and intruded by dykes of younger granites.

Sphagnum peat bogs found on the east shore of Lake Winnipeg, near Berens River, may have excellent potential for horticultural peat production if the peat can be transported economically by barge to Selkirk. Sections exposed on the shore near the mouth of the Pigeon River indicate at least 3 m of good quality sphagnum.

Further evaluation of the Berens River, Poplar River and Bloodvein River area for dimension stone and sphagnum peat potential will be continued by Northern Affairs and Geological Services.

The remote sensing inventory of sphagnum bogs in the Interlake (Dixon and Schmidtke, 1986) has been completed. The report, "Peatland Inventory of Manitoba III — Interlake Region Using Landsat V Thematic Mapper" by Roy Dixon and John Stewart, and thematic maps are available through the Manitoba Remote Sensing Centre and Geological Services. Several large areas of sphagnum bog were identified during this study.

Several projects, funded under Sector C, Mineral Policy, to promote Manitoba granite were carried out during the summer and fall of 1988. The City of Winnipeg installed granite curbing produced by Canadian Shield Quarry on a part of Lombard Avenue in downtown Winnipeg. The curbs will be monitored for wear and snowplow damage.

Granite cobblestones and bollards produced by Canadian Shield Quarry and Cold Spring Granite (Canada) Ltd. are being installed on Green Lane in downtown Winnipeg. This project is scheduled to be completed in the late fall.

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GS-20 CROSS LAKE GEOLOGICAL INVESTIGATIONS

by M.T. Corkery, P.G. Lenton, M. Breedveld[1] and D.W. Davis[2]

Three programs within the Cross Lake area were the focus of field and laboratory work this year. Ongoing geological mapping at a scale of 1:20 000, carried out by P. Lenton and M.T. Corkery, filled in several gaps in coverage. A 12 week program by M. Breedveld forms the basis of a pilot study to include geothermometry-geobarometry and related tectonic development of the Cross Lake area. D. Davis (1988) determined U-Pb zircon ages for selected units (Table GS-20-1) as part of the MDA Northern Superior U-Pb geochronology program (see GS-23, this volume).

[1]Instituut voor Aardwetenschappen, Free University, Amsterdam, The Netherlands.

[2]Department of Geology, Royal Ontario Museum, Toronto, Ontario.

Mapping by Lenton and Corkery concentrated on solving problems encountered in previously mapped areas. Extremely low water conditions increased exposure on the lake allowing more detailed mapping in these areas. As well, two days were spent in a bay on Cross Island (Figure GS-20-1) to investigate the contact between Pipestone Lake group metabasalts and Cross Lake group metasediments. A sample from an alteration zone containing tourmaline and sporadic arsenopyrite, along the southeast shoreline of this bay, contains 23 ppb gold.

TABLE GS-20-1
U-Pb ZIRCON AGES FOR THE CROSS LAKE AREA.

Order of Geological Events (Cross Lake area)	Age (Ma)	Unit Dated (unit numbers from Preliminary Maps 1987N-1 and 1987N-2) (4)
Late brittle deformation manifested by fault breccia, pseudotachylite and erratic foliation developed in some Molson dykes		
Intrusion of Molson dyke swarm; most abundant in the major NE shear zones	1883.7 +1.7/-1.5 Ma (1)	Plagioclase, hornblende pegmatitic segregation in large Molson dyke (unit 20)
Periodic reactivation of shear zones accompanied by minor folding		
Intrusion of late granite plugs and pegmatites largely controlled by the major shear zones	2653 ±3 Ma (2)	Garnet-tourmaline-muscovite granite (unit 18b) probably co-genetic with rare-element enriched pegmatites (unit 19d)
Period of regional metamorphism, granite plutonism and folding concomitant with activation of major linear shear zones	2694 Ma (2)	Gabbro pegmatite (unit 4b); unabraded zircon fraction, altered and fractured
Intrusion of small gabbro dykes and plugs		
Initiation of volcanism - high potassium basalt and rhyodacite - with sedimentation of greywacke sandstone and siltstone	2707 ±3 Ma (3)	Fragmental quartz-feldspar porphyritic rhyodacite, (unit 13a)
	2732 +5/-4 Ma (2)	Feldspar porphyry, intrusive into Pipestone Lake basalts
Deposition of Cross Lake group alluvial and fluvial conglomerate and sandstone	2709 ±2 Ma (2) 2725 ±3 Ma (2) 3043 ±3 Ma (2)	Detrital zircon fractions in quartz-rich arkose (unit 11a)
Uplift and erosion of the Pipestone Lake group and batholithic terrain		
Intrusion of batholiths; probably concomitant with the development of early folding and formation of major shear zones	2719 ±2 Ma (2) 2747 ±3 Ma (2)	Tonalite (unit 8a,b), intrusive into Pipestone Lake group basalt, overlain unconformably by Cross Lake group metaconglomerate. Contains two zircon populations.
Intrusion of anorthosite and anorthositic gabbro bodies	2758 ±3 Ma (2) 2763 ±7 Ma (2)	Gabbro pegmatite and anorthosite pegmatite in Pipestone Lake intrusive complex (unit 4b,a)
Development of Pipestone Lake group basalts with subordinate sedimentary rocks		

(1)Heaman *et al.*, 1986
(2)Davis, D.W., 1988a
(3)Davis, D.W., 1988b
(4)Corkery and Cameron, 1987a and 1987b

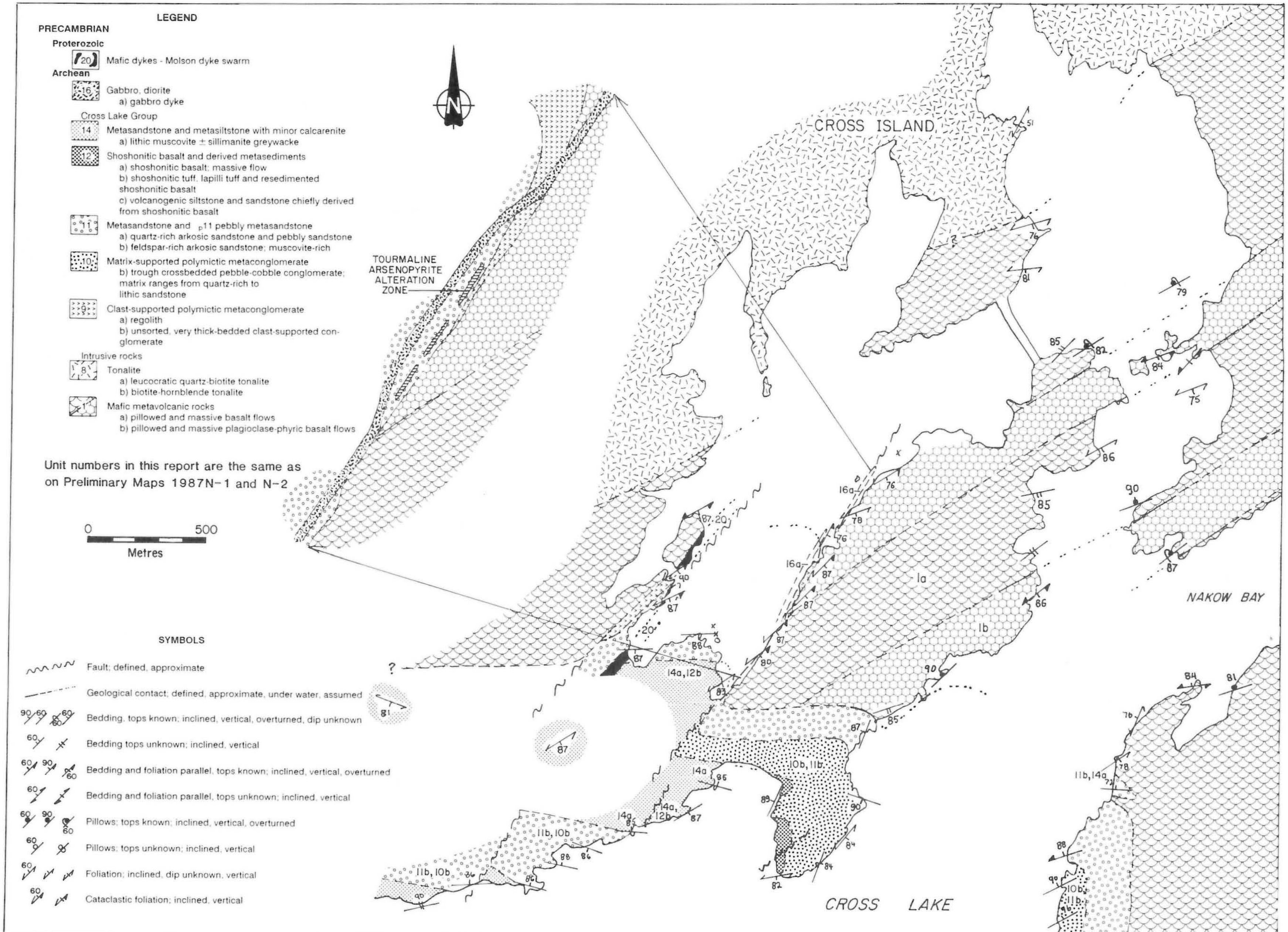

Figure GS-20-1: Geology of the Pipestone Lake group — Cross Lake group contact zone; southwest corner of Cross Island.

East-trending Cross Lake group metasediments occupy the bay, flanked to the southeast and northwest by Pipestone Lake group basalts. Within the bay, portions of a sequence of conglomerate (unit 9), sandstone (unit 11), and sandstone and siltstone (unit 14) occur with numerous south-facing bedforms. On both the southeast and northwest shorelines sedimentary layering is transposed into a strong shear fabric trending 060°, parallel to the contacts with Pipestone Lake group basalts. Gabbro dykes (unit 16) and Molson dykes (unit 20) intrude along or near the volcanic-sediment contact.

Tourmalinization and associated arsenopyrite mineralization, which parallels the contact of Cross Lake group — Pipestone Lake group rocks along the southeast shoreline, occur predominantly in strongly sheared metasediments. Plagioclase-phyric Mission Point member basalts along the contact are typically unaltered; however, thin zones of garnet-biotite alteration occur sporadically near the contact with the metasediments. Mineralization is most abundant in thin wedges of metasediment caught between Pipestone Lake group basalts and a gabbro dyke (unit 16) parallel to the 060° shear zone.

The Cross Lake U-Pb zircon geochronology program carried out by D. Davis at the Royal Ontario Museum reported ages for several units in the area (Table GS-20-1). These ages provide a chronological framework for the geological development of the Cross Lake area. Three ages for detrital zircon populations in quartz rich arkose (unit 11a) were also reported (Davis 1988a). The youngest zircon fraction at 2709 $\pm$ 2 Ma places an upper limit on Cross Lake group sedimentation. Plutonism occurring between Pipestone Lake group and Cross Lake group is represented by tonalite with an age of crystallization at 2719 $\pm$ 2 Ma and inherited 2747 $\pm$ 3 Ma zircons. The detrital zircon dated at 2725 $\pm$ 3 Ma is interpreted to indicate that more extensive magmatism occurred during this interval. Three zircon grains "are significantly older and range back to a minimum age of 3043 $\pm$ 3 Ma. It is likely therefore that much older crust was in proximity to the greenstone belt at the time of deposition of the sediments" (Davis 1988a).

TECTONO-METAMORPHIC PILOT STUDY OF THE CROSS LAKE GREENSTONE BELT

by M. Breedveld

INTRODUCTION

A pilot study of the thermotectonic evolution of the Cross Lake greenstone belt (CLGB) was initiated this summer. This study represents the start of a Dutch research program in the Cross Lake area supervised by L. Westra of the Free Unversity of Amsterdam. This report is an abstract of results from this summer's fieldwork. The project is financed by the Dutch SchÜrmann fund and the Geological Survey of Canada.

Objectives of the study are:

1. to investigate the increase in metamorphic grade from upper greenschist to granulite facies from Pipestone Lake towards the Pikwitonei granulite domain;
2. to provide a tectonic model for the CLGB and to correlate the structural and metamorphic evolution;
3. to provide a basis for further detailed structural and metamorphic studies in subsequent years.

This summer's work concentrated on two structurally different domains (Fig. GS-20-2): (1) Pipestone Lake — south and central Cross Lake and (2) central and northwest Cross Lake to the southeast margin of the Pikwitonei granulite domain. These domains are interpreted to be representative of the tectono-metamorphic evolution of the CLGB.

STRUCTURE AND TECTONICS

The sequence of fabrics and folds indicates at least three major episodes of deformation.

The first episode (D_1) is characterized by isoclinal to open folding of a compositional layering (So) in the supracrustals with an axial plane foliation (S_1) or an axial plane LS-fabric (LS1). F_1 fold axes plunge moderately to steeply. Meso-scale Z and S folds occur as secondary folds on the fold limbs of macro-scale F_1 folds. S_1 is the dominant foliation in the greenstone belt and is generally parallel to its boundaries. S_1 is thought to be formed in a more or less upright position in an episode of compression. The LS1 fabrics are best preserved in conglomerates and pillowed basalts throughout the area. Rodded clasts and pillows display a consistant plunge within certain domains. The plunge is moderate to steep. The origin of the lineations is unknown but there are indications that they formed parallel to F_1 fold axes. The first episode of deformation (D_1) may be responsible for the formation of the dominant foliation in the gneiss complexes. Clearwater Bay gneisses exhibit a quartz lineation, most pronounced near the contact with the supracrustals, which is parallel to LS1 fabrics in that specific domain of the supracrustal belt.

Evidence of early macro-scale subhorizontal thrust-tectonics and/or structures predating the Cross Lake group have not been recognized.

The second episode of deformation (D_2) is marked by generation of extensive ductile shear zones and associated shear folds parallel to the greenstone belt boundaries in a compressive stress regime. In domain 2 the east-trending CLGB is folded in a northeast direction and intensively compressed. In domain 1, the east-trending arm, structures remain more or less in post-D_1 position. The shear zones have a dextral sense of movement and a vertical component responsible for the relative uplift the south side in domain 1 and the northwest side of domain 2. Syn-D_2 shear zones are commonly reactivated post-D_2 and display a complex history. F_1 related structures are refolded by dominantly tight meso-scale Z-folds with steep axial planes and steeply plunging fold axes. Conjugate Z- and S-folds occur but Z-folds are dominant. Closed folds occur in zones of high strain. Z- and S-folds may have a weak axial plane foliation. F_2 folds developed in fine grained metasandstones are commonly accompanied by a crenulation cleavage. Overprinting patterns between F_1 and F_2 are type 2 refoldings (Ramsay, 1967).

The D_3 episode of deformation Z-folds D_1 and D_2 related structures on a macro-scale in the northwest Cross Lake area. Axial planes and fold axes are subvertical. Moderate to strong crenulation foliation (S_3) is developed in the F_3 folds. Meso-scale Z- and S-folds with a weak axial plane foliation occur as secondary folds on the fold limbs of macro-scale Z-folds. Considering the fold style and orientation, F_3 is probably a progressive episode of F_2.

A cleavage with a very typical rhombohedral weathering habit oriented at a high angle to compositional layering and/or S_1 fabric has been observed throughout the CLGB area. The nature and age of this cleavage is unknown at the present time. In domain 1 it appears to predate D_2; alternatively, in domain 2 it postdates D_2.

Ductile to brittle fault systems were generated post-D_2 in the supracrustal belt and gneiss complexes. They represent a progressive compression and uplift at higher crustal levels.

The primary fault system in domain 1 is dextral. Its northwest-trend makes an angle of 0-30° to the east-southeast trend of the supracrustal belt. A vertical displacement component is responsible for the relative uplift of the south side of these faults. High angle, conjugate fractures and faults turn into and out of the main fault system. Faults in the northwest direction are dominantly dextral, whereas northeast-trending faults are dominantly sinistral. The northeast-trending faults form the dominant system of the conjugate pair. The conjugate fractures and faults may displace the main fault system indicating they were active longer. Increase of metamorphic grade from Pipestone Lake towards central Cross Lake is partly

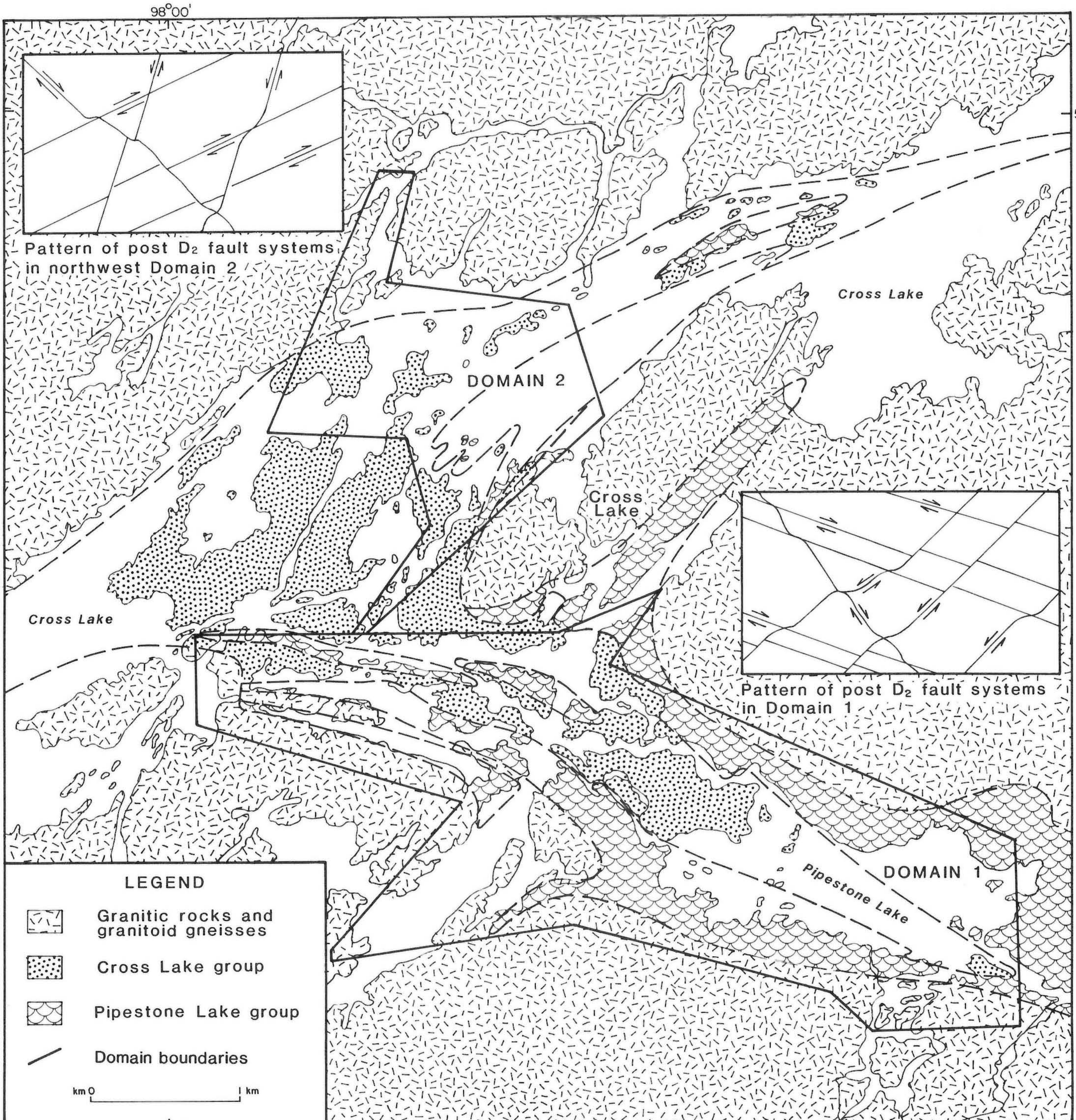

Figure GS-20-2: Structural domains and trends of post-D_2 ductile to brittle fault systems in the Cross Lake-Pipestone Lake area.

attributed to a vertical displacement component on the northeast sinistral fault system.

The major fault system in domain 2 (central and northwest Cross Lake) trends northeast. Faults along the north shore of the lake are dextral, whereas parallel faults to the southeast in the central part of the lake are sinistral. Post-D_2 dextral faults, northwest of the supracrustal belt in the Eves Rapids gneiss complex, display a vertical displacement component indicating relative uplift of the southeast side. However, this vertical sense of movement is reverse of the syn-D_2 movements along the margin and within the CLGB. High-angle conjugate fractures and faults turn into and out of the main northeast-trending fault system. North-northeast-trending conjugate faults are sinistral whereas northwest-trending faults are dextral. Their combined vertical displacement components indicate dominant relative uplift of the west side.

Time relationships between the northeast dextral and sinistral fault systems in domain 1 is not clear nor is the relationship between the fault systems in domain 1 and domain 2. Data from the fault system in domain 2 indicate a progressive rotation of the principal stress from an east-west to a north-south direction. In domain 1, data show a progressive rotation of principal stress from north-northwest to west-southwest. This may be the result of: 1) a variation in the principal stress due to syn-D_2 greenstone belt configuration; 2)an indication of time difference in development of the fault systems. This will be one of the principal problems in structural studies of the late evolution of the Cross Lake greenstone belt.

I would like to express my gratitude to E. Froese of the Geological Survey of Canada and T. Corkery and P. Lenton of the Manitoba Geological Services Section for their support and for introducing me to the geology of Cross Lake.

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GS-21 THOMPSON NICKEL BELT PROJECT — PIPE PIT MINE[1] (part of 63-O/8NE)

by W. Bleeker[2] and J.J. Macek

INTRODUCTION

Aphebian metasediments and metavolcanics of the Thompson Nickel Belt are collectively known as Ospwagan Group (Scoates et al., 1977). All major Ni-sulphide deposits of this world-class mineral belt occur within or associated with ultramafic bodies contained within complexly deformed Ospwagan Group supracrustals. The commonly differentiated dunite-pyroxenite bodies originated probably as subvolcanic sills (Peredery et al., 1982). Despite the fact that the orebodies and associated ultramafic parent rocks generally are stratabound (a detailed Ospwagan Group stratigraphy would thus have important bearing on the identification of favourable horizons, the genesis of the sulphide orebodies and the elucidation of the large-scale geometry of this complex belt) only a generalized outline of the Ospwagan Group stratigraphy has been published (Peredery et al., 1982).

Outcrops in and around the presently producing Thompson Open Pit and the exhausted Pipe II Open Pit (see Fig. GS 21-2 for locations) provide the most complete exposures of Ospwagan Group supracrustals and associated orebodies. Detailed structural and lithological mapping of both pits has led to the recognition of a more refined supracrustal stratigraphy (Bleeker and Macek, in prep.), an outline of which will be presented below. The supracrustal sequence is best exposed and most complete at Pipe II Open Pit, whereas the sequence is more condensed and/or structurally disrupted elsewhere. The Pipe II section is therefore described as the type section against which other localities (Ospwagan Lake, Manasan Quarry, Thompson Mine, etc.) can be correlated. At Ospwagan Lake a several metre wide band of quartz-phyric rhyolite is exposed, the first reported occurrence of felsic volcanics in the Thompson Nickel Belt; these rocks may finally allow precise U-Pb dating of the Ospwagan Group.

RESULTS OF GEOLOGICAL MAPPING

The Thompson Open Pit has been mapped at a 1:1200 scale. This map with accompanying description, will soon be available as a Geological Survey of Canada open file (W. Bleeker, in prep.). This summer, mapping of the Pipe II Open Pit was completed, using low altitude aerial photographs (Macek, 1987). Eight sheets (1:400) cover Pipe II Open Pit and surrounding outcrops (Preliminary Maps 1988T-1 to -8; Bleeker and Macek, 1988). It is intended to finalize them as coloured maps with accompanying descriptions.

OSPWAGAN GROUP STRATIGRAPHY

In spite of complex multiple folding (F_1-F_5; Bleeker, 1988), nearly continuous exposure at Pipe II Open Pit allows recognition of a detailed lithostratigraphy of parts of the Ospwagan Group supracrustals. A simplified column of the Pipe II sequence is shown in Figure GS-21-1, together with three additional columns that are derived from the west shore of Ospwagan Lake, Manasan Quarry and Thompson Open Pit (see Fig. GS-21-2 for locations). Dashed lines in Figure GS-21-1 indicate lithostratigraphic correlations. Because of intense deformation involving transposition (F_1-F_2), thicknesses are approximate as individual units may locally pinch out or may be repeated by isoclinal folding. Some contacts are unexposed and could be of tectonic origin.

The columns further include the Ni-sulphide ore zones and associated ultramafic bodies of the Pipe II and Thompson deposits, and mafic dykes that are correlated with the 1883 Ma Molson dyke swarm (Scoates and Macek, 1978; Heaman et al., 1986). As some structural features are included to illustrate important relationships, the columns are tectonostratigraphic rather than lithostratigraphic in character.

Basement to the Ospwagan Group

Archean basement gneisses are variably reworked and metasomatized. In well preserved domains, they vary from potash-poor tonalite and dioritic gneisses to amphibolites, with rare ultramafic and ubiquitous metasedimentary bulk rock compositions. The overall compositional spectrum is very similar to that of the Pikwitonei granulite domain.

In the mine environment, however, Archean structures and textures are completely erased and the gneissic foliation is parallel to the layering in the metasediments, a feature attributed to F_1-F_2 transposition. Tight to isoclinal F_2 and F_3 folds can be demonstrated in the gneissic shoulders of the Thompson and Pipe II Open Pits (Bleeker, 1988). Grain size is much reduced, although even in the mine environments a coarse relict texture may be preserved in small lens-shaped domains. Stretching of original heterogeneities, such as mafic xenoliths or enclaves, has enhanced the banded appearance of the gneisses and their colour ranges from pink to grey. Pink bands are rich in microcline and the apparent potassium influx can generally be linked to Hudsonian pegmatites.

The Ospwagan Group

Metasedimentary units in contact with gneisses consist of pebbly conglomerates, quartzites and metasiltstones (unit 1, first column, Fig. GS-21-1). Yellow-grey or white quartzites generally predominate. At Pipe II Open Pit, thin laterally restricted layers of a bluish quartz-rich pebbly conglomerate occur at the inferred base of this unit. Graded bedding is preserved in some layers showing sharply bounded pebble-size layers grading upwards into sand or silt-size material. An even better preserved pebbly conglomerate has been observed on Ospwagan Lake at the contact between gneisses and quartzites. Stratigraphically, the same quartzites occur at Manasan Quarry and Thompson Open Pit. At all localities this 1-10 m thick basal quartzite unit is overlain by 1-10 m of semipelitic biotite schists or gneisses. This unit (unit 2) is characterized by a purplish grey colour, abundant quartz-feldspar mobilizate and pegmatite stringers, and absence of aluminous porphyroblasts. However, at Thompson, where metamorphic grade is above the second sillimanite isograd (Bleeker, 1987), sillimanite and rare garnet may occur in this unit.

The presence of minor quartz-rich pebbly conglomerates on the contact between basement gneisses and Ospwagan Group quartzites, and the fining-upward sequence of the lower metasedimentary units from local pebbly conglomerates, quartzites, metasiltstones, semipelitic schists, and chemical sediments, to pelitic schists (see below) strongly suggest a transgressive sequence and a continuous basement cover relationship.

This transgressive sequence is the strongest top-bottom criterion preserved in the Ospwagan Group supracrustals and is consistent with the magmatic differentiation profile of the Pipe II ultramafic body, ranging from massive sulphides concentrated at the base, through dunites to pyroxenite at the top (cf. Peredery et al., 1982). The presence of an original angular unconformity has to be inferred, however, since gneissic layering in the reworked basement, the gneiss-metasediment contact, and transposition layering in the metasediments are all parallel to each other, qualitatively indicative of the very high strains involved.

The semipelitic biotite schists are overlain by grey-white, banded or laminated cherts with thin boudinaged calc-silicate bands (unit 3; 0.5-2 m). The cherts are overlain by grey marble with interlayered chert and boudinaged diopside bands (unit 4; 0.5-2 m). A thin sulphide facies iron formation (0-0.5 m) occurs near the top of this carbonate-rich unit and con-

[1]This account reports progress realized under the Canada-Manitoba Mineral Development Agreement in two related projects. The federal project is a Ph.D. study of the structure of the Thompson area by W. Bleeker, supported by the Geological Survey of Canada, and the provincial project is a study of the supracrustal rocks of the Thompson belt by J.J. Macek, Manitoba Energy and Mines.

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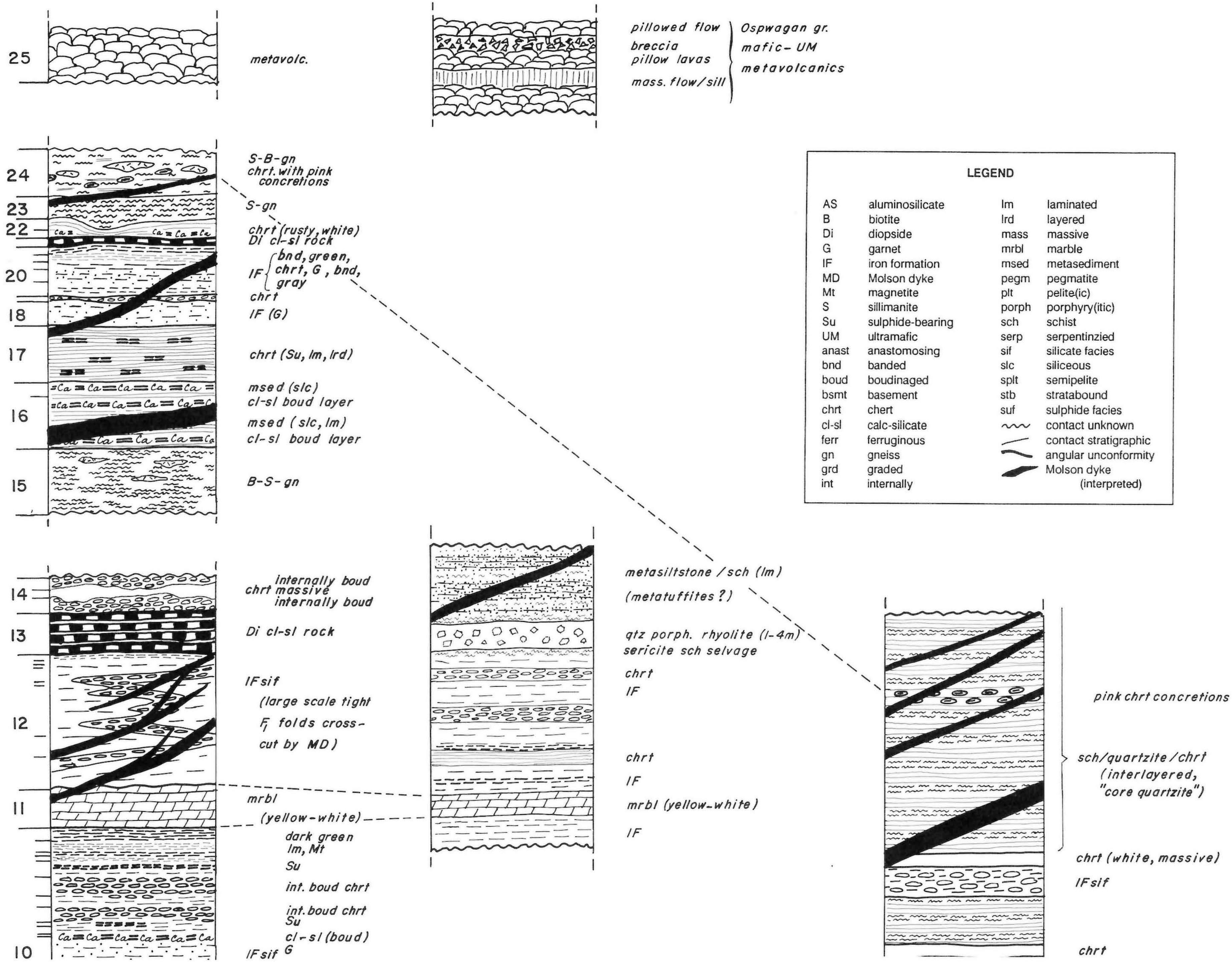
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metavolc.
pillowed flow
breccia
pillow lavas
mass. flow/sill
Ospwagan gr.
mafic- UM
metavolcanics
24
23
22
20
18
17
16
15
S-B-gn
chrt. with pink concretions
S-gn
chrt (rusty, white)
Di cl-sl rock
IF { bnd, green, chrt, G, bnd, gray
chrt
IF (G)
chrt (Su, lm, lrd)
msed (slc)
cl-sl boud layer
msed (slc, lm)
cl-sl boud layer
B-S-gn
LEGEND
AS aluminosilicate
B biotite
Di diopside
G garnet
IF iron formation
MD Molson dyke
Mt magnetite
S sillimanite
Su sulphide-bearing
UM ultramafic
anast anastomosing
bnd banded
boud boudinaged
bsmt basement
chrt chert
cl-sl calc-silicate
ferr ferruginous
gn gneiss
grd graded
int internally
lm laminated
lrd layered
mass massive
mrbl marble
msed metasediment
pegm pegmatite
plt pelite(ic)
porph porphyry(itic)
sch schist
serp serpentinzied
sif silicate facies
slc siliceous
splt semipelite
stb stratabound
suf sulphide facies
contact unknown
contact stratigraphic
angular unconformity
Molson dyke (interpreted)
14
13
12
11
10
internally boud
chrt massive
internally boud
Di cl-sl rock
IF sif
(large scale tight F_1 folds cross-cut by MD)
mrbl
(yellow-white)
dark green
lm, Mt
Su
int. boud chrt
int. boud chrt
Su
cl-sl (boud)
IF sif
G
metasiltstone / sch (lm)
(metatuffites ?)
qtz porph. rhyolite (1-4m)
sericite sch selvage
chrt
IF
chrt
IF
mrbl (yellow-white)
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pink chrt concretions
sch/quartzite/chrt
(interlayered, "core quartzite")
chrt (white, massive)
IF sif
chrt

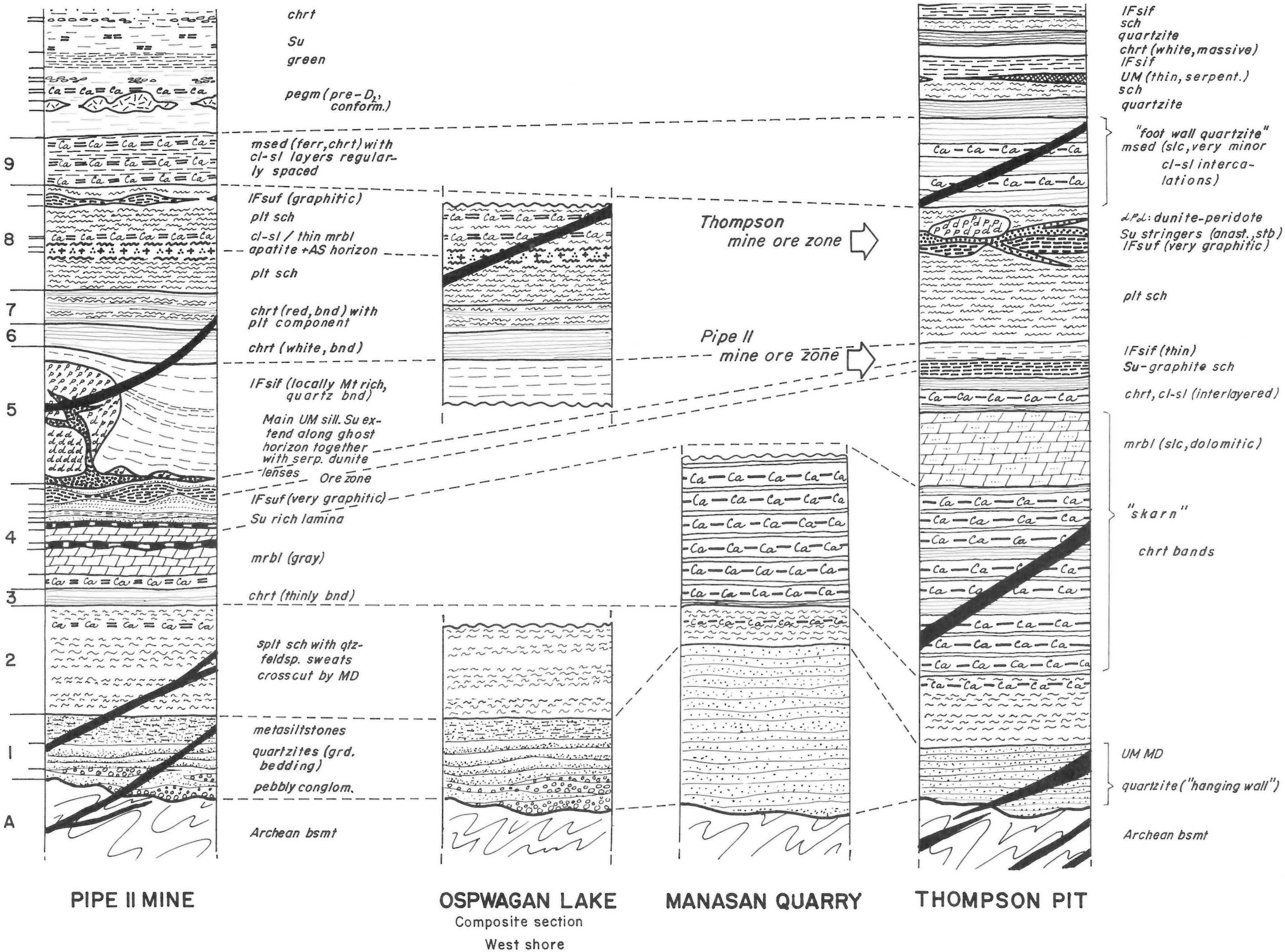

Figure GS-21-1: Ospwagan Group lithostratigraphy in Thompson-Pipe region.

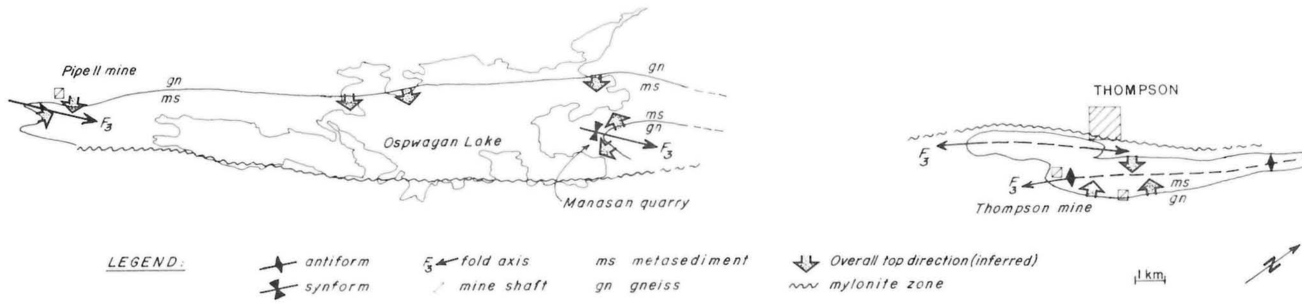

Figure GS-21-2: Simplified map of Thompson-Pipe region showing the distribution of Ospwagan Group supracrustals and their inferred younging directions. Note that upright F_3 structures at Thompson Mine and Manasan Quarry are both downward facing and probably belong to the same inverted limb of the early recumbent fold of regional extent, whereas west shore of Ospwagan Lake represents the lower limb of the same recumbent fold.

sists of a massive pyrrhotite matrix with numerous inclusions of chert and graphitic schist. Pentlandite is a trace mineral in the sulphide facies iron formation.

The Pipe II ultramafic body occurs between the carbonates with interlayered chert, diopside-rich bands and sulphide facies iron formation and the overlying cherty silicate facies banded iron formation, i.e. at the interface between units 4 and 5. Although the internal structure of the ultramafic body is complex, massive nickeliferous sulphides occur concentrated at the base and extend beyond the ultramafic body following this single horizon. Locally, coarse grained nickeliferous sulphides "intruded" the fine grained graphite-rich sedimentary sulphides. Small lenses of serpentinized dunite accompany the massive nickeliferous sulphides.

The shape of the ultramafic body with the massive sulphides extending into the wallrock is attributed to boudinage of the competent ultramafic sill, with the massive sulphides and small serpentinite lenses being smeared out along the stretched horizon formerly occupied by the sill. The abrupt termination of the ultramafic body, an F_1 or F_2 boudin-neck, forms a strong linear anisotropy that controlled the position of the tight macroscopic F_3 fold, which dominates the structure at Pipe II.

The upper enveloping surface of the ultramafic body, and massive sulphide zone that extends beyond the parent body, is formed by a silicate facies banded iron formation, locally rich in magnetite (unit 5, 2-5 m); it is overlain by white banded chert (unit 6, 0-2 m) and dark red, laminated cherts and ferruginous schists (unit 7, 1-2 m). The latter unit is transitional towards the main pelitic schists (unit 8, 10-20 m). The pelitic schists contain abundant thin (0.5-2 cm) red chert bands at the base, a few thin marble or calc-silicate bands and several aluminous bands with abundant garnet, staurolite, sillimanite and locally retrograde andalusite.

Some chert bands are rich in apatite and magnetite. A prominent sulphide facies iron formation, up to 1 m thick, occurs near the top of the schist unit. Both the pelitic schist unit and the sulphide facies iron formation are of regional extent and can be correlated with occurrences on Ospwagan Lake and the ore-hosting schists at Thompson Mine.

It is important to note that the massive nickeliferous sulphides and accompanying ultramafic bodies of the Thompson deposit occur characteristically near the stratigraphic top of the schist unit, close to or along the sulphide facies iron formation, and therefore occupy a different lithostratigraphic horizon than the Pipe II ultramafic body and sulphides. The spatial association of nickeliferous sulphides with sulphide facies iron formations is probably of genetic significance and explains the association of "barren sulphides" with the Ni-sulphide ore zones (W. Bleeker, work in progress). Although distinction of the two sulphide populations in Thompson may be complex, in Pipe II Open Pit chemical, mineralogical and textural differences between the two sulphides are sharp, even where in contact with each other.

The schists are overlain by banded siliceous metasediments with abundant calc-silicate bands (unit 9, 5-10 m) grading upwards into varied silicate facies iron formations, cherts, yellow-white marble and diopside-rich calc-silicate rocks (units 10 through 24). Several of these units can be correlated regionally, such as unit 24 of interlayered schists and quartzites with typical pink chert concretions, found both at Thompson and Pipe II open pits.

The quartz-phyric rhyolite discovered on Ospwagan Lake occurs within this upper sequence dominated by silicate facies iron formations, cherts and ferruginous laminated schists. The rhyolite forms a conformable 2-4 m wide band of very fine grained, light coloured quartzofeldspathic schist, marginally altered to sericite schist. Relict quartz phenocrysts are regularly distributed throughout the sugary quartzofeldspathic matrix. Most relict quartz phenocrysts are lens-shaped but some have retained HT-quartz habits.

At all localities discussed, supracrustal rocks are crosscut by mafic dykes. Several attributes of these dykes, such as thin flame-like offshoots, their disposition in short en echelon segments and their occurrence in closely spaced clusters, the cuspate magmatic layering in some of the wider dykes, and their mafic composition are all reminiscent of typical Molson dykes. Chemical work on these dykes is in progress in order to further test this correlation (W. Bleeker, in prep.). Despite the intense deformation and amphibolite facies metamorphism, the dykes are often well preserved, although they have been folded by F_2 and F_3 folds, and locally show primary grain size variations from coarse subophitic cores to fine grained margins. At Pipe II Open Pit these dykes probably post-date tight to isoclinal F_1 folds in the Ospwagan Group supracrustals (cf. Macek, 1987). This would indicate that Hudsonian F_1 overthrusting/recumbent folding (Bleeker, 1988) was initiated prior to 1883 Ma. This has an important bearing on possible correlation between convergence along the Thompson Nickel Belt and the thrusting in the Kapuskasing Belt (Percival and McGrath, 1986). It would further indicate that Ni-ore related ultramafic bodies, which predate F_1, are much older and therefore unrelated to the Molson dyke swarm mafic/ultramafic magmatism. This is further supported by the observation that one of the mafic dykes penetrates the Pipe II ultramafic body (INCO geological staff, pers. comm.).

IMPLICATIONS FOR THE REGIONAL STRUCTURE

A complex deformation history has recently been identified (Bleeker, 1988). The most prominent structures are nearly upright, en echelon and double plunging F_3 folds, which overprint two generations of tight to isoclinal folds (F_1-F_2).

Detailed structural observations at Pipe II Open Pit further support the proposed scenario although providing evidence that F_1 and F_2 are two different events, separated by Molson dyke intrusion at 1883 Ma. F_1 folding, or possibly F_2, must have involved large-scale recumbent folding to explain the downward facing character of the double plunging Thompson F_3 antiform and the Manasan Quarry F_3 synform (Fig. GS-21-2) This picture is further enhanced by the stratigraphic analysis that distinguishes downward facing structures from upward facing structures and thus defines the extent of the overturned limb of the early recumbent fold.

CONCLUSIONS

In spite of intense deformation, including polyphase folding (Bleeker, 1988) a detailed stratigraphy for most of the Ospwagan Group sequence is established. Although individual units may be repeated, pinched out or undergo lateral facies changes, correlation on the basis of the established stratigraphy between Pipe and Thompson localities is excellent and the former distinction between a "Pipe band" and "Thompson band" of Ospwagan Group supracrustals (cf. Peredery et al., 1982) appears to be unwarranted.

Much of the metasediments contain 1-3% disseminated sedimentary sulphides. However, two main reservoirs of sedimentary sulphides exist in the form of sulphide facies iron formations, respectively at the top of unit 4 and within the pelitic schist of unit 8. Both units appear to be of regional extent and can be correlated between Pipe II and Thompson open pits.

The Pipe II ore zone is conformable with the lower sulphide facies iron formation whereas the Thompson ore zone is closely associated with the sulphide facies iron formation in the pelitic schists. The two ore zones, therefore, occur at different lithostratigraphic horizons, both spatially associated with sulphide facies iron formation. The latter association is proably of genetic significance. Bulk assimilation in the magmatic stage of sulphide facies iron formation by ultramafic sills intruded along these particular horizons may have been a controlling factor in the generation of voluminous Ni-sulphide ore. This process can explain the similarity in Se/S ratios between nickeliferous sulphides and sedimentary sulphides (O.E. Eckstrand, pers. comm.), which indicate that as much as 80% of the sulphur within nickel sulphide ore may be of supracrustal rather than juvenile origin (O.R. Eckstrand, pers. comm.), whereas the overall geochemistry of the ores, such as the narrow range in Ni-Cu-Co bulk ratios for the different deposits (Peredery et al., 1982) and the PGE spectrum of Pipe II ore (Naldrett et al., 1979), favour a magmatic origin. An extensive suite of different ore and sedimentary sulphide samples is presently being collected for a detailed geochemical study (W. Bleeker, in progress).

The recognition of a pebbly conglomerate at the contact between Archean gneisses and a fining upward lower metasedimentary sequence suggests a continuous basement-cover relationship and provides an overall top indicator consistent with the differentiation profile of the Pipe II ultramafic body. The lithostratigraphy can now be used to distinguish downward facing structures from upward facing structures. Although separated by a major dip-slip mylonitic gneiss zone, the downward facing F_3 folds of Manasan Quarry and Thompson Mine define the inverted limb of a regional recumbent fold (probably F_1). The (preserved) extent of this nappe-like structure, which is refolded by tight to isoclinal F_2 and F_3 folds, controls the extent of Ospwagan Group supracrustals in the Pipe-Thompson region, and therefore, the probable extent of mineralized ultramafic rock and Ni-sulphide ore.

The discovery of a quartz-phyric rhyolite, the first reported felsic volcanic rock for the Thompson Nickel Belt, may allow precise U-Pb dating of the Ospwagan Group.

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Inco Limited is gratefully acknowledged for the access granted to their property, geological maps and sections, and drill core. The first author would like to express his gratitude to Manitoba Energy and Mines for extensive logistic support and cooperation.

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GS-22 TECTONIC SETTING OF CIRCUM-SUPERIOR MAFIC AND ULTRAMAFIC MAGMATISM IN MANITOBA

by N.M. Halden[1]

INTRODUCTION

The Trans-Hudson orogenic terrane of central Manitoba is a complex amalgamation of tectonic units which comprises deformed intraoceanic rocks, continental foreland margins, magmatic arcs and reworked accretionary sediments (cf. Hoffman, 1988). Considering the analogies that have been drawn between this terrane and those produced by thin skinned plate tectonics (cf. Stauffer, 1984, Green et al., 1985), ophiolites and ophiolitic assemblages are noticeably absent from the reconstructions. Remnants of such rocks would play a pivotal role in the interpretation of the Trans-Hudson orogen. The distribution of major tectonic units, and more areally restricted yet distinctive lithological units such as the mafic and ultramafic rocks (Fig. GS-22-1) of the Circum-Superior belt (Baragar and Scoates, 1981, 1987), represents a post-collisional, modified geometry. Any original association between such units will probably have been obliterated by deformation and dislocation along major fault boundaries, e.g. the Thompson lineament, making identification more difficult.

Baragar and Scoates (1987) indicate that the volcanic component from the northern part of the Circum-Superior belt comprises low-K tholeiites of oceanic type, intimately associated with sediments that would preclude their emplacement by obduction. This limitation poses severe constraints upon the development of the Superior margin and conflicts with Hoffman's (1988, Fig. 5) interpretation that the boundary of the Fox River belt was a thrust zone. Scoates (1981) proposes that the development of the Fox River belt was associated with rifting and that its present attitude is a function of later deformation. The possibility that at least the Fox River belt was obducted onto the Archean margin cannot be excluded when compared with other mafic volcanic suites of similar age (Park et al., 1984; and Park, 1988). An obduction related emplacement for the Purtuniq ophiolite in the Cape Smith belt was proposed by Scott et al. (1988). If thrusting and imbrication did indeed play an important role in the early development of the Churchill-Superior boundary zone then it is conceivable that there may be some genetic connection between the isolated occurrence of mafic and ultramafic volcanic rocks that has been obscured.

Hoffman (1988) makes direct reference to tectonic significance of the magmatism being unclear. Trace element data has hitherto been unavilable for the Fox River belt, some trace element data for the Ospwagan volcanic suite was published by Paktunc (1984). The objective of this study is to compare major and trace element geochemical characteristics of the Ospwagan Group volcanic rocks, the Fox River belt (trace elements were determined for a subset of samples from the work of Scoates (1981)), Moak Lake, and some metavolcanic rocks at Assean Lake. The major and trace element data for the Assean volcanic group, the Moak Lake amphibolites and the trace element data for the Fox River belt represent new data.

GEOLOGICAL SETTING OF THE MAFIC AND ULTRAMAFIC VOLCANIC ROCKS

Ospwagan Lake

The geology of the Ospwagan Lake area (Fig. GS-22-2) has been described by Stephenson (1974) and Macek and Russell (1978). The sampling for this study was based upon this later mapping as it contains a more detailed lithological subdivision of the mafic and ultramafic rocks.

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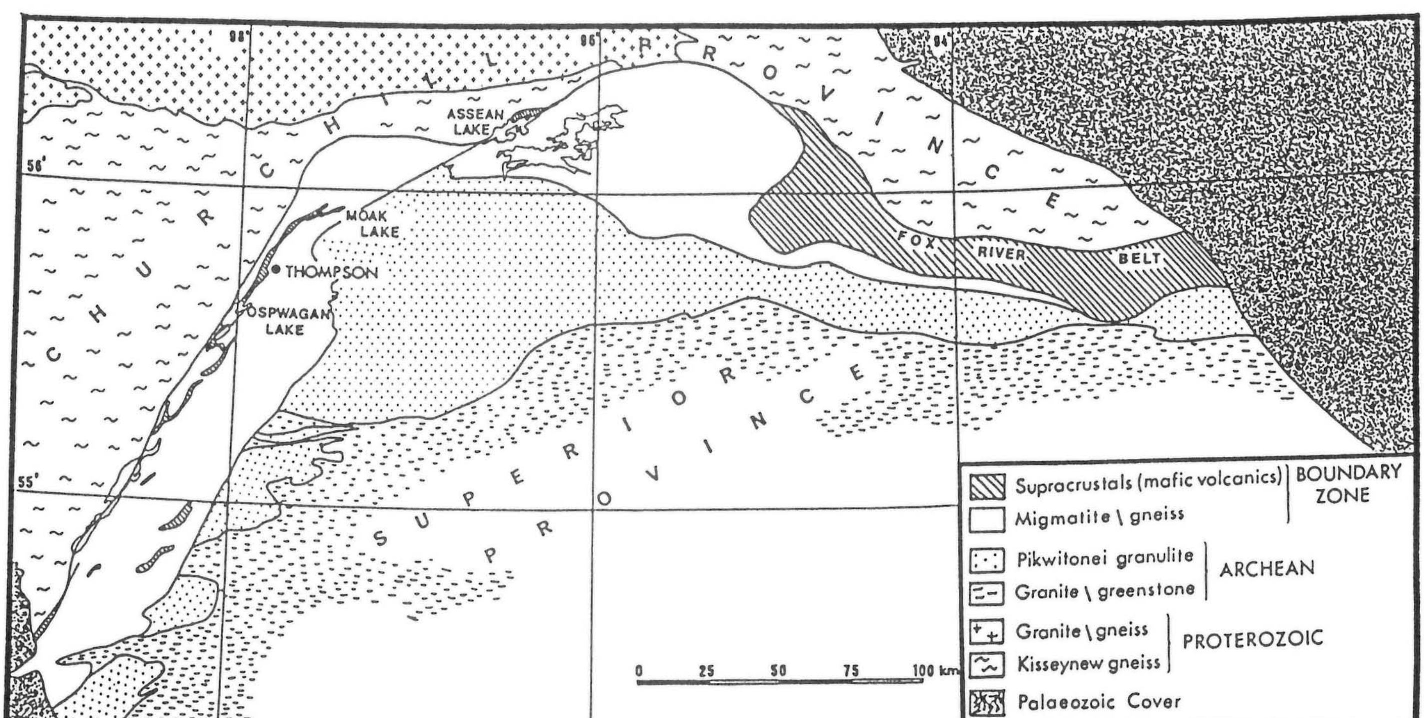

Figure GS-22-1: Schematic geological map of north central Manitoba showing the distribution of Proterozoic supracustal rocks which include mafic and ultramafic volcanic rocks.

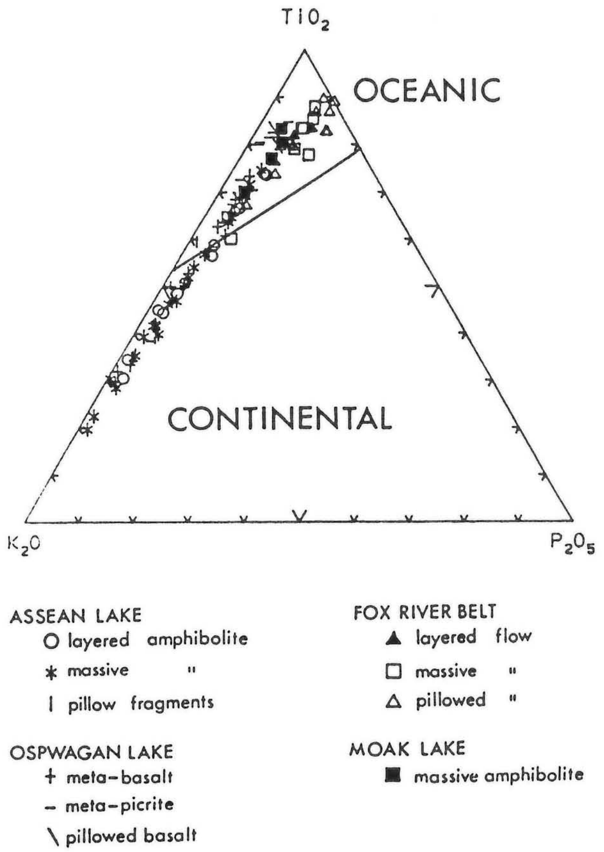

Figure GS-22-2: *K_2O-TiO_2-P_2O_5 ternary plot showing the continental and oceanic fields described by Pearce (1976). The symbols used in this plot for the various rocks are the same as are used in Figures GS-22-3, -4, -5, and -6.*

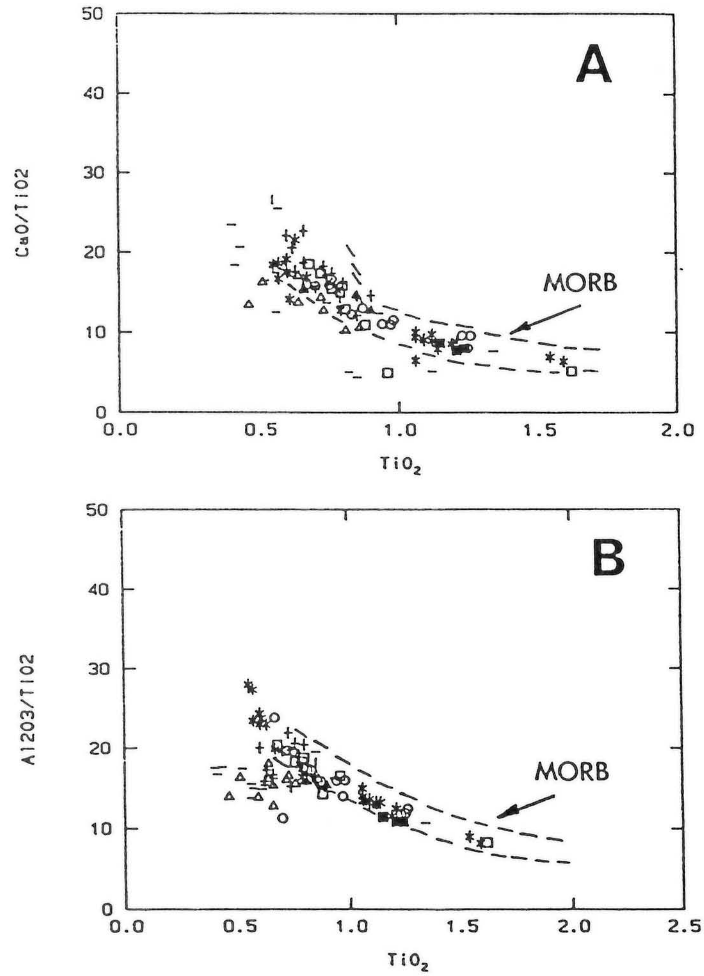

Figure GS-22-3: *CaO/TiO_2 vs. TiO_2 and Al_2O_3/TiO_2 plots. The dashed line indicates the limits of the MORB field described by Sun and Nesbitt (1976).*

Assean Lake volcanic rocks

Volcanic rocks at Assean Lake (Fig. GS-22-3) have not received as intense examination as those of the Fox River belt and Ospwagan Lake. There are, however, a small number of occurrences of flattened pillowed volcanic rocks and breccia units at the northern end of Assean Lake. The Assean Lake area is of interest as it lies between Ospwagan Lake of the Thompson belt, and the Fox River belt at the northern margin of the Superior Province.

Fox River Belt

The geology of the Fox River belt has been described by Scoates (1981). The belt forms part of the Circum-Superior belt along the northern margin of the Superior craton (Baragar and Scoates, 1981, 1987). The Fox River volcanic rocks are intercalated with sediments and differentiated sills, Scoates (1981) subdivided the volcanic rocks into lower and upper volcanic formations. These were further subdivided into massive, layered and pillowed flows.

Moak Lake

The geology of the Moak Lake area was described by Patterson (1963), and Scoates and Macek (1977). In the immediate area of the Moak Lake mine site exposure is poor precluding any sophisticated interpretation of structure and stratigraphy. The amphibolites analyzed in this study come from an outcrop located 4.5 km southwest of the Moak Lake mine site. Scoates and Macek (1977) reported igneous layering within the outcrop, and Patterson (1963) referred to some units of the mafic amphibolites as possibly being pillowed; observations made during this study could not confirm pillowed structures.

GEOCHEMISTRY

Sampling and analytical procedures

A representative selection of the data is given in Table GS-22-1. The prefixes 'O', 'A86' and 'MK' refer to samples from Ospwagan, Assean and Moak lakes, respectively. Other sample numbers are those for the Fox River belt and these correspond to the sample numbers from Scoates (1981, Table 2).

All samples were prepared as fused glass discs (excluding those of the Fox River belt) in the manner described by Harvey (1982) for major element analysis, and as pressed powder pellets (Leake et al. 1969) for trace element analysis. All analyses were performed on an ARL wavelength dispersive X-ray spectrometer, trace elements were analyzed using the compton scatter technique.

Major element geochemistry

Figure GS-22-2 illustrates the distribution of the data on the classification diagram of Pearce T.H. et al. (1975); the data straddles the boundary between oceanic and continental environments. The spread of data towards the K_2O apex is interpreted as being indicative of alkali element mobility during either weathering or metamorphism. Rocks from each locality occur within the oceanic field suggesting, at least for some, an oceanic affinity.

Sun and Nesbitt (1976) argued that Al_2O_3/TiO_2 ratios in mid-ocean ridge basalts vary with the degree of partial melting and the nature of the source region being melted. Figures 3a and 3b show the variations of

TABLE GS-22-1:
REPRESENTATIVE SELECTION OF THE DATA OBTAINED FROM META-BASALTIC ROCKS FROM OSPWAGAN LAKE (01-08), ASSEAN LAKE (A8622-A8676), MOAK LAKE (MK1-MK5) AND THE FOX RIVER BELT (57-2, 215-2, 217, 98-2).

	AB622	AB623	AB626	AB627	AB676	57-2	215-2	217	98-2	MK1	MK5	01	02	07	08
SiO_2%	50.53	49.89	49.73	49.76	43.03	51.95	54.00	50.00	51.50	50.57	49.50	51.86	48.38	49.82	50.60
TiO_2	0.75	0.76	0.70	0.67	0.85	0.72	1.62	0.85	0.81	1.15	0.80	0.79	0.74	0.40	0.57
Al_2O_3	14.69	14.75	13.77	13.32	15.43	11.55	13.47	14.15	12.80	13.19	14.99	13.50	11.24	7.01	8.53
Fe_2O_3*	12.69	12.68	12.57	12.31	13.75	1.36	2.93	2.84	1.34	14.51	10.98	11.41	11.68	9.45	9.32
FeO	0.00	0.00	0.00	0.00	0.00	1.36	8.98	7.60	8.10	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.22	0.23	0.21	0.23	0.56	0.16	0.16	0.18	0.15	0.26	0.19	0.18	0.17	0.15	0.21
MgO	6.69	6.80	8.21	9.18	10.49	9.45	4.82	7.33	9.04	7.22	7.91	8.50	12.84	21.83	14.92
CaO	11.88	12.81	10.90	11.29	12.24	10.30	8.34	12.40	8.27	9.98	12.62	11.31	12.69	9.37	14.53
Na_2O	1.68	1.62	1.41	1.53	1.03	1.71	2.33	1.40	3.58	2.20	2.04	2.61	1.49	0.72	0.95
K_2O	0.89	0.90	1.23	0.70	0.56	0.04	0.21	0.07	0.18	0.17	0.29	0.27	0.40	0.09	0.55
P_2O_5	0.05	0.03	0.05	0.06	0.02	0.11	0.25	0.10	0.07	0.06	0.05	0.05	0.04	0.01	0.03
H_2O+	0.00	0.00	0.00	0.00	0.00	3,48	2.86	2.52	3.22	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.07	100.27	98.78	99.05	97.96	92.19	99.97	99.44	99.06	99.31	99.37	100.48	99.67	98.85	100.21
Rb ppm	16	20	40	20	9	3	4	2	6	0	0	5	7	0	63
Sr	110	120	112	106	66	60	107	86	90	94	138	179	136	28	90
Y	20	22	20	20	19	18	46	20	16	25	20	22	16	8	13
Nb	0	0	0	0	0	4	11	5	0	0	0	0	2	0	0
Zr	45	47	41	39	42	31	141	37	37	52	48	45	39	21	26
Zr/Y	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2
Zr/Ti	60	61	59	59	49	43	87	44	46	45	60	57	53	53	46
Zr/Nb	0	0	0	0	0	8	13	7	0	0	0	0	20	0	0
P	218	130	218	261	87	480	1091	136	305	261	218	218	174	43	130

Al_2O_3/TiO_2 and CaO/TiO_2 ratios vs. TiO_2 from this study. Low TiO_2 (less than 0.6%) rock types occur at each locality but represent a minority of the samples analyzed. Sun and Nesbitt (1976) point out that such rocks (low TiO_2) might be expected to have high Al_2O_3/TiO_2 and CaO/TiO_2 ratios (as high as 60). With these kinds of values the rocks could have been associated with incipient spreading close to a subduction zone (cf. Gaskarth and Parslow, 1987). For this study, TiO_2 values range as high as 1.54%. These are associated with low Al_2O_3/TiO_2 and CaO/TiO_2 ratios; such rocks fall in the MORB field described by Sun and Nesbitt (1976). The data also show relatively restricted Al_2O_3/TiO_2 ratios (between 8 and 28) and CaO/TiO_2 ratios (between 5 and 28). These values are not too far removed from chondritic values 20 and 17, respectively for these ratios. The mantle producing these kinds of rock would have been comparitively primitive and would not have undergone any high degree of partial melting. The high TiO_2 values allied with restricted ranges for the Al_2O_3/TiO_2 and CaO/TiO_2 ratios are interpreted by Sun and Nesbitt (1976) to be consistent with an origin in either a mid-ocean ridge, an interarc basin or an island arc.

The Al_2O_3/TiO_2 ratios show a more restricted range than those published by Gaskarth and Parslow (1987) for the East Amisk volcanic rocks of the Flin Flon belt which range between 5 and 95. If the high ratios were indicative of high degrees of partial melting of the mantle source regions, this would preclude any simple association between the source region for the Amisk volcanic rocks and those fringing the Superior margin.

Attempting to discriminate the likely tectonic setting of the volcanic rocks, beyond that of oceanic and continental, at the four localities on the basis of major elements, does not lead to an unambigous solution. The data points on Figures 3a and 3b overlap the MORB field. An additional limitation on using the CaO/TiO_2 vs. TiO_2 plot may be the mobility of a Ca during weathering and alteration (cf. Gaskarth and Parslow, 1987). An alternative tectonic classification based on major and minor elements is that of Mullen (1983). This classification (Fig. 4) shows that the Assean and Ospwagan volcanic rocks straddle the boundary between the calc-alkali basalts and island-arc tholeiites, whereas those from the Fox River belt and Moak Lake appear to be restricted to the island-arc tholeiite field.

On the basis of major element data it is only possible to conclude that the rocks have an oceanic affinity, and were probably derived from a relatively primitive mantle. The possibility that their environment of emplacement could have been transitional to either an island arc or marginal basin setting cannot be excluded.

Trace element geochemistry

Trace elment geochemistry can provide for both a comparison of the rocks and the tectonic discrimination of the rocks. In the case of the HFS elements (Nb, Ti, Zr, Y), they tend not to be affected by weathering and metamorphism (i.e. they are immobile in aqueous solutions, Pearce and Norry, 1979). In addition crystal fractionation processes dominated by the major phases in the basalts will affect the element ratios as a function of the distribution coefficients for those elements in the major phases. These element ratios tend to preserve some of the characteristics of the source region from which the rocks were derived.

Discrimination of tectonic setting on the basis of TiO_2 vs. Zr (Fig. GS-22-5) shows a spread of data within the MORB and arc-lava fields; this tends to reinforce the idea that the rocks are unlikely to be true MORB but have been derived in some sort of anomalous or transitional setting. The data show a similar distribution to that of Pearce et al. (1981) for the Troodos complex, which they interpret as being a Cretaceous arc-basin complex, and the Outokumpu assemblage (Park, 1988), which probably evolved in a Proterozoic arc-basin complex. The tectonic discrimination fields of Pearce and Cann (1973), shown in Figure GS-22-6, lead to a similar conclusion as mentioned earlier, i.e. a strong indication of an oceanic affinity for the rocks (to the exclusion of any data falling in the within-plate basalt field) but an overlap with island-arc tholeiites and calc-alkali basalts.

MORB normalization diagrams (Fig. GS-22-7 to -10) offer a more direct comparison with recent mid-ocean ridge type basalts (normalizing values are taken from Pearce, 1982). Figure GS-22-10 includes (as the stippled field) an area showing the maximum range of these element values from volcanic-arc basalts taken from Pearce (1982). Similarities exist between the Ospwagan and Assean rocks, and differences with the Fox River belt rocks. Extreme alkali enrichment is especially evident in the case of the Assean Lake rocks. All the rocks are, however, less than 1*MORB in terms of their HFSE (Zr, Ti, Y). This may indicate that the source region, although primitive in terms of major elements, had already undergone an earlier melting event under conditions where phases liable to retain these

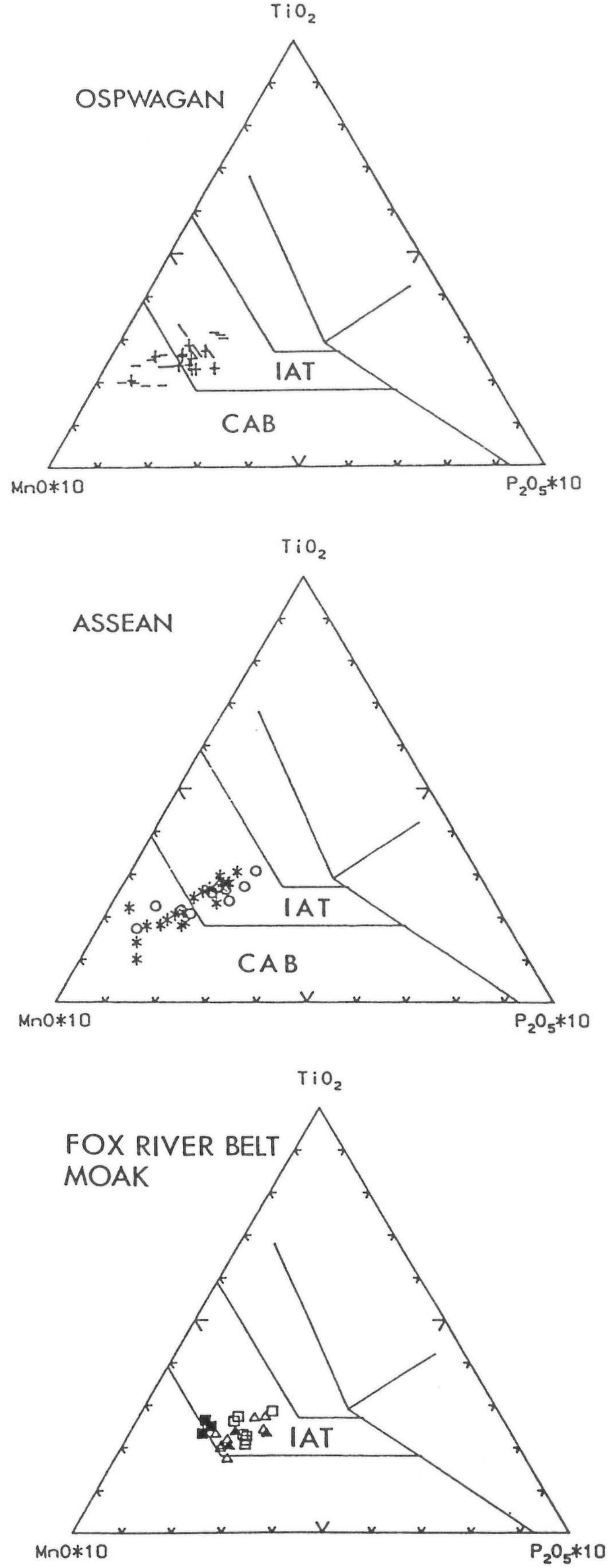

Figure GS-22-4: *MnO-TiO_2-P_2O_5 ternary plots showing the tectonic discriminant boundaries of Ellen (1983). IAT refers to island-arc tholeiites and CAB to calc-alkali basalt.*

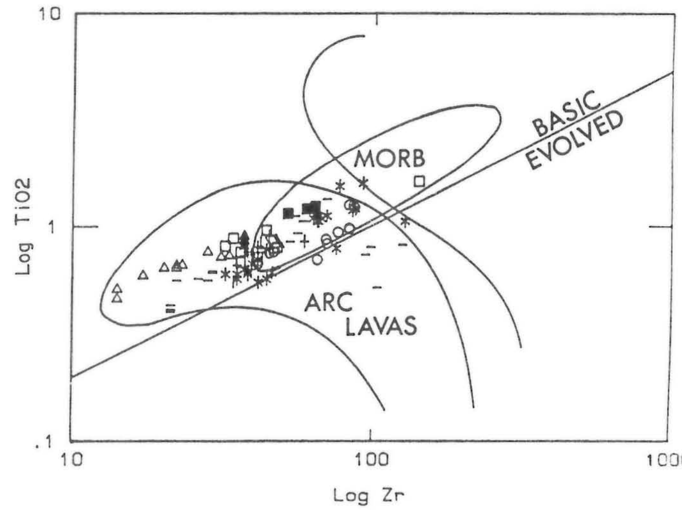

Figure GS-22-5 *Log TiO_2 vs. log Zr plot showing the field boundaries of Pearce (1981). The majority of the data plots above the basic volcanic boundary and within the arc lava or MORB field.*

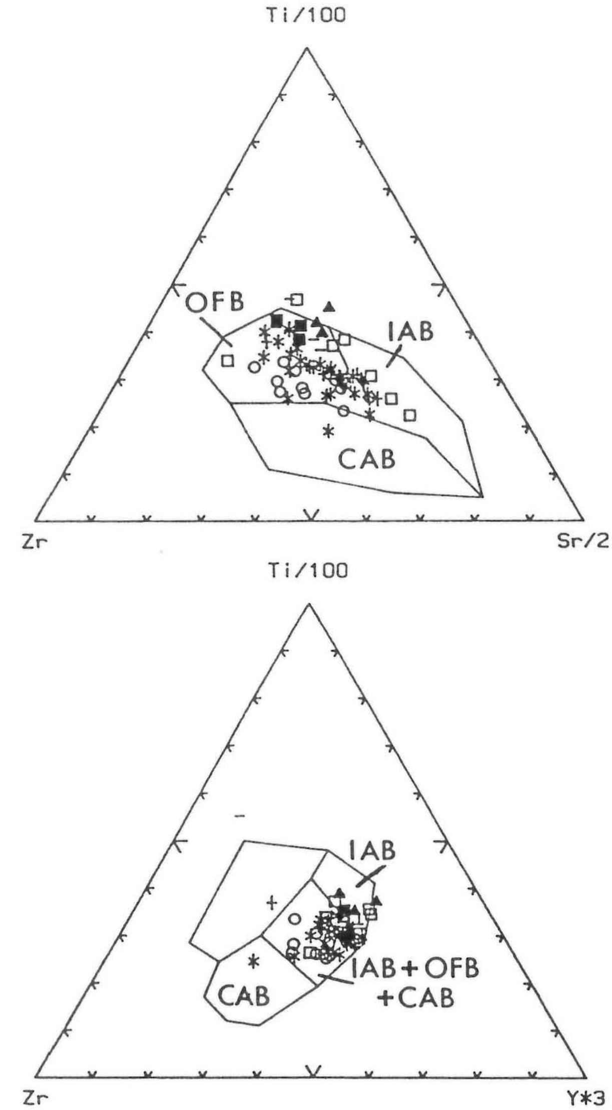

Figure GS-22-6: *Zr-Ti/100-Sr/2 and Ti/100-Zr-Y*3 ternary plots with the discriminant field boundaries of Pearce and Cann (1973). OFB refers to ocean floor basalt, IAB to island-arc basalt and CAB to calc-alkali basalt.*

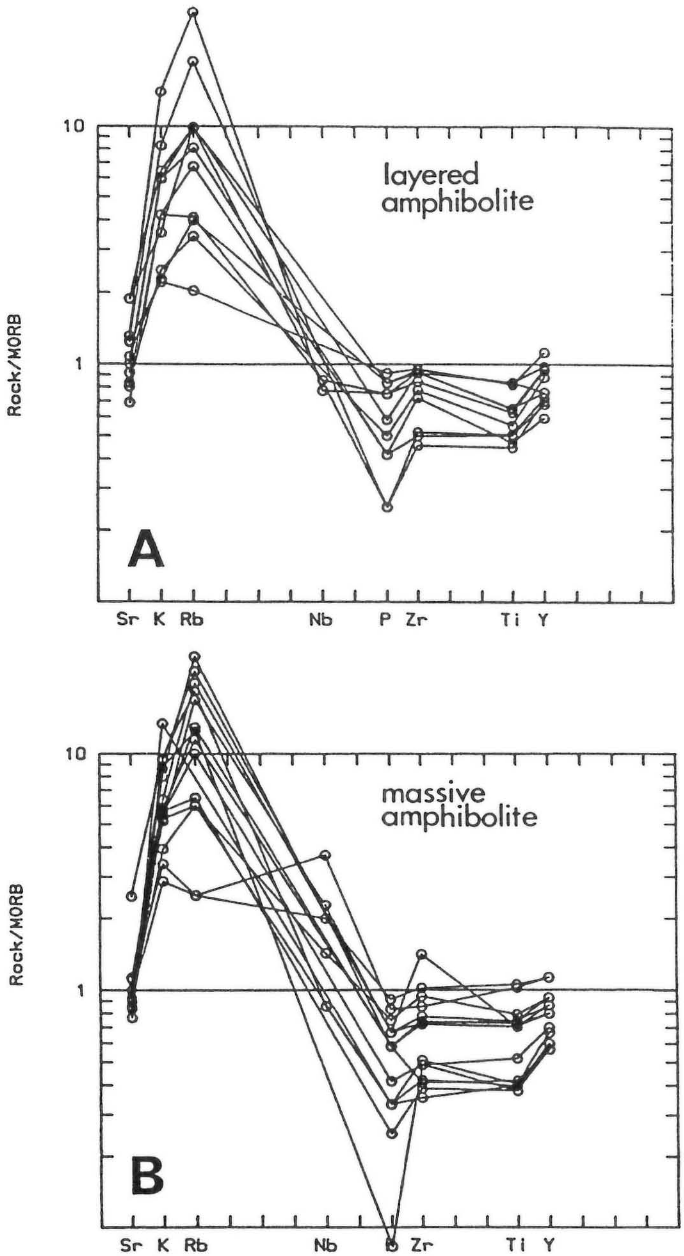

Figure GS-22-7: *MORB normalized plot of K, P and trace element data from Assean Lake. Normalizing values are from Pearce (1982).*

elements (e.g. hornblende, garnet, magnetite, rutile and ilmenite) were unstable. In contrast, Nb is variable.

Comparison of the data in this study with the wide range of volcanic-arc basalt values indicates that the basalts were not MORB but may have been derived in a volcanic-arc setting, which is not inconsistent with the major element data. This might suggest the proximity of a subduction zone.

A comparison of the data with N-type MORB is also possible. This inherently includes a comparison with T- and E-type MORB. In this case the data (Fig. GS-22-11) reveal broad similarities with the patterns for rocks produced in back-arc spreading regimes. The pronouced negative slope to the patterns, i.e. a high LIL to HFS element ratio, is a pattern consistent with back-arc spreading centres (Tarney et al., 1981). The majority of the data for Nb, Sr, P, Zr, Ti and Y is all less than 1 * N-type MORB. This

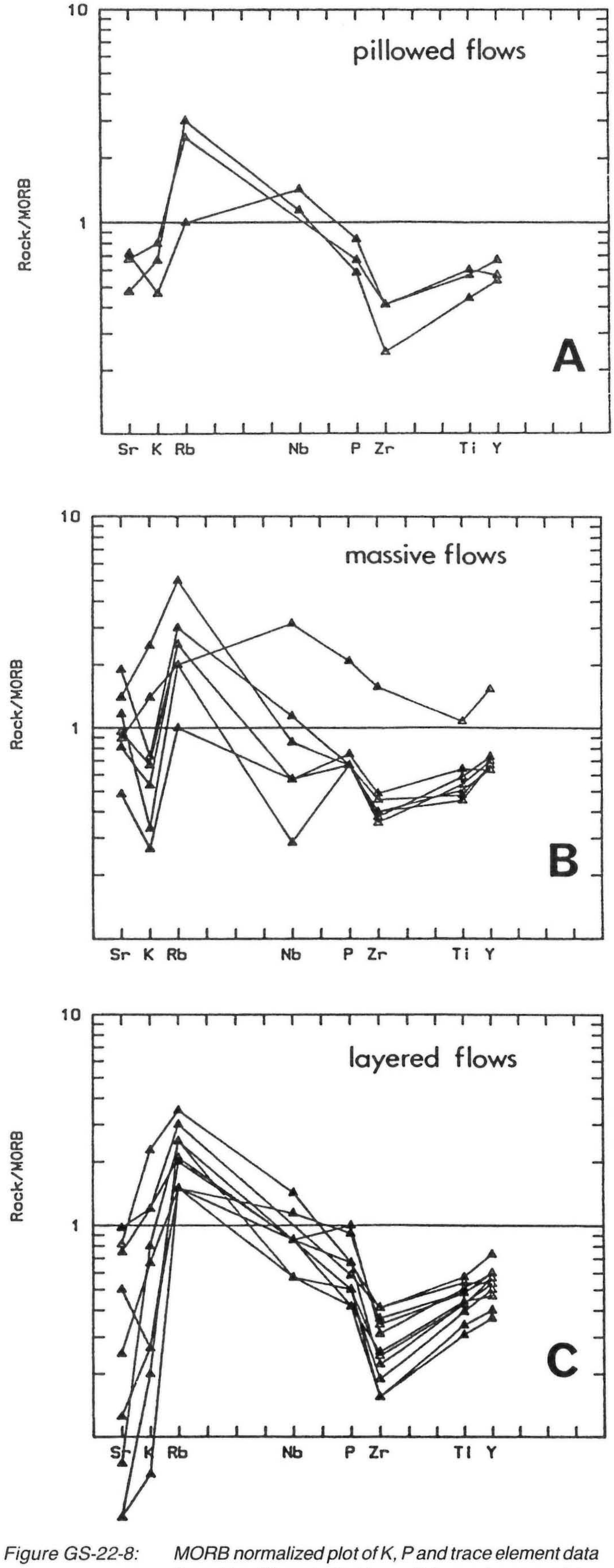

Figure GS-22-8: *MORB normalized plot of K, P and trace element data from Fox River belt. Normalizing values are from Pearce (1982).*

* All Fe was recorded as Fe_2O_3 (X-ray fluorescence analysis) except in the case of the Fox River belt samples.

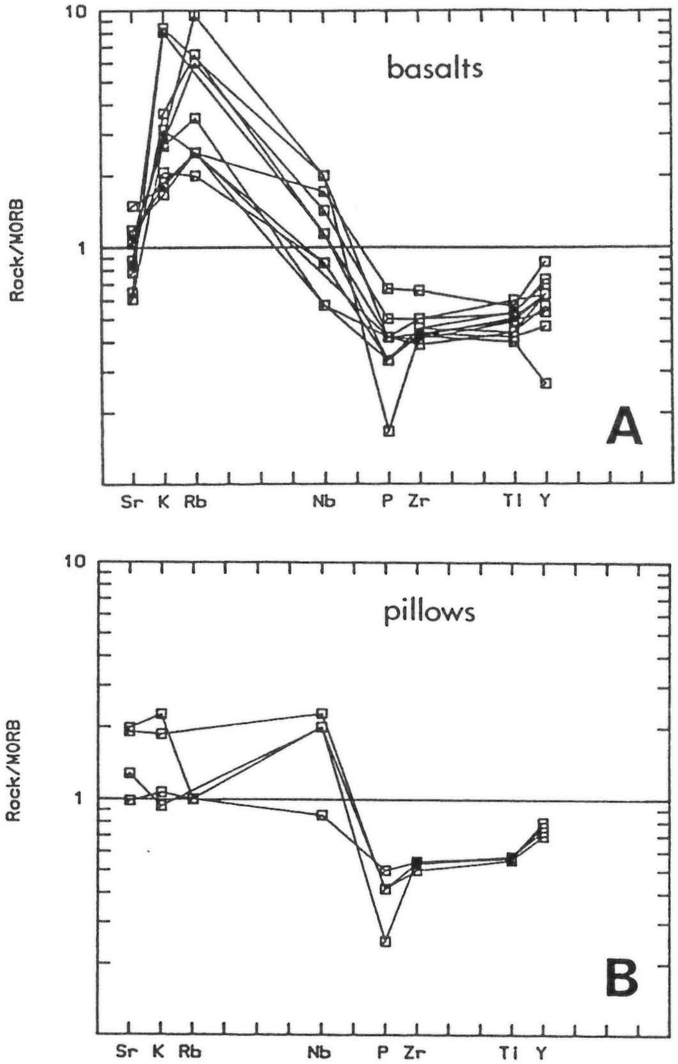

Figure GS-22-9: *MORB normalized plot of K, P and trace element data from Ospwagan Lake. Normalizing values are from Pearce (1982).*

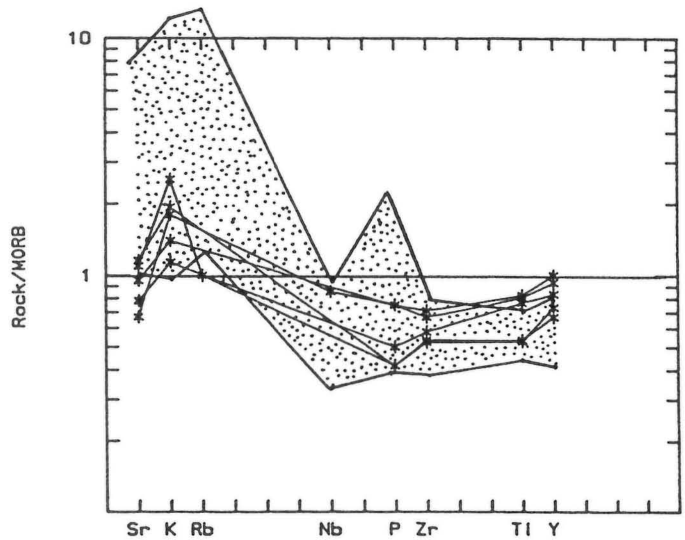

Figure GS-22-10: *MORB normalized plot of K, P and trace element data from Moak Lake. The stippled area represents the maximum of those elements plotted for island-arc basalts; data from Pearce (1982), for comparison with the data from this study.*

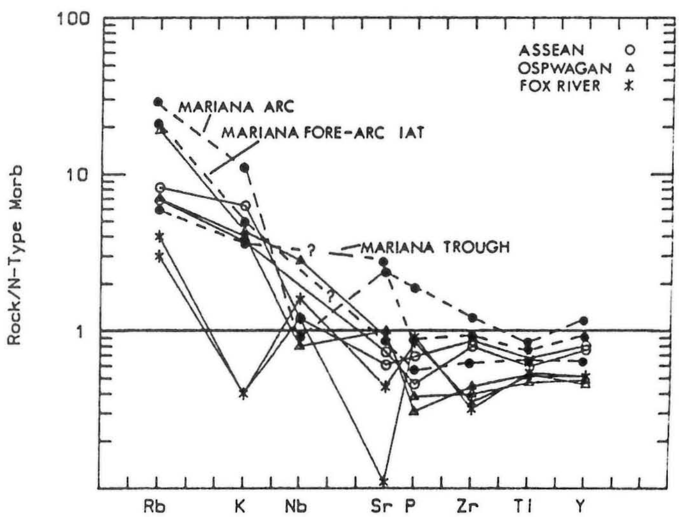

Figure GS-22-11: *N-type MORB normalized plot of a representative selection of rocks from this study in comparison to basalt data from various regions of Mariana arc. Normalizing values are from Tarney et al. (1981).*

clearly differentiates the rocks from N-, T- and E-type MORB. T- and E-type MORB have values considerably in excess of 1*N-type MORB for these elements (up to 15*N-type MORB for Nb in the case of E-type MORB). This would suggest that the majority of the rocks were probably derived from a mantle source comparatively depleted in these elements relative to a mantle that could have produced an N-type MORB type basalt, one that could well have undergone an earlier melting event. Figure GS-22-16 also shows data from basaltic rocks from the Mariana arc (see Tarney et al., 1981). The data in this study show broadly similar patterns.

DISCUSSION

The plate tectonic model for the Trans-Hudson orogen proposed by Green et al. (1985) involved the rifting of an Archean craton during Early Proterozoic, around 2.3-2.4 Ga. The model requires the production of Proterozoic ocean, (e.g. Manikewan, Stauffer, 1984), the extent of which is not known, and which was presumably underlain by basaltic crust. Subsequent closure of this ocean basin is presumed to have led to the development of subduction zones connected with island-arcs (e.g. Snow Lake-Flin Flon belt, Lewry, 1981; Lynn Lake belt, Syme, 1985) and Cordilleran-type magmatism (cf. Fumerton et al., 1984; Halden et al., in press). It is possible that the mafic rocks fringing the Superior craton at Ospwagan, Moak and Assean lakes and the Fox River belt could represent: 1) remnants of a Proterozoic volcanic arc, possibly still preserved somewhere in the Churchill Province; 2) remnants of early oceanic crust connected with the development of Manikewan, which would be difficult to substantiate considering recent geochronological data (cf. Krogh et al., 1987); 3) fragments of marginal basin(s) that could have fringed the Superior craton (which will be difficult to establish in a physical geological sense). The absence of a sheeted dyke complex associated with any of the volcanic rocks in this study, comparable, for example, with what can be observed in the Cape Smith belt (Scott et al., 1988) and in the Penokean orogen (Schulz, 1987) mitigates against the possibility that they could represent mature ophiolitic crust which would be more likely to underlie a large ocean basin.

Comparison of the data in this study with data from the Churchill Province, (Flin Flon area, Gaskarth and Parslow, 1987) and La Ronge domain (Watters and Pearce, 1987) shows some similarities. Both MORB normalized data sets show high LIL to HFS element ratios consistent with marginal basin settings (Tarney et al., 1981). The K and Rb data for the other areas are lower, a feature considered to be the product of amphibolite facies metamorphism (Watters and Pearce, 1987) i.e. opposite to what is seen at Assean and Ospwagan lakes which show a relative enrichment. This may suggest that the high K and Rb values at Assean and Ospwagan lakes are related to sea floor alteration. Another difference with Gaskarth and Parslow's (1987) data is that a considerable proportion of the basalts at Flin Flon, East Amisk and Annabel lakes shows a within-plate affinity. In addition, the data obtained from these areas show a trend towards much higher Al_2O_3/TiO_2 ratios than those observed in this study. If there had been a genetic connection between the Circum-Superior belt volcanic rocks and volcanic rocks in the Churchill Province the geochemical data would suggest the selective structural removal of those rocks that were derived by limited partial melting of a comparatively primitive mantle, i.e. those rocks occurring now at Ospwagan, Assean and Moak lakes and the Fox River belt.

A number of problems remain to be considered. Even though there has been considerable deformation at the Superior margin the continuity of the Circum-Superior belt is a significant geological feature (Baragar and Scoates, 1987). Assuming a rifting process was responsible for producing a series of basins marginal to the Archean craton, what was rifted from the margin? It may be that this rifting was the product of wrench tectonics active at the Superior margin. This could have been associated with continental crustal thinning; in addition, any thinned continental margin could have itself been significantly modified by a wrench tectonic environment. If a marginal basin had developed at the Superior craton margin its closure may have involved the obduction of the basin's contents onto the Superior margin. This does not require the immediate proximity of a subduction zone nor the subduction of oceanic crust beneath the Superior craton, for which there is no magmatic evidence. Such a model was proposed for the origin of the Outokumpu assemblage by Park et al. (1984). The subduction zone association in this case was separated from any interaction with the Samaritan craton by the marginal basin itself. Other similarities include the absence of sheeted dykes and the emplacement of the magmas into an environment including carbonates, chemical sediments and massive sulphides.

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GS-23 U-Pb GEOCHRONOLOGY PROGRAM: THOMPSON BELT AND NORTHWEST SUPERIOR PROVINCE[1]

by N. Machado[2], L. Heaman[2] and W. Weber

U-Pb data are in the process of being finalized and reports and papers are being prepared.

A U-Pb isotope study of monotypic zircons and titanite of a migmatite near Sasagiu Rapids (Machado, submitted) indicates the formation of the paleosome protolith at 3038 ± 6 Ma, followed by metamorphism at 1809 ± 14 Ma and 1737 ± 5 Ma. At 1726 ± 12 Ma the paleosome was intruded by granitic neosome containing inherited zircons dated at 2655 ± 10 Ma. The presence of gneisses older than 3.0 Ga not affected by late Archean metamorphism (2.6-2.7 Ga) which are associated with rocks containing "Pikwitonei"-type 2.64-2.7 Ga zircons indicates that two Archean terranes of different histories were involved in the evolution of the belt. The age 1726 ± 12 Ma for granite intrusion is the youngest so far measured and seems to be restricted to the southern half of the Thompson belt.

During the FONB (Friends of the Nickel Belt) field workshop in June results were discussed and incorporation of U-Pb data and structural data generated by W. Bleeker (cf. GS-21, this volume) are in progress.

[1]This account reports on a cooperative federal-provincial MDA project. The analytical work is being undertaken by the Geochronology Laboratory of the Royal Ontario Museum and is supported by the Geological Survey of Canada. Manitoba Energy and Mines manages the project and is funding the fieldwork portion. Additional results of this project are reported in GS-20, this volume.

[2]Department of Geology, Royal Ontario Museum, Toronto, Ontario.

During the 1988 field season a felsic volcanic flow was discovered in the Ospwagan group at Ospwagan Lake by W. Bleeker and J. Macek thanks to low water levels. A U-Pb zircon age of this flow to be determined this winter should finally date the Thompson belt Proterozoic supracrustal rocks and determine whether the Ospwagan Group is older than Molson dyke and Fox River supracrustals, as suggested by Macek (1987) based on contact relations observed last year in the Pipe Pit. U-Pb results from the Thompson belt will be published in the GAC Special Paper on Trans-Hudson Orogen (Machado, in prep.).

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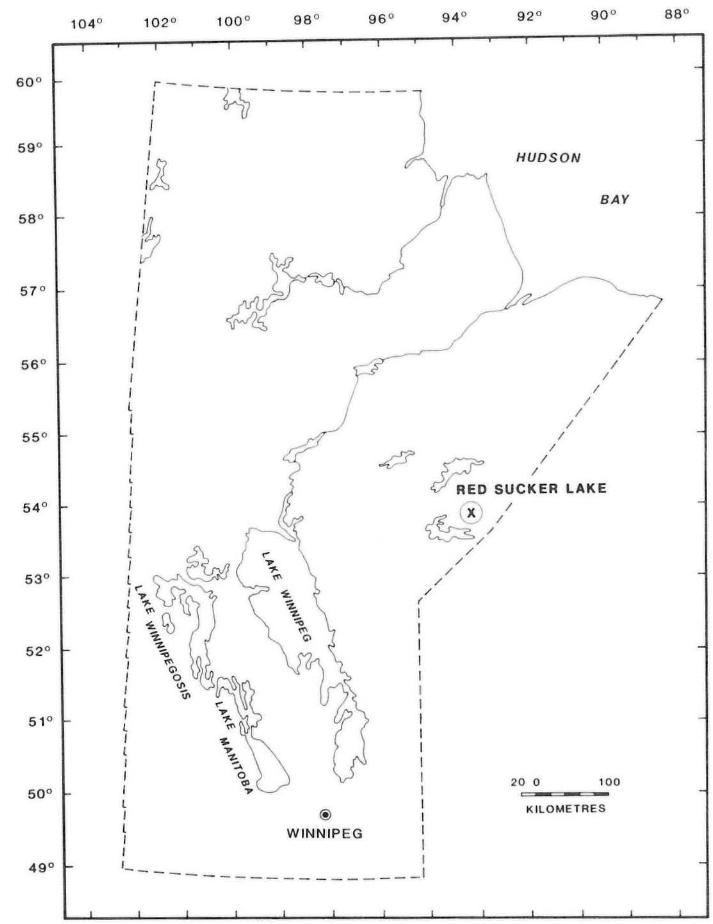
GS-24 PETALITE LEUCOGRANITE AT RED SUCKER LAKE

by W.R. Gunter and L.E. Chackowsky

Petalite-rich to petalite-dominant pegmatitic leucogranite (PLG) occurs on several islands in the Red Sucker Lake area (Fig. GS-24-1). It was initially described by Chackowsky and Cerny (1986) and described in more detail by Chackowsky (1987) as part of a Master's thesis on pegmatitic rocks in the Red Sucker Lake area. Outcrops of PLG that were estimated to contain 20-25% petalite occur at locations B and C of Chackowsky and Cerny (1986). The objective of the current study was to map the distribution of petalite in the PLG on a scale of 1:100, and to collect samples to test for the suitability of the PLG as a ceramic raw material.



Previous work on pegmatitic rocks in the Red Sucker Lake area has concentrated on the tin- and tantalum-bearing dykes farther to the west. The Tin Bar claims, centred on the cassiterite-bearing dyke at location TD of Chackowsky and Cerny (1986) were first staked in 1941 although the tin-bearing dyke was noted by prospectors as early as 1928 (Bateman, 1943). The presence of petalite in the leucogranite was discovered in 1984 during analysis of samples collected by Len Chackowsky (Chackowsky and Cerny, 1984). Bannatyne (1985) describes the tin- and tantalum-bearing dykes but did not examine the PLG during his 1973 study of the area.

The present study (Fig. GS-24-1) consisted of four days of field work to map lithologic units at 1:100, estimating the petalite content, and sampling the exposures of petalite-rich PLG at location B of Chackowsky and Cerny (1986). A portion of the detailed map (Fig. GS-24-2) shows the distribution of petalite, beryl and the three units described in this report. These units are:

Unit 1: Petalite-K-feldspar pegmatite. Coarse- to very coarse-grained (crystals up to 50 cm) with euhedral crystals of white, graphic potassium feldspar and columnar crystals of grey petalite in a groundmass of 2-3 cm quartz and muscovite. A specific orientation of these crystals is not evident, and adjacent mineral grains commonly grow at a high angle to one another. Small platy fragments of unit 3 commonly occur between the crystals of this unit.

Unit 2: Grey aplite. Fine- to medium-grained albite-rich unit with columnar to tabular feldspar grains and banded muscovite and garnet aggregates. The banding in this unit is caused by concentrations of mica grains. This rock generally does not occur within unit 1 but occurs as discrete layers that contain small lenses of unit 3. In the area mapped, the layers are vertical to steeply dipping.

Unit 3: White aplite. A medium- to fine-grained albite-rich unit with columnar to tabular feldspar grains and subhedral to euhedral garnet. Muscovite is generally a minor constituent and does not form bands within the unit. In several places large crystals of petalite appear to nucleate from the surface of lenses of unit 3 that occur within unit 1.

The mineral chemistry of the petalite, K-feldspar, albite, garnet and muscovite are discussed by Chackowsky (1987). This is the first record of beryl at this location and it is presently being documented.

Pegmatitic rocks at Red Sucker Lake occur in a 2-3 km wide east-trending greenstone belt that extends from the northwest part of Red Sucker Lake to the Manitoba-Ontario border (Schledewitz and Kusmirski, 1979). The petalite-bearing pegmatitic leucogranite is exposed over a length of approximately 1 km (Fig. GS-24-3) and forms the central part of a 15 km long east-trending belt of pegmatitic granites. The PLG, and the pegmatitic granite to the west of it, intrude medium grained metabasalt of the Hayes River Group. Pegmatitic granite east of the PLG intrudes metasedimentary rocks of the Oxford Lake Group (Downie, 1936). The pegmatitic granite becomes progressively less fractionated east and west of the PLG (Chackowsky, 1987).

Highly fractionated pegmatites intrude metabasalts several kilometres to the east and west of the PLG, and geochemically barren pegmatites intrude metasedimentary rocks in an east-trending belt about 1 km north of the pegmatitic granites (Chackowsky, 1987).

The youngest rocks of regional extent are granitic batholiths that flank the greenstone belt to the north and south. Field relationships in this area are difficult to determine due to the thick layer of predominantly swamp throughout the area that leaves only extremely limited outcrop that is mostly restricted to shorelines and islands.

Three areas in this belt of potential economic interest are: 1) the PLG; 2) the albite-spodumene-bearing dyke (SQ on Fig. GS-24-1) and the cassiterite-bearing dyke (TD on Fig. GS-24-1). The cassiterite-bearing dyke, (Bannatyne, 1985) was drilled in 1943 by Gods Lake Gold Mines Limited. It contains moderate grades of tin (0.42% Sn over a width of 1.8 m, Bateman, 1943) that were not of economic interest at the time of drilling.

The albite-spodumene dyke (SQ), described by Chackowsky (1987) was discovered by Tanco in 1981. Extensive overburden immediately inland from the shoreline outcrop has not been stripped along the extension of the dyke; thus its size and shape are unknown. The abundance of green elbaite in this dyke, specifically along the northern contact, indicates that this dyke is dissimilar to most of the other pegmatite dykes in Manitoba described by Bannatyne (1985) and Cerny et al. (1981). The SQ dyke has many similarities to the gem-bearing pegmatites of California, (Foord, 1977) and Brazil, (Pecora et al., 1950; Cassedanne and Lowell, 1982; and Cassedanne, 1983). The SQ dyke is similar to the Buck claim

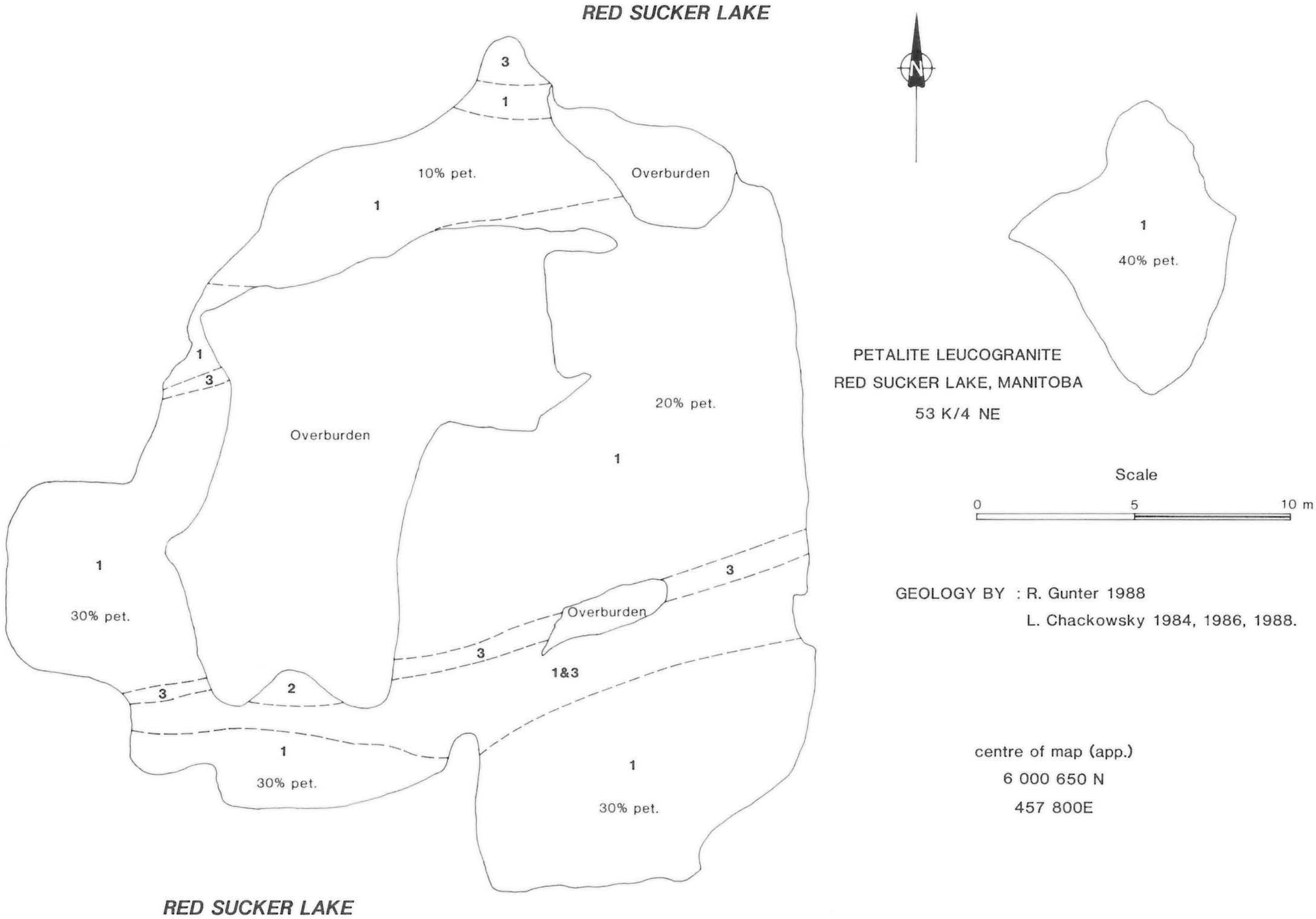


Figure GS-24-2: *Detailed map of island adjacent to location "B" of Chackowsky and Cerny (1986). Unit 1, petalite-K-feldspar pegmatite; Unit 2, grey aplite; Unit 3, white aplite.*

dyke (Lenton, 1979). The presence of abundant small cavities lined with K-feldspar, quartz and albite, the presence of cleavelandite and samples of euhedral green elbaite embedded in both K-feldspar and quartz suggest that this pegmatite has the potential to contain gem grade tourmaline if larger cavities are present. Exploration and production from this type of pegmatite is done as a small-scale family operation in Brazil, and a similar cottage-style industry may be suitable for the SQ dyke, if tourmaline is found lining the cavities.

The petalite-bearing leucogranite has the most economic potential. Other petalite-bearing pegmatites that are either present or past producers are at Bikita in Zimbabwe (Russell, 1988) and the Cape Cross area of Namibia (von Knorring, 1985; Diehl, 1986). Further exploration, including drilling, and stripping of overburden-covered sections, would be required to determine the volume of the petalite-bearing unit and the presence of other incompatible elements.

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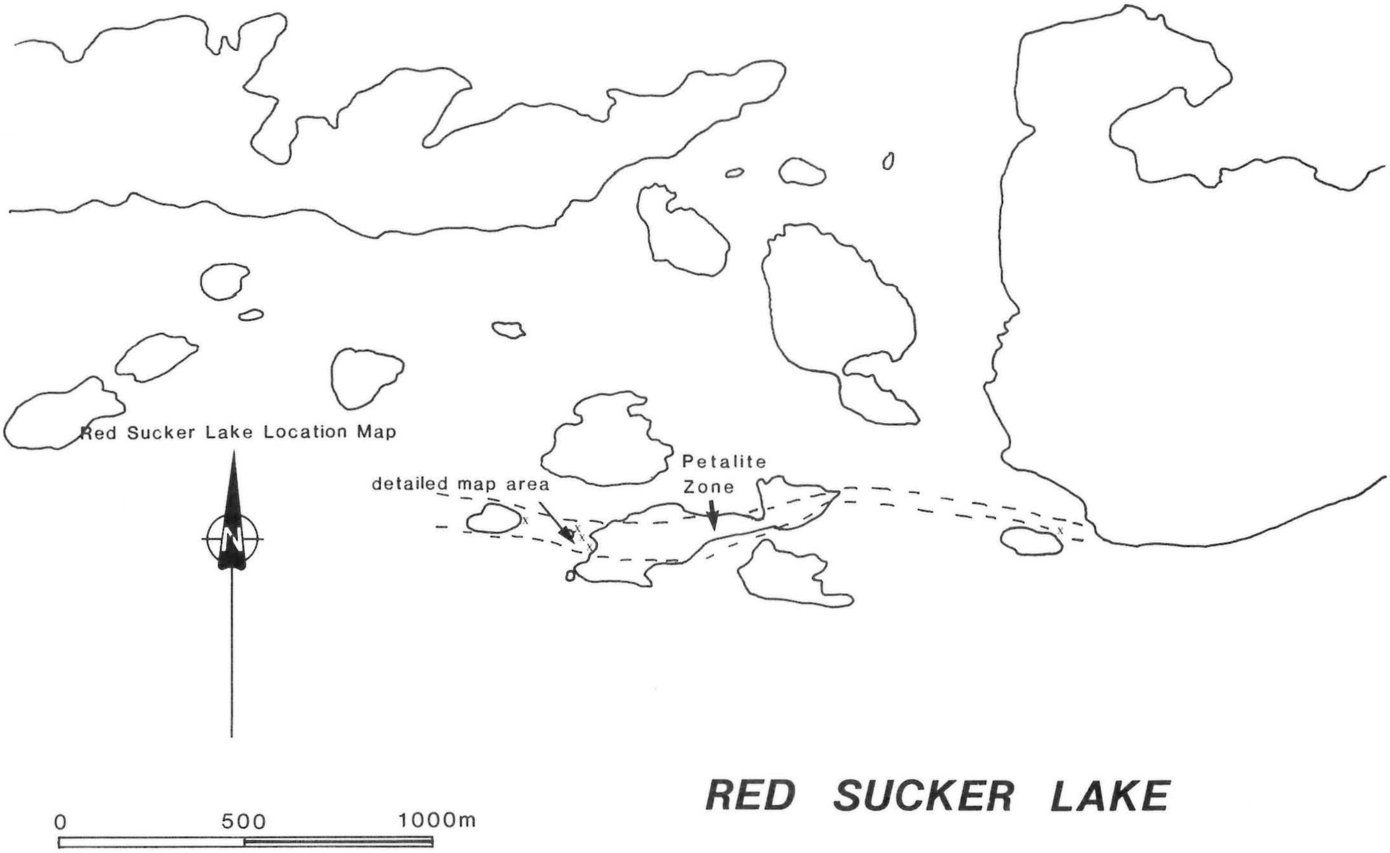

Figure GS-24-3: Location of the petalite-bearing leucogranite (PLG) on Red Sucker Lake.

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GS-25 THE MAGILL GRANITE AND ASSOCIATED PEGMATITES NEAR MAGILL LAKE

by R.E. Meintzer[1], P. Cerny[1], H. Odwar[1]

INTRODUCTION

Detailed sampling of Magill granite and associated pegmatites, begun in 1987 (cf. Meintzer et al., 1987), was continued for geochemical, mineralogical, and petrological studies. Sampling was concentrated in the area around the southern end of Knee Lake with additional sampling near Brown Lake and between Magill Lake and McLaughlin Lake (Fig. GS-25-1). Additional samples of the Semple River granodiorite were obtained from Wapisew Lake.

The Magill granite and associated pegmatites are Late Archean intrusions into metavolcanic and metasedimentary rocks within a greenstone belt in the Cross Lake subprovince of the Archean Superior Province of the Precambrian Shield. Gilbert (1985), Hubregtse (1985), Bannatyne (1985), and Lenton (1985) have provided results of recent mapping and pegmatite reconnaissance.

SOUTHERN KNEE LAKE AREA

Barry (1959) and Gilbert (1985) mapped the area around the southern part of Knee Lake and noted the occurrence of a small stock of granite and several dykes of pegmatitic granite and granite pegmatite. Subsequently, Lenton (1985) reconnoitred the granite and pegmatites and Meintzer et al. (1987) conducted reconnaissance geochemical sampling of the Knee Lake pluton.

The largest body in the area, the Knee Lake pluton, is a small stock of leucogranite that has an ellipsoidal outcrop pattern about 0.8 x 1.5 km. Lenton (1985) noted the textural facies of the unit that correspond to four textural facies of fertile granite as defined by Cerny and Meintzer (1988): "fine-grained" leucogranite, pegmatitic leucogranite, sodic aplite, and potassic pegmatite.

An additional very small (ca. 100 m across) plug of leucogranite (Northeast stock) outcrops at the extreme northeastern part of the southern embayment of Knee Lake and also comprises the same four textural facies. Accessory mineralogy in this plug is typical of the Magill granite with common garnet, and rare biotite and schorl that are more prevalent near the contacts with the metasedimentary rocks of the Oxford Lake Group. Plates of molybdenite, 1 cm in diameter, also occur near the granite-schist contact. In addition to the Northeast stock, an extensive outcrop along the cliff across the bay from the stock is similar petrologically and displays ductile deformation of the host rock.

Numerous dykes of potassic pegmatite and pegmatitic granite outcrop along the shores of the southern bay as indicated in Figure GS-25-1.

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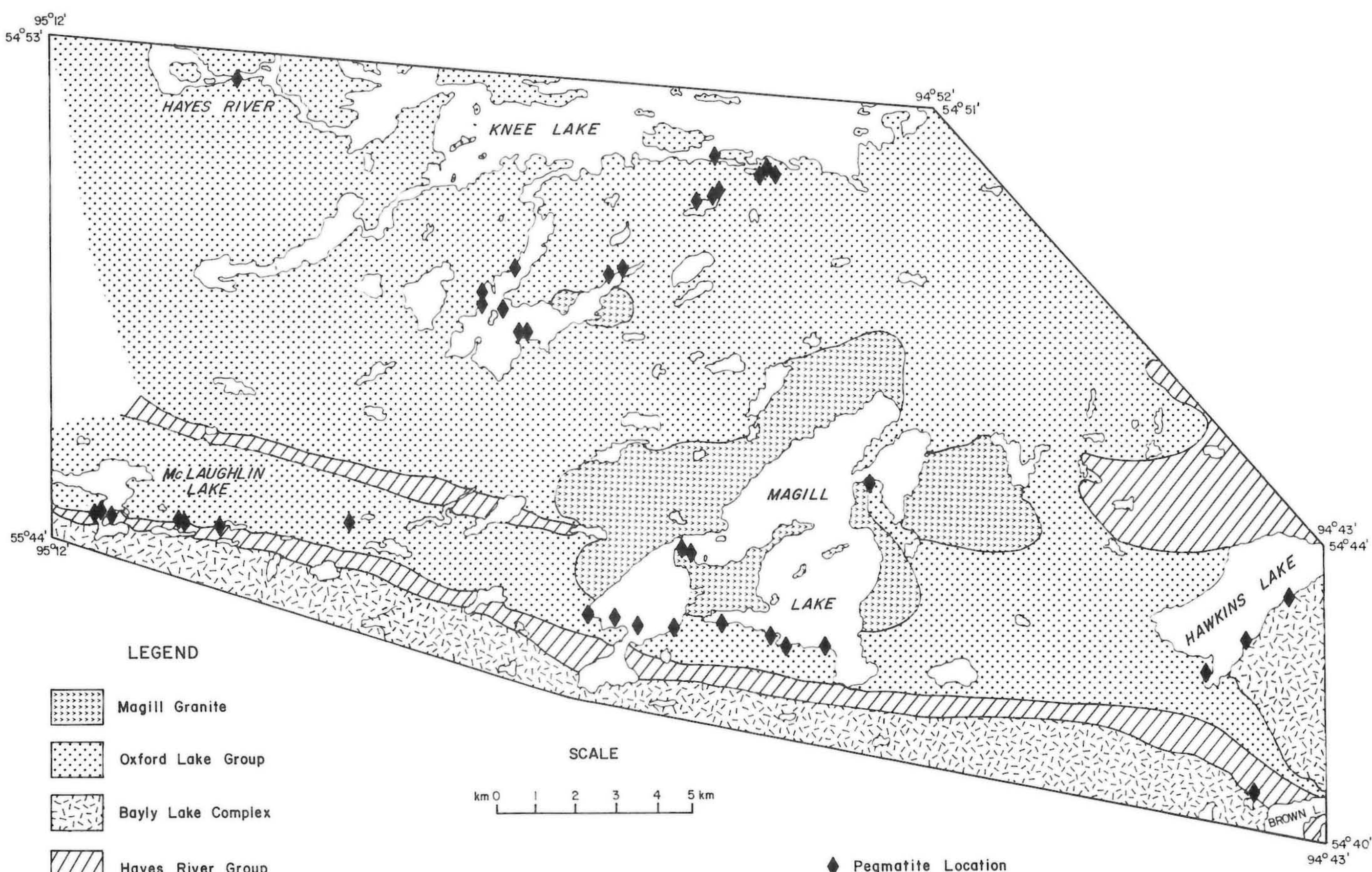

Figure GS-25-1: General geology of the Magill Lake-Knee Lake area modified from Gilbert (1985); Hayes River Group: metamorphosed volcanic and volcanogenic sedimentary rocks, Bayly Lake Complex: metamorphosed intrusive rocks of tonalite to syenite composition, Oxford Lake Group: metamorphosed volcanic and sedimentary rocks.

Little variation in mineralogy and internal zoning occurs and, beyond the occurrence of molybdenite, the dykes comprise an unzoned assemblage of Qtz + Kfs ± Pl ± Bt ± Srl ± Gt.

Dykes sampled northeast of the southern bay along the shores of the main body of Knee Lake and northwest of the lake along the Hayes River also display little variation in mineralogy from that noted above, or in internal structure, although one 33 cm-wide dyke is partly zoned with a distinct quartz core. Lenton (1985) also described a 1 m-wide zoned dyke that contains green beryl.

BROWN LAKE AREA

Gilbert (1985) noted the occurrence of a lone pegmatite dyke that outcrops northwest of Brown Lake. Examination of the dyke revealed an unzoned dyke composed of Qtz + Pl ± Kfs ± Gt with rare, very fine grained muscovite. An additional dyke with similar mineralogy and structure was also uncovered about 4 m to the southwest of the mapped dyke.

MCLAUGHLIN LAKE AREA

Barry (1959) and Gilbert (1985) mapped a set of pegmatites that lie along a nearly east-west trend between Magill Creek and McLaughlin Lake. Sampling of all dykes was conducted in addition to revisiting the spodumene-bearing *McLaughlin* pegmatite at McLaughlin Lake described by Barry (1959, 1962), Bannatyne (1985), and Lenton (1985).

Spodumene was not observed in the possible extension of the *McLaughlin* dyke that outcrops on the southeastern shore of the lake. Nonetheless, the eastern dyke displays similar mineralogy, texture, and internal structure to the *McLaughlin* dyke. An additional dyke, possibly that noted by Barry (1962), was observed about 12 m south of the *McLaughlin* dyke and consists of Qtz + Kfs + Pl in addition to irregularly distributed sodic aplite, but spodumene was not observed.

As noted by Lenton (1985), most other dykes east of McLaughlin Lake have a simple mineralogy of Qtz + Kfs + Pl ± Msc ± Gt ± Srl and are unzoned to crudely zoned. One dyke swarm, designated the *Shasta* swarm, comprises three dykes that trend between 070° and 102° and are primarily composed of an assemblage of Qtz + Kfs + Pl ± Srl. Moreover, the northernmost dyke contains a zone of Qtz + Kfs + Pl with what is tentatively identified as greyish blue to greyish purple lepidolite and greyish green to dark yellowish green lithian muscovite. In the middle body, the "lepidolite"-bearing unit is a zone about 3.1 m x 0.8 m with quartz, saccharoidal albite, and cleavelandite with a rare, very fine grained black opaque mineral. The "lepidolite" ranges from a greenish grey variety associated with pale blue-green apatite to a pale purple variety dispersed in saccharoidal albite. All three dykes intrude schist and metaconglomerate of the Oxford Lake Group, lie south of a pegmatitic granite dyke mapped by Gilbert (1985), and have not been previously mapped.

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GS-26 STRATIGRAPHIC MAPPING AND CORE HOLE PROGRAM

by H.R. McCabe

Studies were initiated or continued on five separate projects: detailed drilling of the Winnipegosis reef at the Bluff, Dawson Bay area; a regional Silurian correlation project; regional outcrop mapping in the Moose Lake area; Project Cormorant drilling through Paleozoic cover near North Moose Lake; drilling and mapping north of Grand Rapids; and drilling in the City of Winnipeg area in support of a Water Resources Branch aquifer study of the upper Red River (Fort Garry Member). Fourteen core holes were drilled for a total of 1260 m.

THE BLUFF PROJECT

Previous Devonian studies have been largely of a regional nature, to define the stratigraphy and to determine the size, shape and distribution of Winnipegosis reefs. In 1987, a detailed core hole profile was completed for the Steeprock Bridge Reef (McCabe, 1987). The Bluff drilling, initiated this year, will supplement this with a detailed profile of the internal structure and lithology of a single Winnipegosis "pinnacle-type" reef.

"The Bluff" consists of a small peninsula on the west shore of Dawson Bay (Twp. 45, Rge. 25W; Fig. GS-26-1). The northern portion of

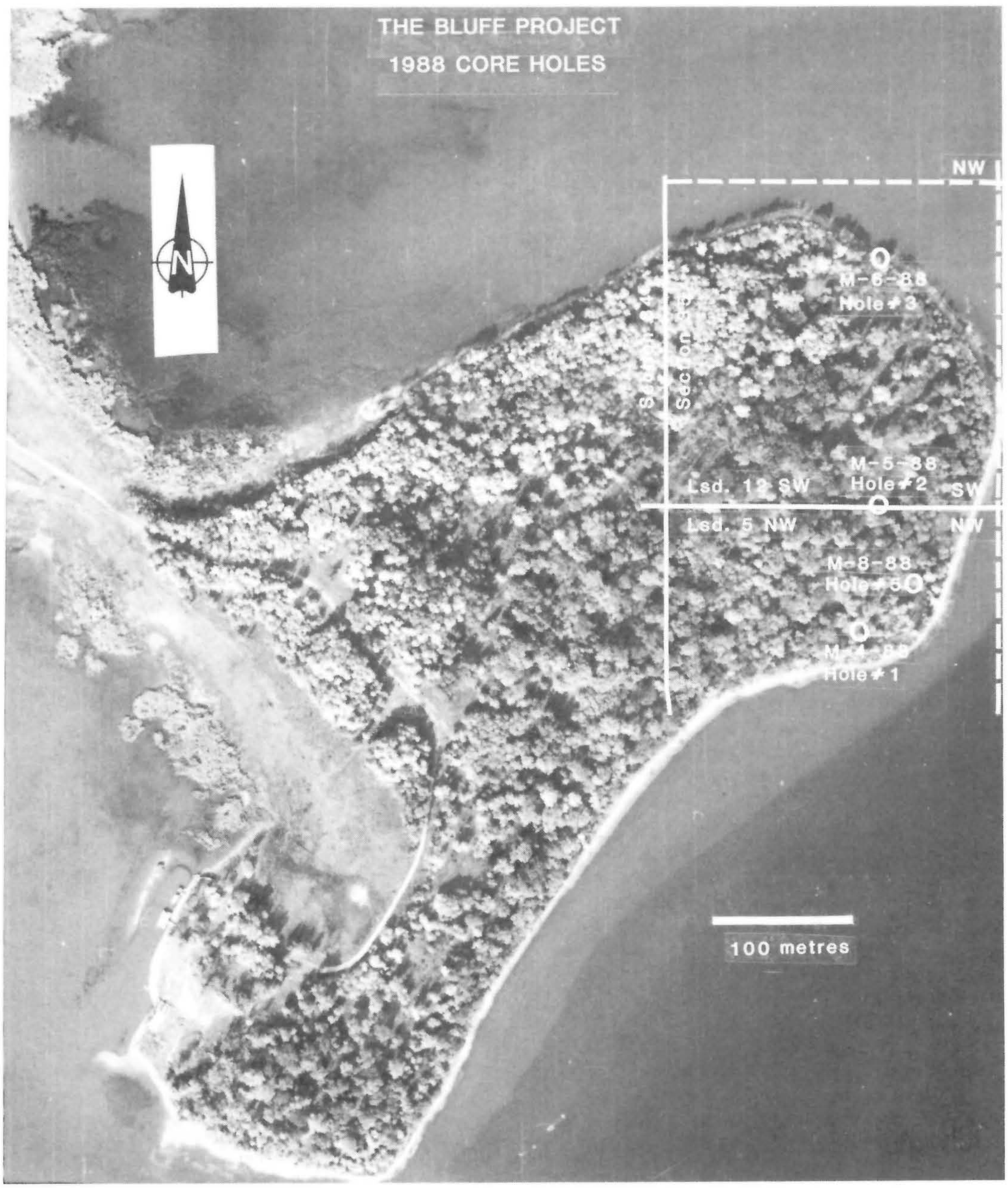


Figure GS-26-1: The Bluff area, showing location of five core holes drilled in 1988.

the peninsula, covering a roughly circular area 300 m in diameter, provides one of the best road-accessible reefal outcrops in the Manitoba outcrop belt. Excellent "clean" exposures on The Bluff show a highly fossiliferous, stromatoporoid-rich rock that may represent a reef-framework lithology. In addition, a sparsely fossiliferous lithology with poor horizontal bedding occurs towards the centre of the outcrop area, possibly representing an interior lagoon facies. Relatively steep dips of up to 10° to 20° are evident at the northern and southern limits of the outcrop.

A total of 5 core holes were drilled on the Bluff in 1988, and additional drill holes are planned. The holes provide a roughly north-south profile across the reef, and recovered a total of 350 m of core (Table GS-26-1). Two of the holes penetrated the entire Winnipegosis thickness of 81.7-84.0 m, and bottomed in the basal Devonian Ashern Formation. The observed thicknesses are close to the estimated thickness, indicating that no appreciable structural anomaly is associated with reef development. The three remaining holes had to be abandoned before reaching the base of the Winnipegosis because of "sanding in" of the holes. Numerous sand-filled solution caves have been encountered in the nearby Mafeking Quarry, where the sand infill is believed to be of Mesozoic (Swan River?) age. The occurrence of sand, apparently as pore infill, in The Bluff holes suggests a similar origin. Future drilling of The Bluff reef may be limited by this unexpected occurrence of sand.

Detailed petrographic, faunal and lithofacies studies of the reef core are being undertaken as a research project at the University of Regina, under the direction of Dr. Don Kent, as part of a continuing study of Winnipegosis reefs in Saskatchewan and Manitoba. Dr. Nancy Chow, University of Manitoba, also will be undertaking a study of Winnipegosis reefs in Manitoba, and will utilize this and other core hole data.

MOOSE LAKE MAPPING PROJECT

Shoreline mapping of the northern part of Moose Lake was carried out in 1986 (McCabe, 1986). The remainder of Moose Lake, the entire portion south of the causeway, was mapped in 1988. This completes the regional remapping of the northern Paleozoic outcrop area in 63F, 63G, 63K and 63J. All known outcrop occurrences are noted in Figure GS-26-2. Mapping was limited to checking all shoreline outcrops, as well as selected short traverses over adjacent topographic highs to acquire as complete a stratigraphic sequence as possible. This mapping is essentially on a reconnaissance basis, as extensive areas of outcrop pavement with numerous scarps are as yet unmapped, especially in the northwest portion of 63G, south of Davidson Lake and east of Moose Lake. Access to this area by ATV is now possible via forestry trails.

Results of the mapping show a considerable change in distribution of the various formations, primarily a more northerly extent than previously reported. Elevations of contacts were determined where possible and the extension of these contacts has been conformed as closely as possible to the NTS topographic contours (on the assumption that overburden is thin throughout the map area). Preliminary structure contour trends have been noted where data permit, in order to define more accurately the axis of the Moose Lake synclinal flexure (McCabe, 1971). Northwest of Moose Lake, the structural trend is approximately 75°, whereas the structural trend in the south Moose Lake area is approximately 100°.

The general stratigraphy was as expected (Stearn, 1956). Contacts are rather difficult to determine because of relatively thin exposures, and most contacts tend to be somewhat recessive and difficult to observe. Variability at the Atikameg/Moose Lake contact indicates either local facies variation or minor disconformity. The East Arm/Atikameg and Cedar Lake/East Arm contacts appear to be transitional, which made positioning of these contacts somewhat uncertain.

The most unusual feature in the Moose Lake area is the Shoulderblade Island structure (approx. Sec. 34, Tp. 55, Rge. 18W). Shoulderblade Island is almost perfectly circular in shape, 1.2 km in diameter, although the shoreline is moderately irregular, and the centre of the island is occupied by a small, roughly circular lake 0.6 km in diameter. As had been reported previously by Baillie, (1951) and Stearn (1956), all the numerous shoreline outcrops consist of breccia.

Baillie suggested that the breccia may have been formed by slumping into solution cavities. Stearn proposed an alternative explanation, that "the breccia is due to wave erosion on a reef mass and slump of sediments from its sides". The writer has not examined all outcrops on Shoulderblade Island, and those outcrops visited have not been examined in detail, but the overall impression of the breccia feature is that neither of the previous explanations are tenable. The collapse scenario is the most difficult to rule out, but several features of the breccia argue against a collapse origin. No other collapse of this size is known (the entire extent of the island appears to consist of breccia). Furthermore, the range in fragment size, from a fraction of a centimetre to blocks 30 x 20 m, would not be expected as a result of collapse. Also the breccia appears to show a distinct and rather extreme vertical size gradient, with the uppermost beds of all outcrops examined consisting of a microbreccia of fragments not exceeding ¼ to ½ cm. Finally, all breccia fragments appear to have a Silurian aspect similar to the adjacent undeformed country rocks. Collapse would involve down-dropping of overlying strata into the solution sink, and such a change in lithology is not evident.

The reefal origin also seems unlikely for the same reasons as above, with the addendum that almost none of the fragments appear to be "reefal" in origin, especially the very large 30 m block of thin bedded micritic dolomite.

The writer suggests two other possible explanations: a diatreme breccia or an impact crater. The lack of any igneous admixture or stratigraphic mixing of stratigraphically lower rock types argues against a diatreme origin, leaving an impact structure as the most likely explanation. The circular configuration and the breccia features noted above can all be reconciled with an impact origin, although even with this model the apparent lack of vertical stratigraphic mixing poses a problem. Further studies are necessary to determine the origin of the Shoulderblade Island structure, including more detailed examination of the outcrops to determine the variation in breccia fragment size and composition. A definitive answer will require core hole drilling to investigate the extension of the structure at depth.

GRAND RAPIDS PROJECT

Three core holes were drilled in the area north of Grand Rapids and south of Davidson Lake (Fig. GS-1). The structural-stratigraphic data from these holes will be incorporated into the Silurian correlation project (Lammers, GS-27, this volume) and will provide useful data for determining the Silurian stratigraphic succession and in particular to define the Paleozoic structural trends. A knowledge of such trends is necessary to determine the regional configuration of the outcrop belts.

Earlier drilling undertaken for base metal exploration in the underlying Precambrian had suggested considerable structural relief on the Precambrian surface. Most of these holes were inclined holes, and data generally were insufficient to determine whether the apparent relief on the Precambrian was true structure or the result of hole deflection or deviation. Both 1988 holes appear to conform to regional structural trends, but data are not yet sufficient to determine if true structural deformation (e.g. faulting) is present.

PROJECT CORMORANT DRILLING

The principal objective of Project Cormorant is to determine, by means of diamond drill holes, the geology of the Precambrian basement where it is buried beneath a thin (up to 150 m) cover of Paleozoic sedimentary rocks. A byproduct of the study is Ordovician and Silurian core as well as structural data on the configuration of the Precambrian basement surface (i.e. post-Precambrian structural deformation). Two additional core holes were drilled in 1988, in the North Moose Lake area (Fig. GS-1); data for these holes are shown in Table GS-26-1. The stratigraphic succession in both holes was as expected. Depths to Precambrian basement conform fairly closely to the previously estimated structural trends on the Precambrian — approximately 80°-85° (McCabe, 1986: Fig. GS-43-2A).

WATER RESOURCES BRANCH — FORT GARRY AQUIFER STUDY

Regional groundwater studies by R. Betcher of the Water Resources Branch include a detailed hydrologic study of the upper part

TABLE GS-26-1 SUMMARY OF CORE HOLE DATA

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval	Summary Lithology
M-1-88	13-32-17-2W		0-7.0	Overburden
Inwood West	+262 m	SILURIAN-Cedar Lake?	7.0-11.8	Dolomite, buff, finely crystalline, fossil solution porosity, some breccia
		East Arm	11.8-28.0	Dolomite, buff, microcrystalline, dense, red argillaceous breccia at base ("V" marker?)
		Atikameg/Moose Lake?	28.0-42.5	Dolomite, buff, variable, micro- to finely crystalline, some fossil solution
		Inwood/Fisher Branch?	42.5-54.0	Grey argillaceous marker at top ("V" marker?). Dolomite, buff, microcrystalline, dense, thin vuggy fossil solution zone at base (Fisher Branch?)
		Upper Stonewall	54.0-59.6	Red argillaceous marker at top, grading to buff microcrystalline with fossil solution porosity
		ORDOVICIAN-Lower Stonewall	59.6-63.9	Red argillaceous dolomite at top ("T" marker), grading to buff, vuggy, fossiliferous
		Stony Mountain-(Williams)	63.9-72.2	Red argillaceous dolomite at top and bottom with medial buff vuggy dolomite
		(Gunton)	72.2-81.5	Dolomite, buff, faintly mottled, microcrystalline, slightly nodular, fair vuggy porosity
		(Penitentiary/Gunn)	81.5-93.4	Argillaceous dolomite, burrow-mottled, medium reddish to purplish grey
M-2-88 Inwood Quarry	4-11-18-1W +273.4 m	SILURIAN-Atikameg/ Moose Lake?	0-14.4	Dolomite, variable, light buff, partly mottled, very finely crystalline to microcrystalline, partly fossiliferous, some good fine calcarenite
		Inwood/Fisher Branch	14.4-29.7	Reddish argillaceous bed at top ("V" marker?). Dolomite, buff, variable, pelletal calcarenite to fragmental fossiliferous with good corals, brachopods at base
		Upper Stonewall	29.7-35.5	Red argillaceous marker at top. Dolomite, buff, slight vuggy porosity
		ORDOVICIAN-Lower Stonewall	35.5-38.9	Red argillaceous sandy marker at top ("T" marker). Dolomite, buff, excellent vuggy fossil solution porosity (corals etc.)
		Stony Mountain (Williams)	38.9-44.7	Interbedded red argillaceous dolomite and buff microcrystalline dense dolomite
		(Gunton)	44.7-57.6	Dolomite, buff, faintly mottled, slightly nodular bedding
		(Penitentiary)	57.6-68.5	Argillaceous dolomite to dolomitic shale, burrow-mottled, medium grey to red
		(Gunn)	68.5-80.1	Argillaceous limestone to calcareous shale, medium greyish red, mottled fossiliferous interbeds
		Upper Red River-(Fort Garry)	80.1-81.2	Dolomite, light buff, micritic, partly cherty and argillaceous
M-3-88	8-14-23-3W	SILURIAN-Cedar Lake?	0-7.7	Dolomite, light buff, very finely crystalline, faintly mottled, massive, fair medium vuggy porosity
Broad Valley	+275.8 m	East Arm (?)	7.7-19.6	Dolomite, medium light grey, spheroidal mottling, sublithographic, some dolomite as above
		Atikameg/Moose Lake	19.6-20.7	Argillaceous dolomite, red to greyish red, laminated ("V" marker?)
			20.7-36.5	Dolomite, buff, variable, very finely crystalline to sublithographic, fairly good porosity, partly fossil solution, some fine calcarenite
		Inwood/Fisher Branch	36.5-50.0	Thin grey argillaceous marker at top ("V" marker?). Dolomite sublithographic at top, vuggy fossiliferous at base
		Upper Stonewall	50.0-55.0	Dolomite, pale greyish red slightly argillaceous at top grading to buff microcrystalline dense dolomite
		ORDOVICIAN-Lower Stonewall	55.0-60.7	Reddish argillaceous zone at top ("T" marker?) grading to buff microcrystalline vuggy dolomite
		Stony Mountain-(Williams)	60.7-66.7	Argillaceous dolomite, medium dark greyish red, mottled; medial buff, vuggy dolomite
		(Gunton)	66.7-88.0	Dolomite, buff mottled to partly reddish
		(Penitentiary)	88.0-94.3	Dolomite, argillaceous, burrow-mottled, buff to medium greyish red, non calcareous
M-4-88 The Bluff #1	5-35-45-25W +261.0 m	DEVONIAN-Winnipegosis	0.0-81.7	Dolomite, light buff, massive, variable. Upper part shows excellent pin point porosity to vuggy fossil solution porosity (coral, strome), much calcarenite to coarse intraclastic, fossil content decreases downward, crinoids more common. No appreciable break between reef and platform. Dolomite breccia at base.
		Ashern	81.7-87.3	Grey to brown argillaceous dolomite and dolomitic shale

TABLE GS-26-1 SUMMARY OF CORE HOLE DATA (CONT'D.)

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval	Summary Lithology
M-10-88 John's Lake/S	16-10-58-18W +261 m	SILURIAN-Inwood/ Fisher Branch	0.0-11.5	Dolomite, massive, light buff, faintly mottled, patchy, fair to good pin point porosity to vuggy porosity, partly fossil solution
		Upper Stonewall	11.5-12.4	Dolomite, medium light grey, slightly argillaceous, fine to coarse breccia
			12.4-14.9	Dolomite, massive, buff, faintly mottled, good pinpoint to fine vuggy porosity, partly fossil solution
		ORDOVICIAN-Lower Stonewall	14.9-17.3	Argillaceous dolomite to dolomitic shale, medium grey to greyish red at top and bottom Medial buff vuggy dolomite (T-marker?)
			17.3-23.0	Dolomite light buff, earthy at top grading to prominently mottled with fair to good vuggy porosity, partly fossiliferous, trace white nodular chert
		Upper Stony Mountain	23.0-45.1	Dolomite light grey buff, massive, microcrystalline dense, slightly argillaceous at top, becoming nodular bedded towards base with dark whispy partings
		Lower Stony Mountain	45.1-58.0	Dolomite, massive, light grey to yellowish buff, faint burrow mottling, scattered fossils (coral, crinoid) very finely crystalline somewhat granular
		Upper Red River- (Fort Garry)	58.0-67.9	Dolomite, upper 1 m light buff, grading down to variably argillaceous dolomite, medium to light grey and brownish, some breccia zones, partly bituminous; red stained, ozidized subvertical fracture. Grades to:
		Lower Red River	67.9-71.2	Dolomite, grey to buff, partly argillaceous, abundant white nodular chert (transition zone?)
			71.2-101.7	Dolomite, massive, light grey to brownish buff, streaked and mottled, microcrystalline dense to moderately granular, scattered fossils
			101.7-102.8	Sandy dolomite to dolomitic sandstone, medium to coarse grained
		Winnipeg	102.8-111.0?	Sandstone, friable, medium grey streaked and banded, pyritic, argillaceous and silty (recovered 1.0 m)
		Precambrian	110.0-134.3	Gneiss, highly weathered and kaolinized to about 113 m
M-11-88 Road End Lake	12-27-53-15W +274 m		0-26.8	Overburden
		SILURIAN-Moose Lake	26.8-32.3	Dolomite, light buff, microcrystalline dense, in part relict fine calcarenite, sparsely fossiliferous
		Inwood/Fisher Branch	32.3-41.5	Thin buff sandy bed at top ("V" marker?). Dolomite, light buff, microcrystalline partly mottled, faint fine fragmental texture
		Upper Stonewall	41.5-44.9	Dolomite, grey buff, microcrystalline, granular, faint calcarenite
		ORDOVICIAN-Lower Stonewall	44.9-53.8	Dolomite, medium grey, argillaceous marker at top ("T" marker). Light buff, microcrystalline granular, fossiliferous towards base.
		Stony Mountain-(Williams)	53.8-62.7	Interbedded grey argillaceous dolomite and buff mottled dolomite
		(Gunton)	62.7-77.3	Dolomite, buff, faintly mottled, pronounced nodular bedding
		(Penitentiary)	77.3-93.1	Dolomite, massive, light buff, faintly mottled, slightly fossiliferous
		Upper Red River-(Fort Garry)	93.1-103.5	Dolomite, variably argillaceous, microcrystalline, medium to light grey
		Lower Red River	103.5-148.0	Mottled dolomite, medium light brownish buff, cherty at top, sandy at base
		Winnipeg	148.0-148.6	Shale, medium grey to dark red, grading down to argillaceous sandstone
M-12-88 Reedy Lake/W	14-14-54-14W +288 m	SILURIAN-East Arm	0-7.1	Dolomite, light grey, microcrystalline dense, fine calcarenite, patchy floating sand grains, argillaceous at base
		Atikameg	7.1-11.7	Dolomite, light buff, massive, finely crystalline, moderately granular, patchy vuggy porosity
		Moose Lake	11.7-19.2	Dolomite, buff, microcrystalline, dense, fine calcarenite towards base
		Inwood/Fisher Branch	19.2-28.8	Grey sandy silty bed at top ("U" marker?). Dolomite, light buff, microcrystalline, granular, with good patchy vuggy fossil solution porosity towards base
		Upper Stonewall	28.8-32.2	Argillaceous dolomite at top grading to orangy buff, very finely crystalline granular dolomite
		ORDOVICIAN-Lower Stonewall	32.2-41.9	Argillaceous bed at top ("T" marker) grading to buff, mottled, very finely crystalline granular dolomite
		Stony Mountain (Williams)	41.9-48.2	Interbedded medium grey argillaceous dolomite and buff mottled dolomite

TABLE GS-26-1 SUMMARY OF CORE HOLE DATA (CONT'D.)

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval	Summary Lithology
M-10-88 John's Lake/S	16-10-58-18W +261 m	SILURIAN-Inwood/ Fisher Branch	0.0-11.5	Dolomite, massive, light buff, faintly mottled, patchy, fair to good pin point porosity to vuggy porosity, partly fossil solution
		Upper Stonewall	11.5-12.4	Dolomite, medium light grey, slightly argillaceous, fine to coarse breccia
			12.4-14.9	Dolomite, massive, buff, faintly mottled, good pinpoint to fine vuggy porosity, partly fossil solution
		ORDOVICIAN-Lower Stonewall	14.9-17.3	Argillaceous dolomite to dolomitic shale, medium grey to greyish red at top and bottom Medial buff vuggy dolomite (T-marker?)
			17.3-23.0	Dolomite light buff, earthy at top grading to prominently mottled with fair to good vuggy porosity, partly fossiliferous, trace white nodular chert
		Upper Stony Mountain	23.0-45.1	Dolomite light grey buff, massive, microcrystalline dense, slightly argillaceous at top, becoming nodular bedded towards base with dark wispy partings
		Lower Stony Mountain	45.1-58.0	Dolomite, massive, light grey to yellowish buff, faint burrow mottling, scattered fossils (coral, crinoid) very finely crystalline somewhat granular
		Upper Red River- (Fort Garry)	58.0-67.9	Dolomite, upper 1 m light buff, grading down to variably argillaceous dolomite, medium to light grey and brownish, some breccia zones, partly bituminous; red stained, ozidized subvertical fracture. Grades to:
		Lower Red River	67.9-71.2	Dolomite, grey to buff, partly argillaceous, abundant white nodular chert (transition zone?)
			71.2-101.7	Dolomite, massive, light grey to brownish buff, streaked and mottled, microcrystalline dense to moderately granular, scattered fossils
			101.7-102.8	Sandy dolomite to dolomitic sandstone, medium to coarse grained
		Winnipeg	102.8-111.0?	Sandstone, friable, medium grey streaked and banded, pyritic, argillaceous and silty (recovered 1.0 m)
		Precambrian	110.0-134.3	Gneiss, highly weathered and kaolinized to about 113 m
M-11-88 Road End Lake	12-27-53-15W +274 m		0-26.8	Overburden
		SILURIAN-Moose Lake	26.8-32.3	Dolomite, light buff, microcrystalline dense, in part relict fine calcarenite, sparsely fossiliferous
		Inwood/Fisher Branch	32.3-41.5	Thin buff sandy bed at top ("V" marker?). Dolomite, light buff, microcrystalline partly mottled, faint fine fragmental texture
		Upper Stonewall	41.5-44.9	Dolomite, grey buff, microcrystalline, granular, faint calcarenite
		ORDOVICIAN-Lower Stonewall	44.9-53.8	Dolomite, medium grey, argillaceous marker at top ("T" marker). Light buff, microcrystalline granular, fossiliferous towards base.
		Stony Mountain-(Williams)	53.8-62.7	Interbedded grey argillaceous dolomite and buff mottled dolomite
		(Gunton)	62.7-77.3	Dolomite, buff, faintly mottled, pronounced nodular bedding
		(Penitentiary)	77.3-93.1	Dolomite, massive, light buff, faintly mottled, slightly fossiliferous
		Upper Red River-(Fort Garry)	93.1-103.5	Dolomite, variably argillaceous, microcrystalline, medium to light grey
		Lower Red River	103.5-148.0	Mottled dolomite, medium light brownish buff, cherty at top, sandy at base
		Winnipeg	148.0-148.6	Shale, medium grey to dark red, grading down to argillaceous sandstone
M-12-88 Reedy Lake/W	14-14-54-14W +288 m	SILURIAN-East Arm	0-7.1	Dolomite, light grey, microcrystalline dense, fine calcarenite, patchy floating sand grains, argillaceous at base
		Atikameg	7.1-11.7	Dolomite, light buff, massive, finely crystalline, moderately granular, patchy vuggy porosity
		Moose Lake	11.7-19.2	Dolomite, buff, microcrystalline, dense, fine calcarenite towards base
		Inwood/Fisher Branch	19.2-28.8	Grey sandy silty bed at top ("U" marker?). Dolomite, light buff, microcrystalline, granular, with good patchy vuggy fossil solution porosity towards base
		Upper Stonewall	28.8-32.2	Argillaceous dolomite at top grading to orangy buff, very finely crystalline granular dolomite
		ORDOVICIAN-Lower Stonewall	32.2-41.9	Argillaceous bed at top ("T" marker) grading to buff, mottled, very finely crystalline granular dolomite
		Stony Mountain (Williams)	41.9-48.2	Interbedded medium grey argillaceous dolomite and buff mottled dolomite

TABLE GS-26-1 SUMMARY OF CORE HOLE DATA (CONT'D.)

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval	Summary Lithology
M-12-88 (cont'd.)				
		(Penitentiary)	64.0-80.8	Dolomite, massive, light buff, faintly mottled sparsely fossiliferous
		(Gunton)	48.2-64.0	Dolomite, buff, microcrystalline, prominent nodular bedding
		Upper Red River- (Fort Garry)	80.8-91.5	Dolomite, microcrystalline, medium grey to buff and reddish mottled, variably argillaceous
		Lower Red River	91.5-127.3	Grades to dolomite, medium light grey to buff, mottled, patchy chert
M-13-88	15-4-11-2E		0.0-9.2	Overburden
W.R.B./M.P.#1	+237.7 m	ORDOVICIAN-Stony Mountain- (Gunn)	9.2-26.4	Argillaceous limestone with shale interbeds, purplish to reddish and greenish grey, fossiliferous
		Red River-(Fort Garry)	26.9-44.7	Light grey fine grained limestone at top grading to buff, calcareous, fossiliferous cherty dolomite. Basal 3.5 m buff chalky limestone
			44.7-62.8	Dolomite, dense, pale brown to white, with reddish argillaceous zones
		(Selkirk)	62.8-69.1	Limestone, massive, tight, buff to white with pink to reddish argillaceous zones
M-14-88 Road End Lake/N	15-3-54-15W +288 m	SILURIAN-Cedar Lake	0.0-11.9	Dolomite, light buff, microcrystalline, becoming coarse grained fossiliferous (crinoidal) towards base
		East Arm (?)	11.9-28.9	Dolomite, light grey to buff, microcrystalline, dense, partly breccia, floating sand grains common in lower part; basal sandy argillaceous marker ("V" marker)
		Atikameg	28.9-33.0	Dolomite, buff, relatively coarse grained, fair vuggy porosity
		Moose Lake	33.0-40.5	Dolomite, light buff, sublithographic, grading down to fine fossiliferous intraclastic
		Inwood	40.5-44.1	Thin sandy breccia bed at top ("U" marker?). Dolomite, light buff, microcrystalline, moderately granular, fair pinpoint porosity

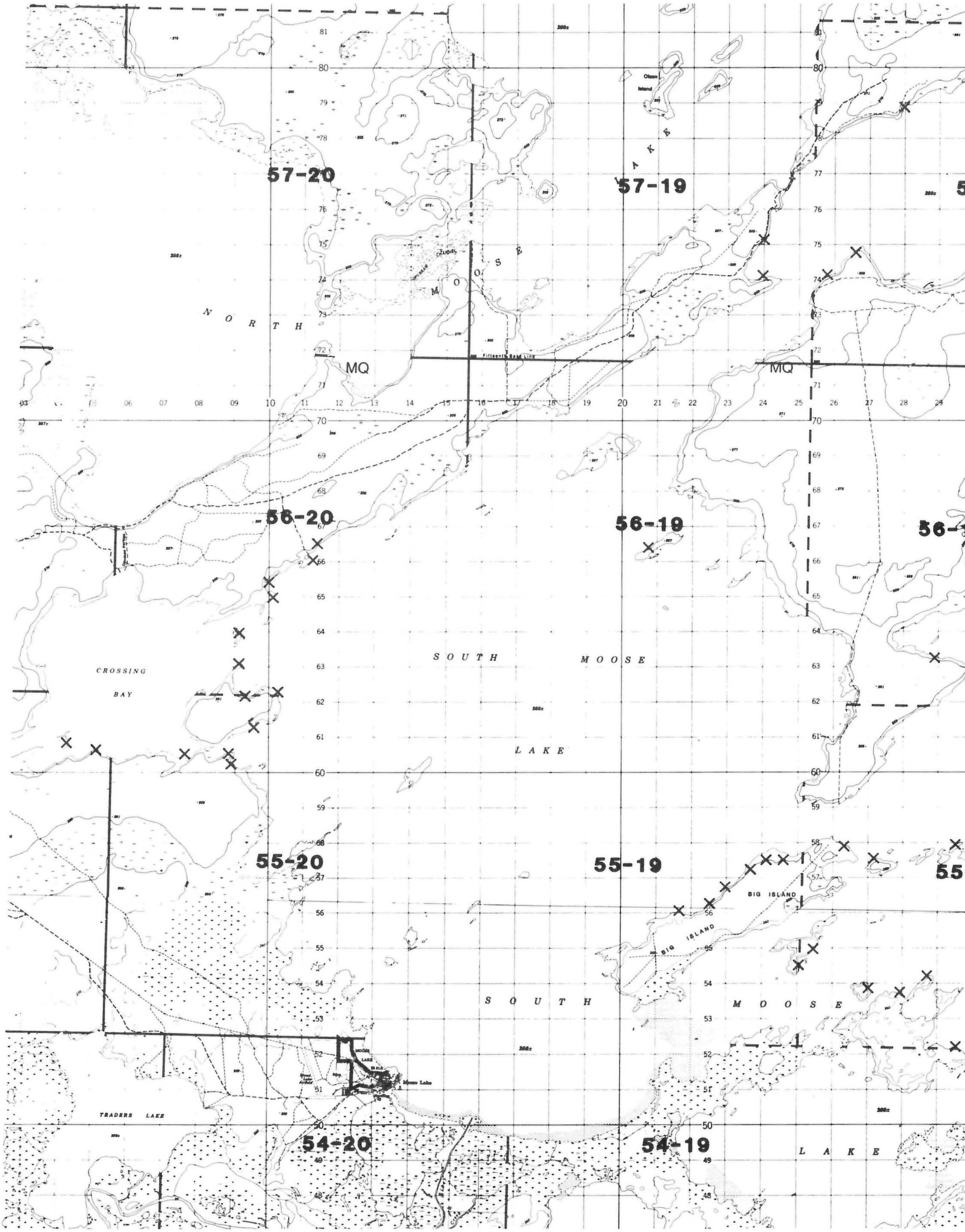
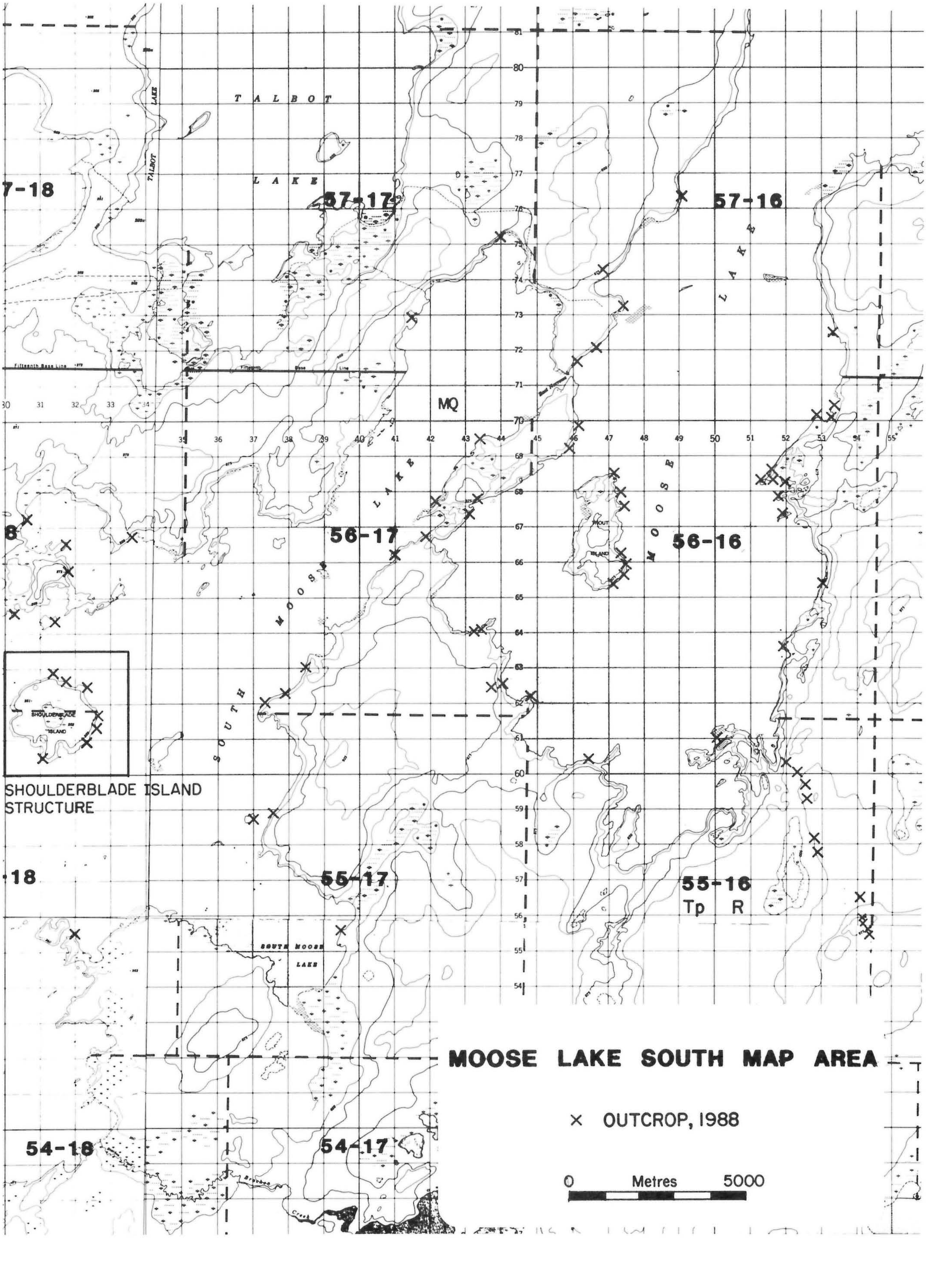


Figure GS-26-2: Geology of the south Moose Lake area.


MOOSE LAKE SOUTH MAP AREA
× OUTCROP, 1988
0 Metres 5000
SHOULDERBLADE ISLAND STRUCTURE
TALBOT LAKE
SOUTH MOOSE LAKE
MOOSE LAKE
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a)

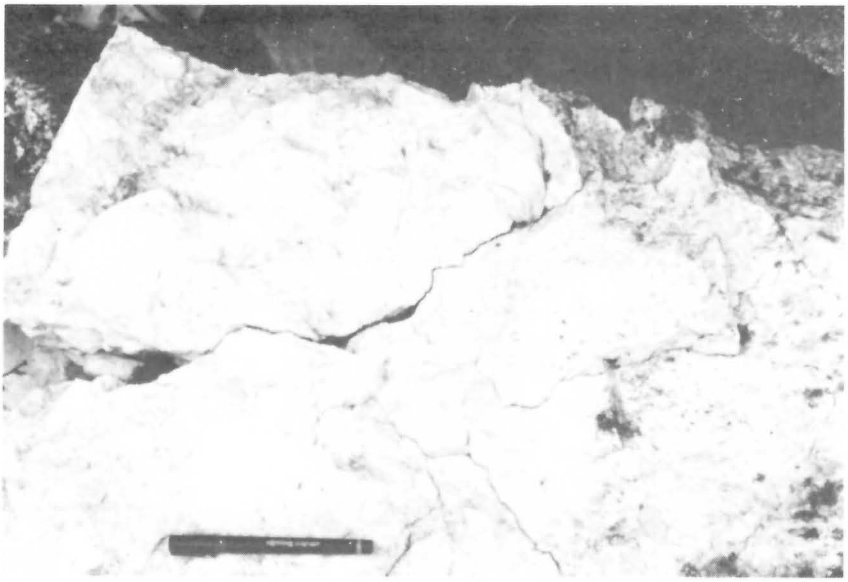

Figure GS-26-3: *Shoulderblade Island Structure: a) typical medium to fine breccia; b) largest observed breccia block 20 x 30 m, included in fine breccia as in a).*

b)

of the Red River Formation — the Fort Garry Member. This member forms an important aquifer in the Winnipeg-South Interlake area, and detailed measurements of reservoir characteristics have been taken. Data suggest that fracturing (and associated solution) is an important factor in controlling reservoir performance, rather than primary porosity and permeability. To date, all test holes had been drilled with water well rigs and the only lithologic data obtained was from well cuttings. In order to obtain a more precise correlation between the lithology, fracturing, solution porosity and reservoir potential, Water Resources requested a diamond drill core hole be put down as close as possible to a Water Resources Branch test hole. Unfortunately the core hole diameter is not sufficient to permit the use of downhole geophysical logging tools (e.g. gamma ray, S.P., resistivity and caliper logs), but the proximity of the holes should permit a close correlation of lithology with other reservoir characteristics.

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GS-27 SILURIAN STRATIGRAPHY OF THE INTERLAKE AREA

by G.E. Lammers[1]

INTRODUCTION

Several workers in the past, notably Tyrrell (1982), Baillie (1951) and Stearn (1956), have studied the lithology and fossils, and attempted to divide the Silurian sequence into correlatable stratigraphic units. The literature is extensively reviewed in the latter reference. Other references listed at the end of this report refer to new information using the terminology of Stearn (Fig. GS-27-1) as well as experimenting with new stratigraphic terminology and the introduction of marker beds for correlation.

FIGURE GS-27-1:
TABLE OF FORMATIONS

Era	Period or epoch	Formations and thickness in feet
Paleozoic	Silurian or Devonian	Ashern Formation 0 - 25
		Disconformity
	Middle Silurian	Cedar Lake Formation 150 Chemahawin Member Cross Lake Member
		East Arm Dolomite 40
		Atikameg Dolomite 16
		Moose Lake Dolomite 28
		Inwood Formation 42
		Fisher Branch Dolomite 16
		Disconformity
	Upper Ordovician	Stonewall Formation 30
		Stony Mountain Formation

The purpose and approach for this study was to test these formational names against their lithological definition and to test their usability within the Interlake outcrop belt in Manitoba and its extension into the subsurface. Specifically, there is the problem of correlating the lower four Silurian formations — the Fisher Branch, Inwood, Moose Lake and Atikameg — from the northern (Grand Rapids) area to the southern (Inwood-Fisher Branch) area, a distance of more than 200 km for which few data are available. Stearn's (1956) correlations were hampered by an almost total lack of regional structural data in the southern area. This resulted in Stearn placing the Inwood (and in part the Fisher Branch) considerably lower in the Silurian succession than is indicated by new data. Consequently, both stratigraphic and faunal miscorrelations occurred between the northern and southern outcrop areas, particularly for the Inwood Formation. This problem has been addressed by: drilling of specific core holes to establish more accurate lithostratigraphic correlations; detailed logging of newly acquired cores (11 holes); measuring and describing newly accessible outcrop sections including faunal collection and identification; and comparison of outcrop and core sequences with electric and radioactivity logs for nearby oil well test holes (Fig. GS-27-2).

Using these newly acquired data, a revised correlation and possibly a revised stratigraphic nomenclature will be proposed for the Silurian outcrop belt of Manitoba. A revised and expanded faunal succession also may be possible.

LITHOLOGY

The dolomite formations included within the Interlake Group are remarkably homogeneous, varying only slightly in such features as grain size, colour, and porosity; none of these features is sufficient by itself to differentiate any of the six formations named by Stearn. They can be used locally, but certainly not reliably between the southern outcrop area and the Grand Rapids area. Facies changes within units and vertical repetition of lithologies (and faunas) make correlation even more difficult. Porter and Fuller (1959) report, "Present core control reveals no appreciable lithological difference from the Lower Interlake" in comparison to the Upper Interlake. Although this statement refers to subsurface subdivision of the Interlake Group, the writer heartily concurs with their conclusion for the outcrop units as well.

Rather than the lithology in a strict sense, certain sedimentological features *may* be more useful for correlation purposes, e.g. rip-up clasts, pseudo-oolites, breccia horizons, fossil horizons, colour changes, changes in fabric, bioturbation, crystal molds, auxilliary minerals, bedding characterisitics. In the more central part of the basin, Andrichuk (1959, p. 2382) reports a persistent horizon of oolites; however, these oolites were not found in the cores and outcrops examined in the Manitoba outcrop belt.

There are subtle differences in the Silurian succession between the northern and southern portions of the Interlake area, i.e. north and south of Gypsumville. Regional facies change may be the reason for this, but more probably the differences are due to a lack of outcrops and core data. With additional cores these facies changes would likely be recognizable and correlation thus possible through this approximate 200 km distance.

SAND GRAINS AND SHALE BEDS

Thin shaly beds and sandy zones in the Silurian strata form the most reliable markers for local and regional correlation purposes. The sand and shale may occur either separately or in combination, but invariably appear to be closely associated. The sand, which is quartzose, fine to medium grained, and well rounded and frosted, may occur over an interval of several centimetres as floating grains in a fine dolomite or argillaceous dolomite matrix. It also occurs in concentrated beds forming a sandstone with dolomite cement, or as a sandy matrix in a dolomite breccia. The shaly marker beds are always red or blue-green. In some places the shales appear to have accumulated as fine layers of sediment; in others, they appear to represent a "soil" formation (terra rosa).

The sandy and shaly beds form a series of distinct markers that are extremely useful in establishing local and regional correlations. Generally the shaly beds are not seen in the field because of their easily erodible and recessive nature. The associated sandy beds, however, because of their resistance to erosion, are relatively well exposed in outcrop, commonly as bedding-plane exposures. In some cores, the sand and shale markers appear to be missing, and it is difficult to determine if this is because of non-occurrence or because the markers have been lost during recovery of the cores. Some markers are missing locally on mechanical logs of holes immediately downdip from the study area, indicating that (some) markers are in fact discontinuous.

These sand-shale "para-time stratigraphic" markers commonly are considered to be single events; some *may* be geologically syn-

[1]Manitoba Museum of Man and Nature, Winnipeg.

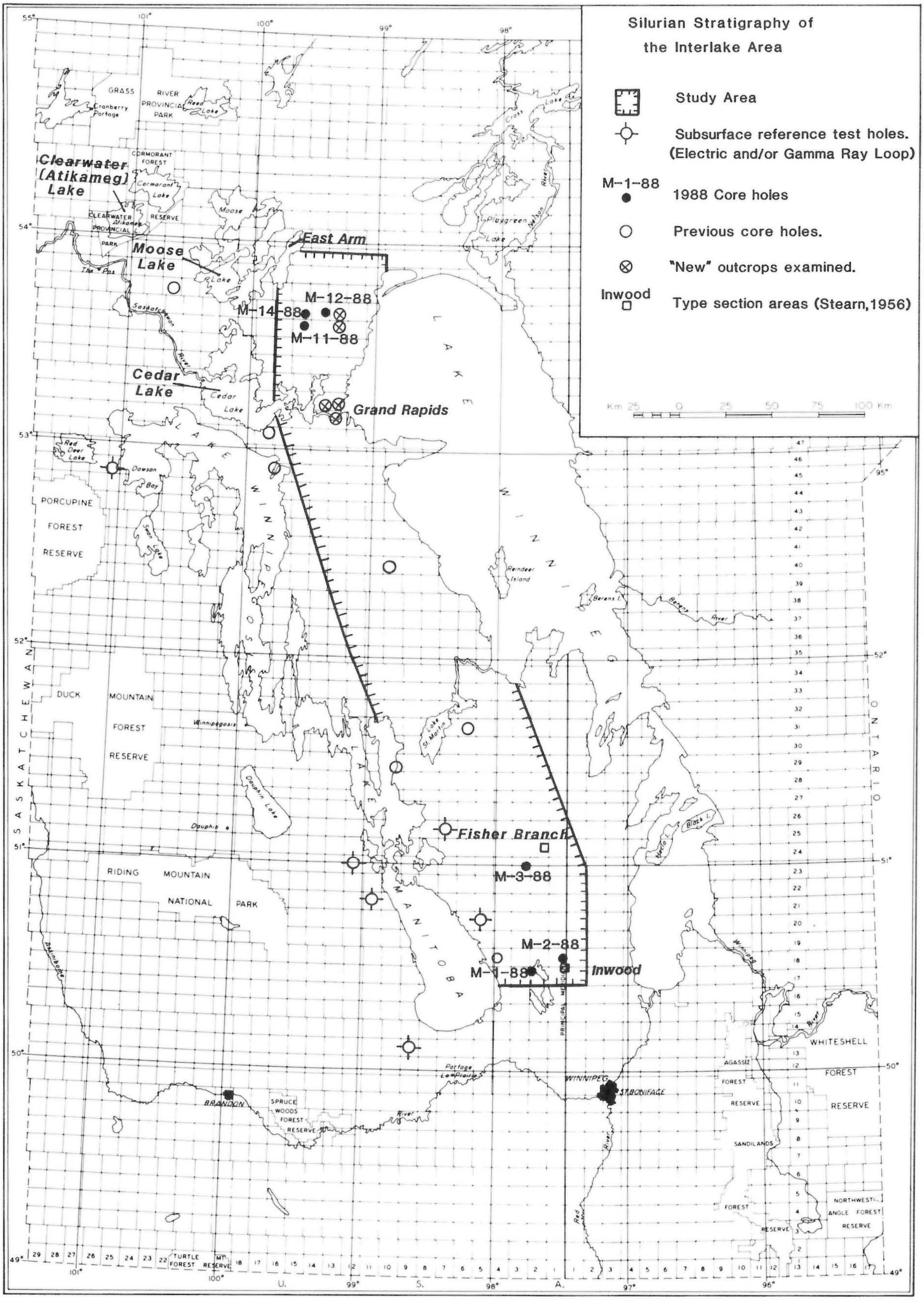

Figure GS-27-2: Outline map of area of Silurian stratigraphic studies.

chronous, but in the Interlake one has the difficulty of identifying which of two or three such markers are synchronous. In some cases it is obvious that there are multiple occurrences of similar markers within the same zone (e.g. sand horizons in the East Arm in the northern study area).

Detailed correlations suggest that the marker sand or shale beds may not be precisely correlatable, but rather may represent zones within which marker beds occur at slightly different stratigraphic levels. Loss of certain beds may occur during coring, or marker beds could be missing due to non-deposition on slight topographic highs on the depositional surface. Alternatively, minor variations in stratigraphic position of marker beds could reflect minor paleotopographic relief on the depositional surface on which the sand was deposited. These marker "zones" are, however, reliable and widespread zones over the study area, even though they may not represent single, precise stratigraphic markers. The cores or logs seem to bear this out. For example, the U marker occurs in each core or log (where identifiable) at least 6 m above the Stonewall basement (chosen datum) within a "zone" of approximately 7 m.

The V marker of the East Arm Formation is one of a series of at least six individual markers and hence is more difficult to correlate accurately than the U marker. This "Marker Zone" occurs approximately 25 m above the Stonewall datum and rather consistently within an 8 m zone.

Another problem results from the downward percolation of red sediment (sand and/or clay) from either the overlying Ashern or from Mesozoic strata unconformably overlying the Silurian. These "exotic" beds can possibly be mistaken for primary Silurian markers such as the U and V.

FOSSILS

At this stage of the study, fossils can make little contribution to correlation, but further work will be done over the next few months and may provide useful data. The most significant contribution at this time is the number of new fossil horizons and sites that were unknown before this study. Fossils are not particularly abundant throughout the Interlake however, and this restricts their usefulness for correlation purposes, particularly in cores. Microfossil (e.g. conodont) studies possibly could provide a more effective correlation tool.

It is difficult to divide a relatively uniform series of rock units such as the Interlake into mappable stratigraphic units on the basis of the contained fauna. Attempts such as Baillie (1951) aided by R.A.C. Brown are useful, but already his horizons are in part invalid because of additional finds of species that are either younger/older, or overlap other zones. Establishment of biostratigraphic zones for a series of isolated outcrops requires a precise time-stratigraphic correlation framework. Definition of both the faunas and the correlation framework requre continual updating. It *is* time to do this again. New data obtained in this study hopefully will improve the scope and accuracy of the faunal succession, and will aid in establishing more accurate regional stratigraphic correlations.

CONCLUSIONS

A number of tentative conclusions can be gleaned from the above discussions. The writer really dislikes "concluding" that *more work needs to be done*, but is sure that with additional collecting, exposures and logs new information will be sifted and distilled, and improved correlation techniques will result.

Although the lithologies can be described, such descriptions are difficult to utilize in identification and correlation of formations. Each of the authors (after Baillie, 1951) had the previous author's descriptions, but chose to describe the lithologies somewhat differently — different colour, grain size, etc., (Baillie, 1951; Stearn, 1956; Porter and Fuller, 1959; Andrichuk, 1959; Lescinsky, 1985). Thus the lithological descriptions currently in the literature cannot be used to separate the formations. This is especially true when applied to the widely separated areas north and south of Gypsumville.

Sedimentological features, such as breccia, pseudo-olites, bioturbation features and stromatolites (Fig. GS-27-3), can be useful locally for correlation of formations. Marker beds as currently employed generally reflect a prominent kick on a log or a visible shale or sand bed in core or outcrops. They are remarkably useful (where little other means exist) for correlation amongst well logs, core and outcrop. These markers should more properly be referred to as zones, and one must accept that each marker does not occur in every outcrop and core or cause the same kind (or number) of responses on logs.

Many new fossils have been collected from several additional sites. These may be useful in the future but will require considerable taxonomic study before they can be used in correlation. Several of the previously named species are probably ecotypes and as such may not be significant for correlation purposes.

One of the conclusions from this study should be some resolution of the "Inwood Problem". There are several possible alternative solutions. Six formations can be defined (with difficulty) in the outcrop, but recognition of the same units in the subsurface is difficult. With the current new correlation data based largely on marker beds, it appears that the lower Inwood of the southern area, as designated by Stearn, includes part of the Fisher Branch (or at least one of the zones of *Virgiana*), and the upper Inwood (certainly the type section) is equivalent to the upper part of the Moose Lake Formation and probably the lower part of the Atikameg Formation. The "anomalous" occurrence of *Virgiana* in the Narcisse area does not require a structural solution, as suggested by Stearn, but rather represents a younger reoccurrence of *Virgiana* within what Stearn designated as Inwood.

It is hoped that the new faunal data can be integrated with previous faunal studies, especially Stearn (1956), and that the previous faunal studies can be revised on the basis of more accurate lithostratigraphic

Figure GS-27-3: Stromatolites within the Silurian Lower Moose Lake Formation. Abandoned quarry, east side of Highway 6, north edge of Grand Rapids, Manitoba.

correlations so that an expanded and corrected faunal succession may be established for the Silurian strata of the Manitoba outcrop belt.

FOOTNOTE

In 1987, samples of fossiliferous "float" containing what appeared to be a *Virgiana* fauna were found within the outcrop belt of the East Arm Formation (vicinity of Sec. 31, Twp. 53, Rge. 13 WPM), and were sent to the Geological Survey of Canada, Calgary, for identification. Confirmation that the samples contain a *Virgiana* (Fisher Branch?) fauna was received recently (B.Norford, pers. comm.). This poses a puzzling problem. The fossiliferous samples certainly are not in place, but the relative abundance of the *Virgiana*-bearing float suggests a nearby source, which could be provided by:

a) some type of structural uplift (faulting?) which has brought underlying Fisher Branch strata to surface (20-40 m). No evidence of any such structure was seen.
b) a further (third?) reoccurrence of the *Virgiana* fauna at a much higher stratigraphic level than previously reported.
c) an "exotic" origin such as accidental glacial erratics.

Further field studies will be undertaken to try to determine the source of the *Virgiana*-bearing float.

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GS-28 KARST INVESTIGATIONS IN PALEOZOIC CARBONATES OF THE GRAND RAPIDS UPLANDS AND SOUTHERN INTERLAKE

by G. Sweet[1], P. Voitovici[2] and W.D. McRitchie

BACKGROUND

Over the last five years the Geological Services Branch has become increasingly involved in numerous studies focussed on the Paleozoic carbonate formations of the Interlake region. The Branch's ongoing stratigraphic drilling program (mounted throughout southwestern Manitoba since 1969) continues to provide essential profiles of the sedimentary sequences in areas of little outcrop, or exploration data (see Report GS-26, this volume). Other studies, namely the evaluation of lead-zinc potential of Paleozoic formations (Devonian, Silurian and Ordovician), have been mounted as and when funding permitted, along with subsidiary yet supportive basal till investigations, and a systematic analysis of all stratigraphic drill core to define geochemical anomalies.

More recent revisions to the stratigraphic map series, and an evaluation of the dolomite potential of the Interlake area, highlighted the need to intensify ground coverage in many areas and to clarify the definition of Silurian formations and formational boundaries especially in the region north of Gypsumville. In this context a cooperative program was sponsored by the Branch with G. Lammers (Manitoba Museum of Man and Nature) to explore the potential for using a paleontological approach to marker bed definition and to firm-up the stratigraphic subdivision and correlation of the Silurian in central Manitoba.

The upsurge in demand for more detailed and authoritative documentation of the bedrock formations has been fueled even further by G. Sweet's concurrent studies of karst features in the dolomites and limestones of the Interlake, and by a growth of interest in evaluating the Grand Rapids Uplands as a site for a park, using its caves as a principal theme. This little known and poorly defined attribute of the region led to the formation of the Speleological Society of Manitoba (SSM) in November 1986, and over the last two years members of this volunteer organization have mounted numerous short-term expeditions into the Grand Rapids and southern Interlake regions exploring for, and mapping, the caves, sinkholes and other solution-related features.

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The following report summarizes the accomplishments and findings of this cooperative initiative between individuals in the University of Winnipeg, the Speleological Society of Manitoba, and various government agencies including the Parks and Geological Services Branches.

The authors extend full acknowledgement to all SSM members who organized and participated in the numerous sortis into the Interlake, including the ventures underground. The track record of discoveries over the last two years is substantial and could not have been sustained without active cooperation and referrals from numerous individuals, including prospectors, firefighters and trappers at Grand Rapids. To these individuals our gratitude is also extended.

G. Sweet authored the main body of the text, P. Voitovici surveyed and directed mapping of the caves, and W.D. McRitchie assisted in navigation and generated location maps for the Grand Rapids region.

For conservation reasons, detailed coordinates of cave locations are classified as restricted; records are maintained in SSM research files. More extensive information on karst-related features of the Interlake is currently being compiled as a doctoral thesis by G. Sweet.

A partial glossary of karst terminology in provided at the conclusion of the report.

INTRODUCTION

The Interlake area of Manitoba presents an unique landscape within the Canadian context, and possibly in global terms. Exposures of Ordovician, Silurian and Devonian carbonates dominate the area. In the south much of the bedrock is covered with till of varying thickness. North of The Pas Moraine large expanses of bedrock are exposed, or partially covered with sporadic vegetation (Fig. GS-28-1 and GS-28-2). These carbonates form part of the eastern lip of the Williston basin and generally dip gently to the southwest, although there are local tectonic anomalies. Several escarpments occur throughout the area, generally oriented in a northerly direction. These provide local hydraulic gradients opposite to that of the dip. The regional water table is controlled by the larger lakes, with numerous small streams issuing from the base of the main escarpment into Lake Winnipeg.

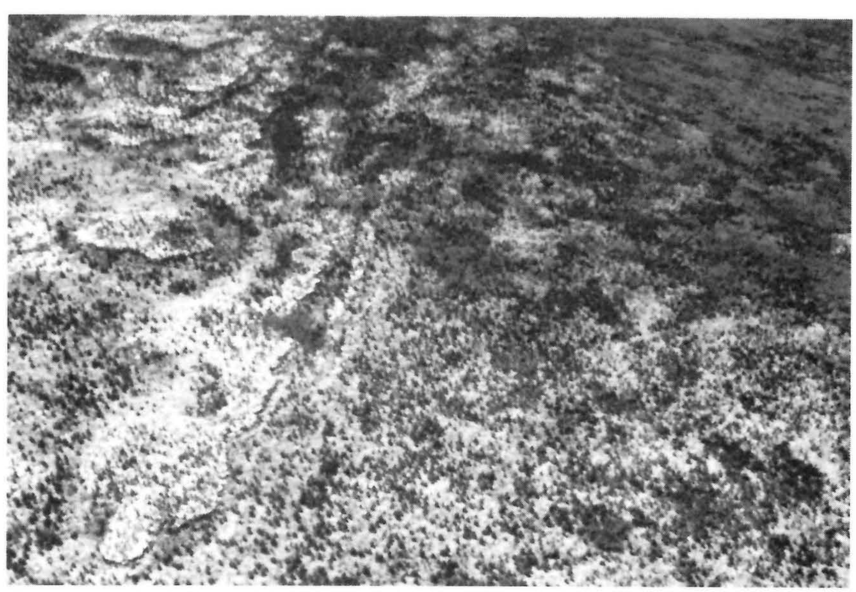


Figure GS-28-1: Extensive pavement and escarpments north of Roadend (Moon) Lake road. Cedar Lake Formation.

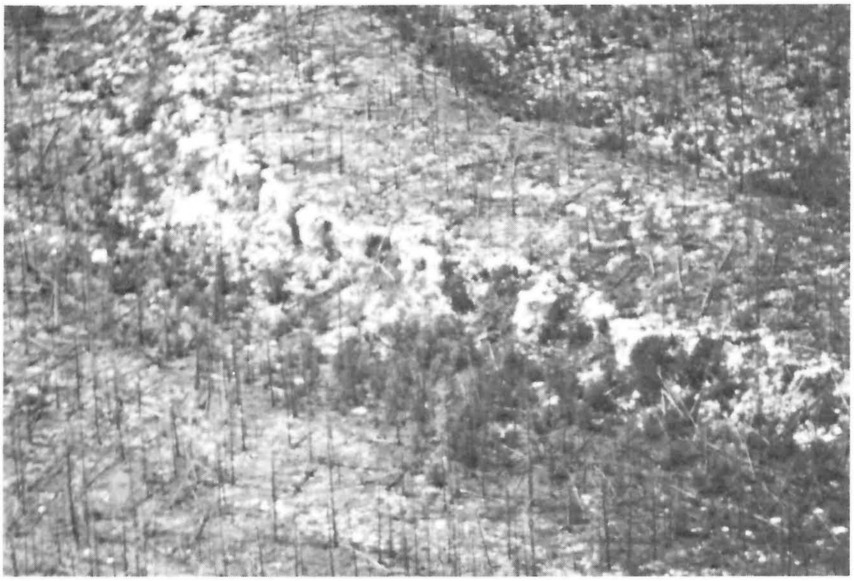


Figure GS-28-2: *Prominent east-facing escarpment of Moose Lake Formation with capping of Atikameg Formation, near Sturgeon Gill Road.*

Figure GS-28-3: *Section of East Arm escarpment south of Honeymoon Lake.*

The most ubiquitous of the karst features in the north is bedrock pavement (Fig. GS-28-4). The large expanses of bedrock exhibit widespread grikes and clints (Fig. GS-28-5) and are liberally sprinkled with sinkholes and trenches, many of which contain cave entrances (Fig. GS-29-6). In addition there are several intermittent swallow holes or ponors and at least one of these is an estevalle. The area is littered with small sink points, where surface water can drain away locally, so there is no systematic surface drainage. Locally, lakes are apparently perched, and hydrological evidence from the caves and springs confirms a series of perched water tables.

Although surficial deposits cover much of the southern and central region, such features as sinks and trenches are not uncommon and a number of caves are known in the Dallas area, as well as a few small cavities farther south, including the now famous Narcisse 'Snake Dens'.

All of these features can be found in other parts of Canada, but none occur in this particular climatic environment, nor in such flat terrain. Indeed studies of karst landscapes in a semi-arid continental climate are rare. The Interlake is an ideal site for the study of mechanical as well as chemical weathering (Fig. GS-28-7 and GS-28-8). It has a large variety of surface karst features and has been largely untouched by man, so the chemical and physical processes are quite natural.

FINDINGS

Between May, 1987 and September, 1988 considerable progress has been made in compiling an index of karst landforms in the Interlake (Table GS28-1 and GS28-2). Previously, several small caves had been located and sketched and surface features noted. During the last two years work has continued in several directions:

a) continued exploration,
b) accurate surveying and mapping of the interior of the cavities,
c) recording of stratigraphic sequences in the caves,
d) continued monitoring of the local waters,
e) initial classification of pavement morphology,
f) location of all karst features.

While all of these are important and make a contribution to the overall knowledge of the geology of the area, the stratigraphic sequences seen in the vertical sections of the caves, are especially informative. In addition this exploration may add a new dimension to the geologic appreciation of the area.

During the last two years several trips have been made to the area, by various sized groups, with the express purpose of exploring for caves. The observations stemming from these ventures are summarized in the

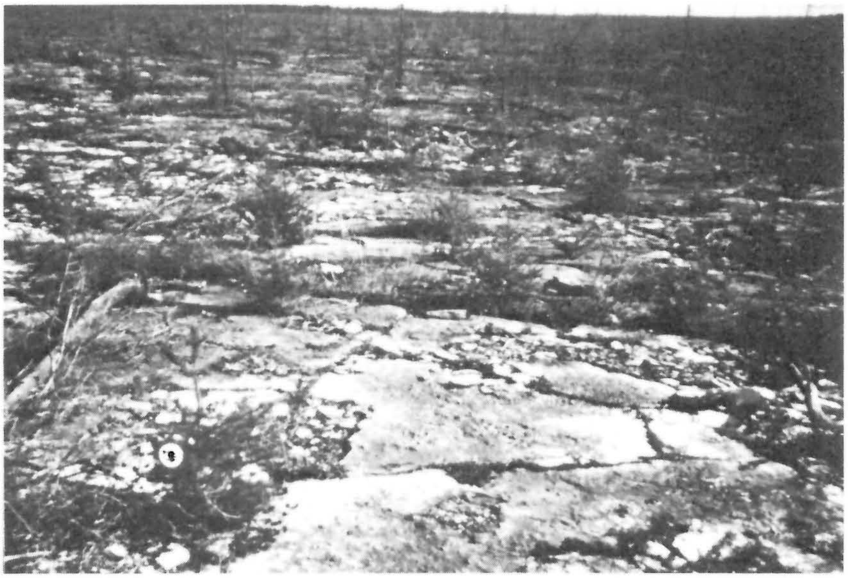


Figure GS-28-4: *Highly jointed pavement near Honeymoon Lake.*

Figure GS-28-5: *Clints and grikes, south of Honeymoon Lake.*

following two sections dealing respectively with the Grand Rapids Uplands, and the Southern Interlake.

a) *Northern Interlake, Grand Rapids Uplands* (see Fig. GS-28-9)

WEST OF REEDY LAKE

Bear Cave is a narrow diagonal shaft, opening into a small chamber. Although there are stromatolites in cross-section and the side walls of the passage are solutionally pitted there is no distinctive stratigraphic marker. The cave apparently partially fills with water at times, but this is not a regular occurrence.

Dale's Cave is located in a well defined but shallow sink. It has a typical vertical entrance, dropping about 3 m into a relatively large bell-shaped room. The walls show evidence of solution, possible scalloping, and there are solution pockets on the ceiling. There is, however, considerable breakdown on the floor, presumably from the open area of the room. In addition part of the floor is buried under a layer of forest litter. The geological units in the lower part of the cave are thinly bedded, and are overlain by more massive material; it is vuggy and desiccated and contains fretted spongework, reminiscent of the Atikameg. Above this, small stromatolites grade into larger ones; phreatic tubes and what appears to be poorly developed scallops were observed. Towards the base of the chamber some evaporitic deposits form pseudo-popcorn. Some of the surface is modified by condensation fretting. Two side passages of note (Fig GS-28-10) both have a phreatic upper portion and vadose development below. One of these passages has a deep layer of organic fill, the other has small phreatic sponge tubes and an unknown thickness of clay on the floor. Both chambers are totally solutional. The forest litter is probably washed in by rainfall and snow melt. There is evidence of water in the cave and in early spring nearly a metre of standing water was present in the base of the cave.

Knoll Chimney is a vertical shaft dropping about 15 m. The top 4 m exhibits a fracture face, below which there is a fretted zone, probably indicative of a water level. Below this the walls are solutional and the bottom of the shaft has standing water. The cave has been visited several times and the water level has fluctuated from less than 10 cm to more than 3 m. This cavity is only about 100 m from Dale's Cave but there is no relationship between the hydrologic regime of the two.

The area between Reedy and Roadend (Moon) Lakes has been explored only superficially; to date only a number of elongate, rock-lined depressions up to 3 m deep have been found. These may be defined as zanjones, although the term is typically used in tropical regions.

Figure GS-28-6: *Solution-enlarged grikes close to escarpment edge* or *snow filled trench results from solution-enlarged grike.*

JACKPINE LAKE — REEDY LAKE

This summer saw the first foray into the area between the two lakes. There are several places where enlarged joints form elongate depressions, 2-3 m wide and up to 25 m long; these are generally aligned on an azimuth of 115-125°. Pavement areas were located on the west side of Jackpine Lake on the top of the escarpment rising towards Reedy Lake. These might be useful for stratigraphic records, but could only be used after extensive and accurate elevation surveys. Two small caves were found each opening to a depth of about 4 m. As this was a reconnaissance, accurate surveying was not done but a description of the stratigraphy and the weathering within each were noted.

Cave 20-2 has a narrow entrance, and opens out below; azimuth 112°. This is a joint enlargement, which opens about 2 m wide; about half way down there is a bed about 1 m thick, containing brachiopods. This lies immediately below about 1.5 m of vuggy rock, which shows the fretted weathering commonly associated with the Atikameg unit.

Cave 20-3 is similiar in form. The uppermost section is of laminated dolomite and at a depth of 3 m there is evidence of stromatolites 30 cm in diameter. Between the two there is a band of the fretted weathering.

SOUTH OF JACKPINE LAKE

Parts of this region were first explored several years ago and so far it has yielded the highest density of cavities. On almost every trip something new has been found. The area has a number of small cavities, similar to those mentioned before. Many trenches are as long as 20 m and up to 4 m wide. There is even an example of a natural arch, but none of these features were of great stratigraphic importance, as they do not show clear sequences, and in most cases breakdown covers at least part of the walls. There are several significant caves and during the last two years these have been accurately located. This year an effort has been made to map them and to describe their stratigraphy.

Strome Cave is entered through a short vertical drop in a shallow sink. There are two parts to the cave, the first of which is a small room with much breakdown on the floor and a virtually flat roof, showing the underside of a stromatolite layer. The most interesting feature of this cave is the possible paleosurface which can be seen in the beds immediately below the stromatolites. The bed is more massive, about 6-10 cm thick, and the surface of the bed appears to be flat. The stromatolites above are rounded and even pendular in places. Sand fills the space in this unconformity. A closer look in the inner chamber, which is much smaller but extends closer to the surface, shows several bands of this unconsolidated sand between the beds. A possible explanation is an infilling into spaces enlarged by solution. Below this is a brecciated bed with abundant intraclasts, similar to that found in Porcupine Cave. Measurements have not been done to see if they are directly correlated; this should be attempted in the future.

Porcupine Cave is a fine example of joint enlargement and breakdown, very similar in form to the Narcisse snake pits. Set at one end of a wide trench, Porcupine also has a stromatolitic ceiling; in this cave it has been breached by solution and several narrow shafts are evolving. The ceiling lowers towards the back of the cave, but the breakdown and infill on the floor make it impossible to determine the base of the sequence.

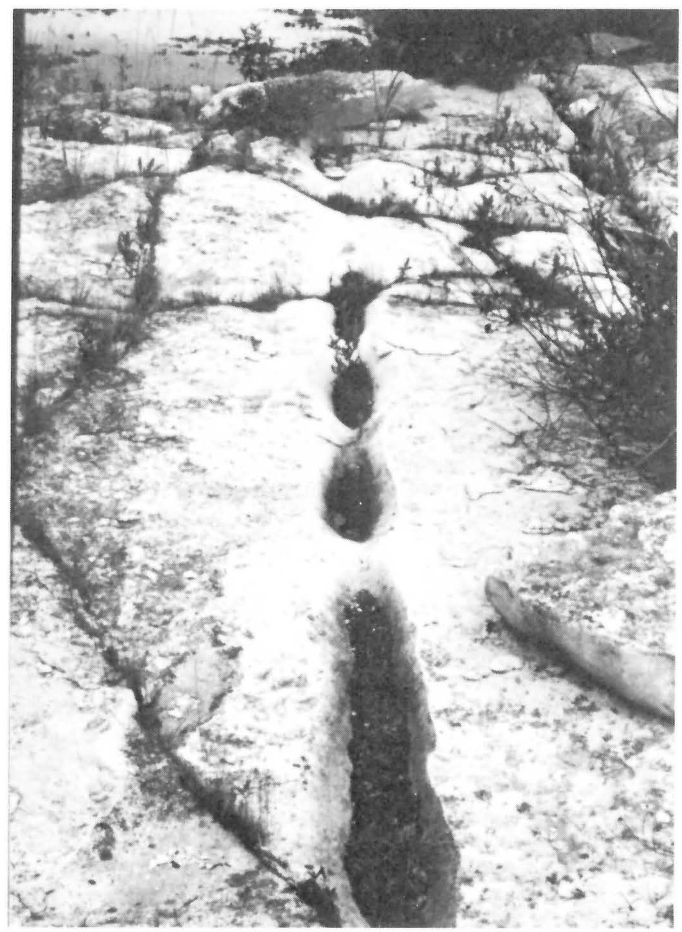
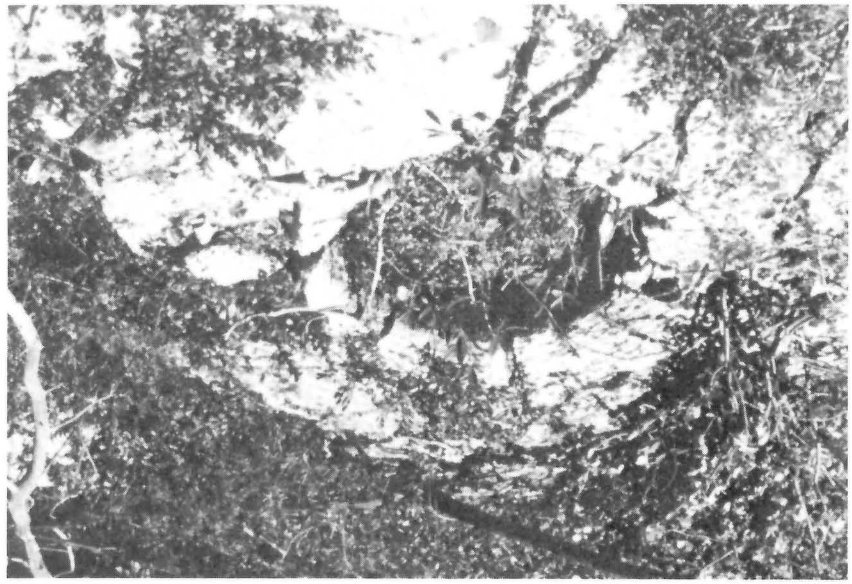


Figure GS-28-7: *Kamenitzas in old Saskatchewan River channel, near Grand Rapids.*

Figure GS-28-8: Preferential erosion of stromatolite cores.



From the floor of the cave to the top of the trench is a section of about 7 m. The walls at the base are massive and overlain about 1 m above by several well defined intraclastic breccia beds which are 2-3 cm thick and interspersed with laminated, calm water sediments. The particles are small and contain remnants of stromatolites. Above this, thinly laminated stromatolites are in evidence. These extend for about 3 m but there are local differences of note. The base of this section is made up of very vuggy stromatolites, probably deposited rapidly in very turbulent water. Upward through the section the laminae become more compact, the stromatolites less domed, as calmer water conditions prevailed. Just below ground level there is evidence of a massive vuggy layer about 1 m thick. This resembles the Atikameg, but may also be another example of turbulent water deposition. There is evidence of local faulting, especially on the south wall of the cave, where blocks about 1 m wide and extending below the floor have been displaced by a little less than a metre. Although the regional dip is less than 3°, there must be local variations. The brecciated beds, which are a metre up on the north wall, are at and below floor level on the south side, and there are large clasts close to the ceiling on the south side, which are not seen on the north. There is considerable evidence of collapse in the trench and the entrance of the overhang, but the inside of the cavity shows more evidence of solution. It is possible that the stromatolites are zones of weakness and once solution has opened the bedding planes, spalling occurs more easily because of the structure inherent in such features. Although there have been a number of visits to this site, there has never been any ponding of water. On one occasion water was observed pouring down the back of the cave and apparently disappearing immediately into the breakdown and fill. The trench itself must be a local sink, but the surrounding surface is not depressed significantly.

'T' Cave and **The Squeeze** are both good examples of joint enlargement. Narrow vertical entrances open out along the joints. 'T' Cave contains abundant large breakdown blocks (Fig. GS-28-11).

Dogtooth Spar Cave is entered from a collapsed pit about 3 m deep. This pit has undercut sides in the vuggy dolomite which is so often the primary collapse zone. The top metre or so is fine grained and thinly bedded and has apparently fallen in after the cavity developed. At the bottom of the pit is an opening into a tunnel that extends diagonally for several metres. The entrance is partially blocked with breakdown, but once inside it opens out into a passage about 2 m high, and over a metre wide. The walls are highly fractured and breakdown from them, and the ceiling, covers the floor. The roof lowers in a series of steps, but the floor appears to slope relatively evenly. The whole tunnel narrows off rapidly and pinches out after 3 or 4 m. The floor of the lower part of the cave is covered with sandy sediment and very little forest litter seems to have gone to the back of the cave. This would suggest that little water is actively flowing in today. The sand may be a glacial remnant, possibly deposited when ice covered the area. It would be helpful to find out the date of deposition, as there is some speculation about the ice margins and dates in this area. At least four different rock units are exposed in the cave, but they are not necessarily stratigraphically different. The lowest unit is more massive and has been subjected to solution. Fine examples of dogtooth spar occur on the walls in this lower passage and many of the vugs are filled with calcite.

MICROWAVE ROAD AND SOUTH

Although **Microwave Cave** was found several years ago, it was only surveyed this summer. The top of this cave may represent the Cross Lake Member of the Cedar Lake Formation. A small entrance opens out into a vertical shaft 8 m deep. At the bottom, a sloping floor leads to a constricted entrance into a second shaft which does not reach the surface. At the lowest point the walls are massive vuggy dolomite. Above this, is a stromatolite unit about 2 m thick, overlain by a series of very thin fossil-bearing beds. The fossils include crinoids. A second crinoid bed is evident about 2 m above this, separated from the first by a massive vuggy layer and a set of very small stromatolites. Several metres of thinly laminated beds overlie this, formed by laterally coalescent crypto-algal mats. The top two metres is very fine grained micritic material, characteristic of the Cedar Lake. The entire feature is formed along an enlarged joint and the walls are highly fractured. Solution appears to be of secondary importance, despite the fact that water is almost always associated with this cave. The hydrologic regime is of interest. Standing water levels range from at least 3 m to nothing. This summer (in early July) standing water fell about half a metre in two days and at the end of August water was pouring in and apparently seeping away after a heavy rainstorm. At that time, standing water was absent on the surface, and other caves in the area (**Popcorn and Baldwin's Lair**) were dry. The cave apparently acts as a sump for the subcutaneous zone surrounding it.

Exploration in the area revealed two additional small but significant caves. The smaller of these, a diagonal passage in the side of a large depression, has at least two crinoid beds and had standing water in the base despite the fact that the base of the dry depression is lower than the floor of the cave. The larger cave (**Baldwin's Lair**, also referred to as **Microwave #2**) has a narrow entrance leading to a low bell-shaped chamber with a floor sloping down to a constricted opening that is currently being excavated.

Popcorn Cave is another fine example of an enlarged joint, and is interesting because of the formations found inside. There is very little

TABLE GS-28-1
CAVES, SINKHOLES AND TRENCHES, GRAND RAPIDS UPLANDS, CENTRAL SECTOR
STATUS OF INVESTIGATIONS SEPTEMBER, 1988

CAVE NAME	UNCONFIRMED REPORT	LOCATED	SKETCHED	MAPPED	FURTHER EXCAVATION REQUIRED	LENGTH M	DEPTH M
REDFOX	---	xxx	xxx	---	---		
SQUEAKY	---	xxx	---	xxx	---	15.5	6.2
KNOLL CHIMNEY	---	xxx	xxx	---	---		
DALE'S	---	xxx	---	xxx	xxx	35.5	5.5
BEAR	---	xxx	---	xxx	---	7.5	3.5
SLOT	---	xxx	---	---	---		
HUGO'S GASH	---	xxx	---	---	---		
10' DEEP	---	xxx	---	---	---		
CRYSTAL	---	xxx	---	xxx	---	24.8	6.0
STROME	---	xxx	---	xxx	---	28.3	7.5
DOME	---	xxx	---	---	---		
PORCUPINE	---	xxx	---	xxx	---	13.5	7.8
THE SQUEEZE	---	xxx	---	xxx	---	14.6	3.5
'T'	---	xxx	---	xxx	---	33.0	7.0
THE BRIDGE	---	xxx	xxx	---	---		
DOGTOOTH	---	xxx	---	xxx	---	21.4	8.5
NERVOUS BREAKDOWN	---	xxx	xxx	---	---		
MICROWAVE #1	---	xxx	---	xxx	---	24.6	9.8
MICROWAVE #2	---	xxx	---	---	xxx		
MICROWAVE #3	xxx	---	---	---	---		
THE PORTAL	---	xxx	---	---	---		
POPCORN	---	xxx	xxx	---	---		
FIRECAMP	---	xxx	---	xxx	?		
ICE	---	xxx	---	---	---		
CAT TRAIL #1	---	xxx	---	---	---		
CAT TRAIL #2	xxx	---	---	---	---		
CAT TRAIL #3	xxx	---	---	---	---		
SUMP	---	xxx	---	---	---		
SINKHOLE #1	---	xxx	---	---	---		
MOOSE ARM PIT	---	xxx	---	xxx	xxx	45.5	5.4
SINK #2	---	xxx	xxx	---	---		
ROOT CELLAR	---	xxx	xxx	---	---		
BUFFALO	---	xxx	---	xxx	---	13.0	+.5
BAT (WALTER COOK'S)	---	xxx	---	xxx	---	29.0	10.1
HONEYMOON TRENCHES	xxx	---	---	---	---		
BAKER LAKE	xxx	---	---	---			
WEST WILLIAM LAKE	xxx	---	---	---	---		
MUSKEG LAKE	xxx	---	---	---	---		
RED EARTH LAKE	xxx	---	---	---	---		
OTHERS:							
MICROWAVE ROAD	xxx	---	---	---	---		
NORRIS LAKE TRENCH	xxx	---	---	---	---		
TRIAD	---	xxx	xxx	---	---		
CAVE 20-2	---	xxx	xxx	---	---		
CAVE 20-3	---	xxx	xxx	---	---		
MUSHROOM	---	xxx	---	---	---		
Total: 45	10	35	10	14	4	306.2	81.3

secondary precipitation in the caves generally, but this one has excellent examples of micro-gours and pseudo-popcorn. In addition, the distinct beds of microfossils may be useful in stratigraphic interpretation.

Other features south of Microwave Road include a number of trenches, the results of enlarged jointing (where the caprock has collapsed), and some wider collapsed sinks with small overhang caves at one end. Unfortunately, none of these add to the stratigraphic information collected so far. However, a careful transect of the area shows the crinoid beds to be extensive and has led to a possible relocation of the Cedar Lake-East Arm contact.

A number of well defined trenches have been found north of Microwave road as well as those described to the south. This area warrants further exploration.

HONEYMOON SOUTH

Honeymoon Lake has no active overland drainage, so an extensive underground system must exist. An excellent cliff section on the island in the lake displays a series of breakdown cliff edge passages at least as good as those in the Clearwater Lake crevice cave park. At least two stratigraphic units can be seen. Several traverses of this area have yielded little in the way of caves, although a number of trenches occur and the pavements are quite spectacular. Several large shallow depressions have central drains. These are without exception rock-edged and the drains all begin as small cavities. There may be some justification for classifying the depressions as poljes.

One cave of note has been found in the area. **Moose Arm Pit** is accessed from a large classically shaped doline, about 5 m deep. The entrance passage slopes downwards and the floor of the cave is some 10 m below ground level which means it cuts through at least two bedrock units (Fig. GS-28-12). This cave is of interest both stratigraphically and hydrologically. Fine examples of cave erosion and deposition occur, with pseudo-popcorn and fretwork similar to that described above. The cave is being activly eroded. Water ponds to a depth of at least 2 m, and sediment and flotsom on the upper part of the walls indicate total filling some of the time. At the same time drainage is rapid. This spring observers saw a water drop of over a metre in two days. This would suggest an extensive underground network and possible perching due to ice plugging, a common feature of karst drainage in high latitudes.

Slightly to the west the situation is more promising. One particularly significant cave has been located close to the road. **Firecamp Cave** is entered through a narrow boulder choked opening and opens out into

Figure GS-28-10: Solution passages with forest litter lined floor. Dale's Cave near Reedy Lake.

Figure GS-28-11: Massive breakdown blocks in 'T' Cave, south of Jackpine Lake.

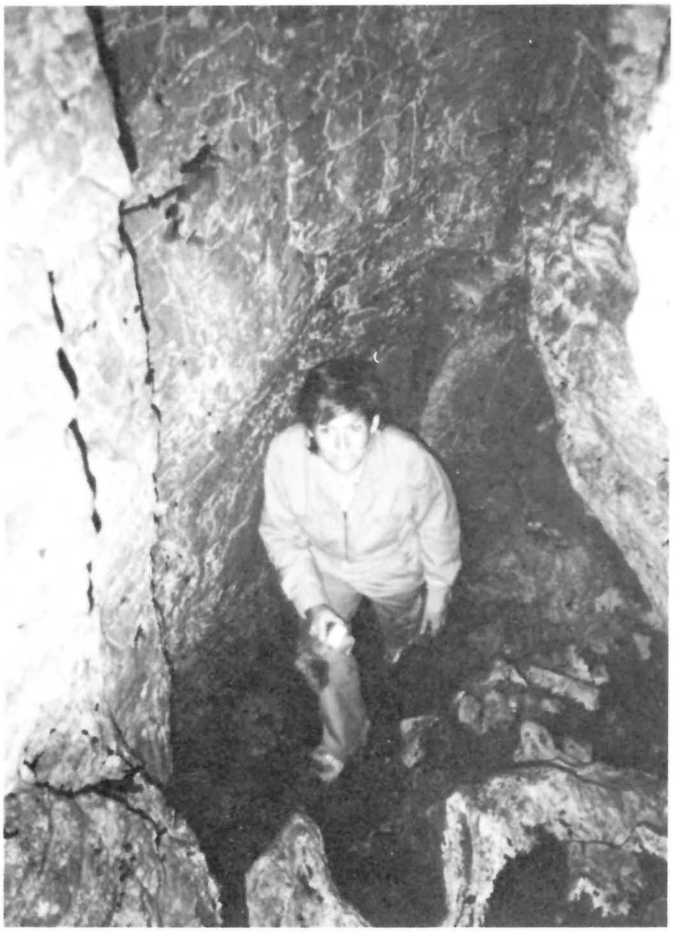


Figure GS-28-12: Vertical joint faces in solution-enlarged passageway; Moose Arm Pit inner chamber.

Figure GS-28-13: Ice covered walls and icicles in Ice Cave near Highway #6.

a 7 m drop to the floor, which slopes down about another 3 m. The stratigraphic sequence is well exposed. This cave is similar to many of the others in the area in that there has been a zone of solution and then the top has collapsed into this. Fossils occur in the pavement at the entrance and the first metre or so is typically thin bedded with stromatolites. This layer, which is about 2 m thick, is immediately underlain by a thin bed containing crinoids. It is possible that this marks the boundary between the Cedar Lake and the East Arm, but it is also likely that this is a small inlier. According to the present knowledge of the area this should be East Arm, but the stratigraphy immediately below this crinoid bed is also stromatolitic. It is very pitted and the surface is covered with solution induced fretwork. Where stromatolites are very small the fretting appears to follow the spacing. A metre below the crinoid marker there is a distinct layer of storm breccia, below which is half a metre of very thinly bedded sediment. This contains crinoids, but more interestingly the structure is crossbedded. This might correlate with the findings of Porcupine cave. The rest of the exposure to the floor of the cave is micritic and more massively bedded, at least 10 cm thick, with thinly laminated material between. At the base of the sloping floor the walls expose big shallow stromatolites. Throughout the cave are fine examples of the sugar-cube size fracturing, which is common on the escarpment edge, and it would appear that this fracturing is post-solutional. If this is indeed the case then one can assume that the caves are at least pre-last ice advance as the fracturing is thought to be the effect of ice pressure and release. A prominent almost spherical "fish bowl" solution pocket (1.5 m in diameter) is perched 2 m above the floor on the northwest wall.

Another smaller cave close by (**Ice Cave**, see Fig. GS-28-13), resembles the many other enlarged joint fractures; however, the stratigraphy in it may be helpful, so it too should be surveyed at some later date.

The Buffalo Lake forest fire this summer has opened up much more of the area west of Highway 6 and several caves on or near the fire trails remain to be explored.

BAT CAVE ROAD

About 18 km from the highway, **Bat Cave** has been explored and monitored for the last five years. This summer it was accurately surveyed. The interior of the cave is largely solutional and only the long sloping entrance ramp is a result of breakdown. The interior walls are apparently formed by large scallops, suggesting solution by slow moving or standing water. There is evidence of upward solutioning in the ceiling, and active solution continues at least in the back of the cave. During spring, meltwater pours down the major fracture zone and disappears through the sediment on the floor. The interior of the cave also shows considerable evidence of secondary precipitation. The walls are coated with a thin layer of calcitic mud and there are micro-gours and pseudo-popcorn on the protruding edges. Sparry calcite is also present. Because of this the interior walls are not helpful, stratigraphically, but the long entrance tunnel, with extensive fracturing could be used as another location for correlation. Drill cores from the immediate area are available.

The pavement typology in this Cedar Lake exposure can be traced at least halfway to the highway. If this can be considered diagnostic, then the Cedar Lake extends farther east than originally thought.

Several other small shafts and some trenches occur along this road, but the area has not been thoroughly investigated.

"THE REST"

Buffalo Cave is a lateral near-horizontal tunnel punched into the side of the escarpment (Fig. GS-28-14). It was originally considered to be a wave-cut feature, but it is too deep for its width. It is possible that large numbers of these water table passages exist, but they would not be exposed at the surface. This may be the key to the many sitings of underground cavities mentioned in hydro reports, local tales and in the drill cores.

GENERAL CONSIDERATIONS

The proximity of caves with different hydrologic regimes indicates the probability of perched water tables. This is also borne out by the proximity of some caves to lakes.

The stratigraphic record found in many of the caves is much clearer than that seen in some of the outcrops and may be more complete as the cave depths are at least as much as the height of cliff outcrops. However, they can be used only if their elevations are accurately determined. Even then it is probable that some beds within the sequence may be missing from a particular site, or may be a local anomaly. Nevertheless, the more stratigraphic sections that can be found, the more complete the record will become. Obviously, the next major project to be tackled is elevation surveys. The narrowness of some stratigraphic units makes it necessary to use a more accurate method than airphoto interpretation.

Dr. G. Lammers (pers. comm.) may be right in suggesting that there might not be enough difference between the several units to warrant subdivision into seven stratigraphic formations. Many differences may represent local lateral facies variations in depositional environments. In addition, such differences as stromatolite size may reflect only the seasonal or spatial changes in depositional environment and are really not enough to warrant a major stratigraphic subdivision.

The caves of the Grand Rapids region can be classified into several categories. A number are formed as drains for sinks, **Moose Arm Pit**, **Dale's Cave**, **Strome Cave**. In each case the cave is in a sink, dropping almost vertically and opens out into a dome-like structure inside. Secondly, there are the narrow, deep shafts such as **Knoll Chimney**, **Cat Road # One**, and **"The shaft"** on Bat Cave Road. These apparently evolved into features like **"T" Cave**, **The Squeeze**, **Popcorn**, and probably **Firecamp Cave**. In this case an enlarged joint system apparently develops below the surface, primarily by solution. It is eventually opened up when the top collapses, or possibly if upwards solution creates an opening. The size of the cavity may depend partly upon the thickness of the capping rock.

Yet another category is represented by **Bat Cave**, where a two-phase system seems to have been in effect. The interior of this cave is solutional, and has developed along a joint, which has not yet opened to the surface. Solutioning along the entrance passage has created a big enough space for the fractured rock to collapse and fall in creating the entrance ramp and opening. **Microwave Cave** and **Dogtooth** may have evolved in a similar way. Cavities like those found in the base of the wide shallow rock lined sinks in the Honeymoon area, may be the only ones which are truly collapsed into a solutional cavity. The wide, scarp bounded, depressions in this area may be a form of polje.

Although the whole region is riddled with small independent caves, the present evidence does not lead one to expect a well developed linking system. There is some question about the age of the caves. Some authors suggest that they are the remains of an earlier much larger system, which was erased by the successive ice advances. An alternative time frame would be intraglacial or immediately post-glacial. The present hydrologic regime does not generally appear to be active enough to produce major cavities; however, this aspect needs more work.

The caves are also interesting from a biological point of view as they appear to be a significant hibernaculum for bats. Work on this has been initiated and members of the group are actively involved, under the leadership of Dr. J. Dubois of the Manitoba Museum of Man and Nature. Over 340 bats were tagged during the summer of 1988, 100 of these in the Southern Interlake.

There are numerous other features, which are of interest to the Karst enthusiast. A number of different pavement morphologies have been identified, which correlate with different stratigraphic types. Some trenches and depressions are defined in classifications previously considered as tropical, or humid in location. A series of steps increase the elevation of the area to almost 300 m, significantly above that of the main escarpment. Sinkpoints at the edge of some of these indicate that local drainage is down-dip, opposite to the regional topographic gradient. Micro-forms such as kamenitzas are evident, but there are few indications of karren.

Figure GS-28-14: Bell-shaped entrance to Buffalo Lake cave; note well bedded dolomite units.

TABLE GS-28-2
CAVES, SINKHOLES AND TRENCHES, HODGSON-GYPSUMVILLE AREA
STATUS OF INVESTIGATIONS SEPTEMBER, 1988

CAVE NAME	UNCONFIRMED REPORT	LOCATED	SKETCHED	MAPPED	FURTHER EXCAVATION REQUIRED
BATS	---	XXX	---	XXX	---
LUCKY	---	XXX	---	XXX	---
MINERAL SAMPLE	---	XXX	---	XXX	XXX
MOOSEHEAD	---	XXX	---	XXX	---
WINDOW	---	XXX	---	XXX	XXX
ANNEX	---	XXX	XXX	---	XXX
NORTHEAST (2)	---	XXX	---	---	---
LOGGING ROAD(2)	XXX	---	---	---	---
SNAKE PITS (?)	---	XXX	---	---	---
MARGO'S ROADSIDE SINKS (2)	---	XXX	XXX	XXX	XXX
CROSS FENCE (SANDRIDGE)	---	XXX	---	XXX	---
MANITOBA ISLAND	XXX	---	---	---	---
HIGHROCK LAKE	---	XXX	---	---	---
C.B.GILL'S	XXX	---	---	---	---
MEADOW PORTAGE	---	XXX	---	---	---
LAGUNA (STEEP ROCK)	---	XXX	---	XXX	---
GYPSUM LAKE	XXX	---	---	---	---
BROAD VALLEY (DEVILS HOLE)	---	XXX	XXX	---	---
RED ROSE	XXX	---	---	---	---

b) *Southern Interlake* (see Fig. GS-28-15)

1) STEEP ROCK

The area has excellent exposures of Devonian limestones in the commercial quarries. The rock, a variably dolomitized limestone, is highly friable and disintegrates into chip-like particles rapidly. In the same place it is possible to see small phreatic passages, and incipient sinks. The shoreline south of town also offers good sections in the cliff. There are examples of wave cut caves, stacks, arches and sinks along this cliff where erosion is very active. Caves such as **Laguna Cave** might be expected to develop very quickly and these features are probably post-glacial. Apparently only one stratigraphic unit is present.

Caves have been located in several places on Lake Winnipegosis, Spence Lake, and Ebb and Flow Lake, but exploration has not been completed.

2) HODGSON AREA

Caves in this area are in the Selkirk Member of the Red River Formation. This Ordovician rock is made up of dolomite, and cherty dolomitic limestone. Cave formation is somewhat different from that found in the exclusively dolomitic Silurian beds of the north. In the region just north of the Peguis Indian Reserve a number of caves have been located and surveyed. Most of these were at least locally known and some have been used regularly for less than scientific purposes.

Probably the most interesting of the caves so far discovered is the St. George's Lake **Bat's Cave**, a generally horizontal feature, with a vertical entrance. The cave, which is 12 m below the surface at its maximum depth, is about 50 m long; it opens out into a long chamber with massive block breakdown. Beyond this the passage narrows and finally tapers out in several small phreatic tubes. There are several small side passages showing evidence of solution although the cave generally is very dry. The surfaces are all coated with fine red sediment (terra rossa?) and the original floor is buried throughout. There are several points of interest. There is secondary precipitation in the form of flowstone and 'broccoli', small bubbles of calcite, highly contaminated by dust. Bands of chert in the bedrock erode out as chert nodules.

Many of the fissures between the larger breakdown blocks are filled with yellow brown, finely layered goethite-rich sand (up to 20 cm thick), locally with vuggy calcitic cores (Fig. GS-28-16). Goethite and limonite also occur as patchy botryoidal encrustations on the roof of the cave and along some fracture lines.

Climatic chamber contains excellent examples of cockscomb drapes (Fig. 28-17) as well as small (2 cm) soda straws, incipient stalagmites (Fig. GS-28-18) and smooth encrustations of flowstone. The cave is a hibernaculum for bats (more than 600 on September 24, 1988)

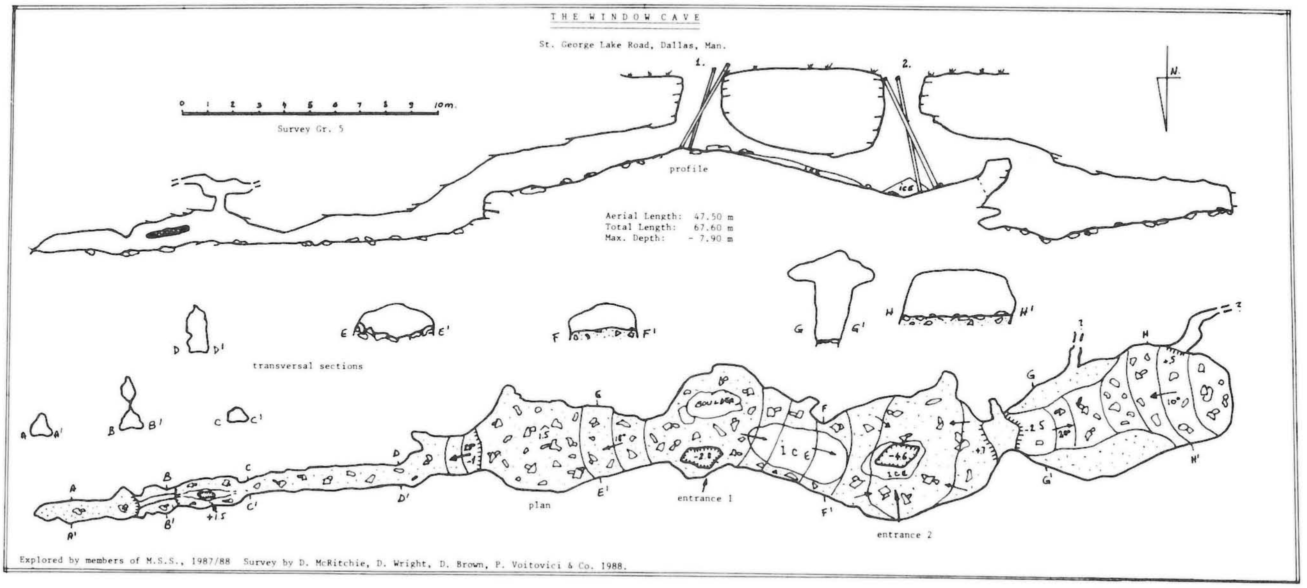
Lucky Cave, **Moosehead Cave**, **The Annex** and **Window Cave** are all examples of enlarged joints of different shapes and lengths. **Window Cave** is a particularly good example extending for more than 60 m. It is generally less than 2 m in width, and appears to follow a bedding plane. Much of the floor is buried in debris, but the end chamber is clear and it is obvious that the cherty band acts as a retardant and may form the base of the cave throughout. The two openings are joint controlled, at right angles to the dominant orientation. Although there is breakdown on the floor, it is not enough to account for the width of the passage, so solution is of primary importance. This is borne out in the smoothness of the walls. There is evidence that this cave and **The Annex** are connected.

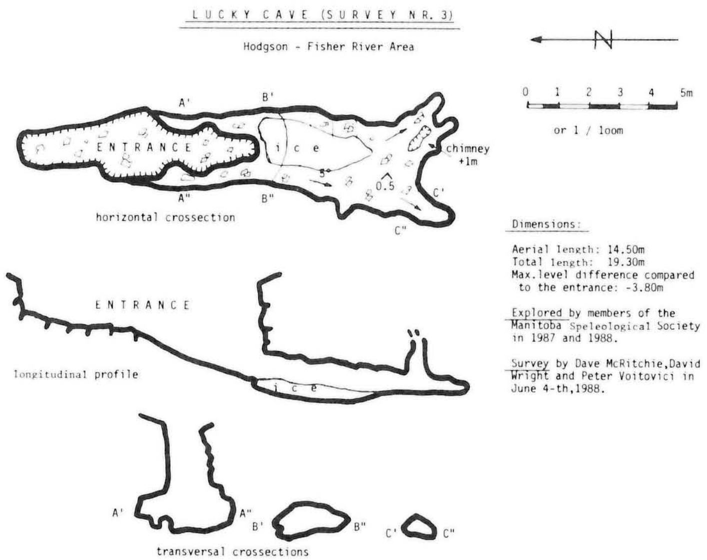
Some caves contain fine samples of minerals, including chert nodules, and calcite crystals. In **Mineral Sample Cave** geodes were also found.

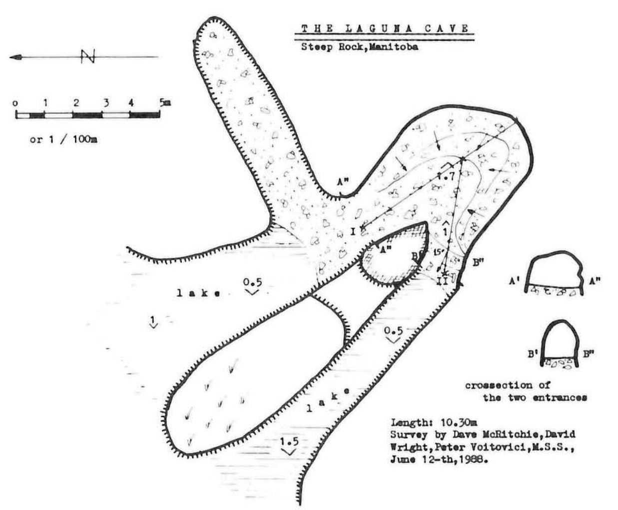
A number of sites have been mentioned by local residents, which have not yet been identified nor explored.

3) NARCISSE

The famous **Snake Dens** are good examples of collapsed sinks, developed in the Silurian, under a thin till overburden. They show signs of breakdown, with tilted blocks and solutionally enlarged tubes in the sides of a sink. In the same area cavities have been explored at Sandridge, Sylvan and Chatfield. In each case they are joint aligned, but there the similarity ceases. At Sandridge a narrow entrance to **Cross Fence Cave** opens into a bell-shaped chamber about 8 m in diameter. At one end there is a narrow passage aligned with the jointing and this extends for some distance. The cave walls are smooth, with a basal massive unit of porous dolomite, overlain by a fossiliferous unit. There is evidence of water flow in the cave although standing water has not been observed. Enlarged joints 1-2







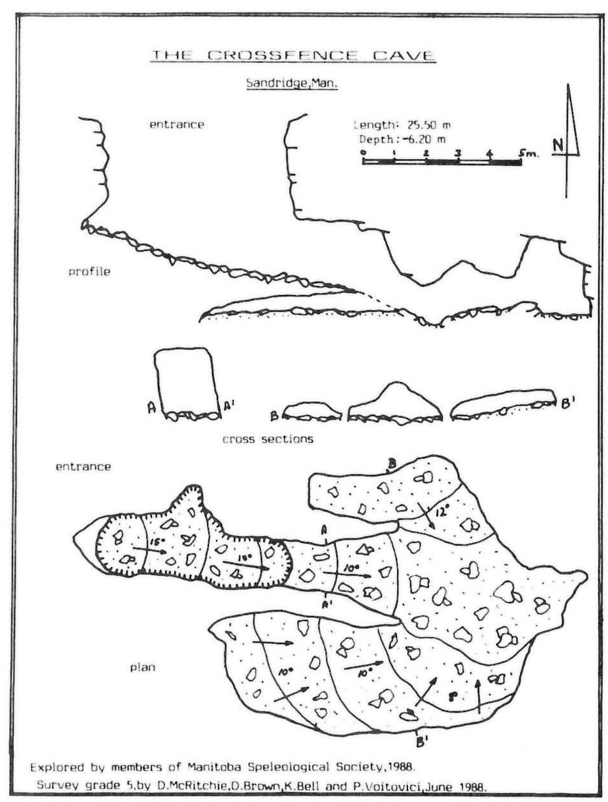
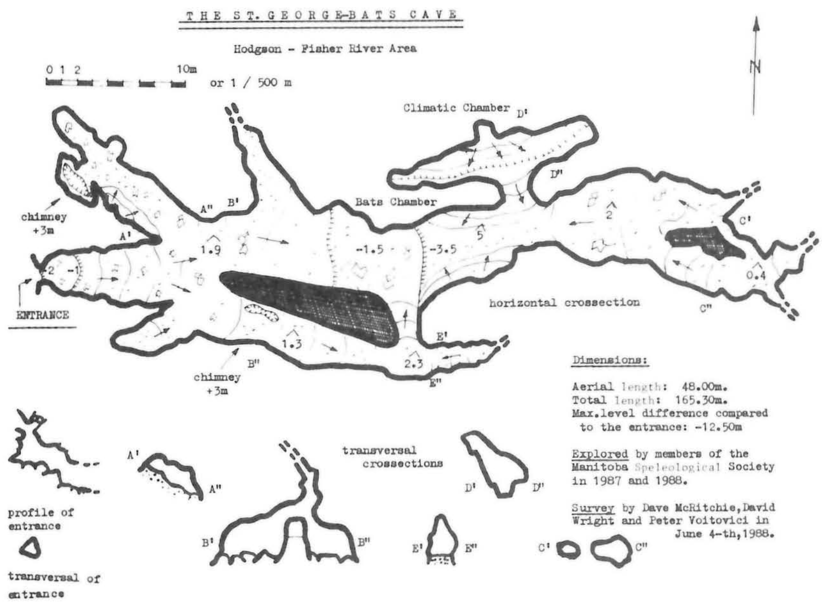
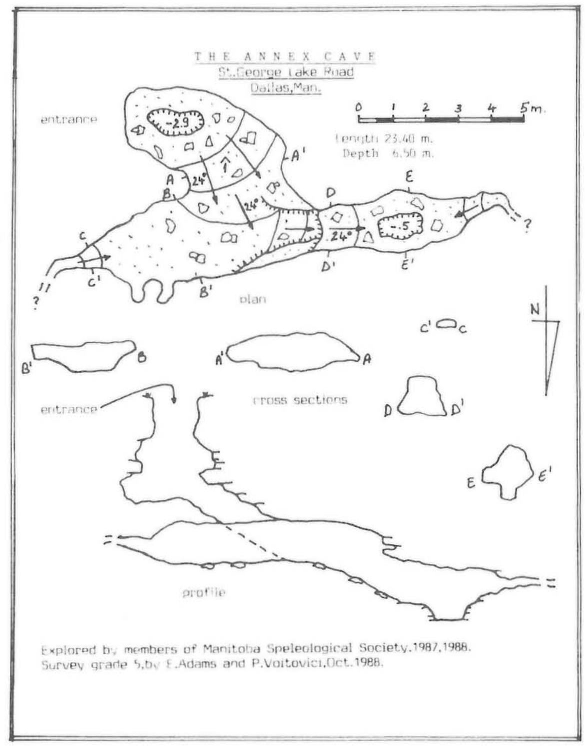
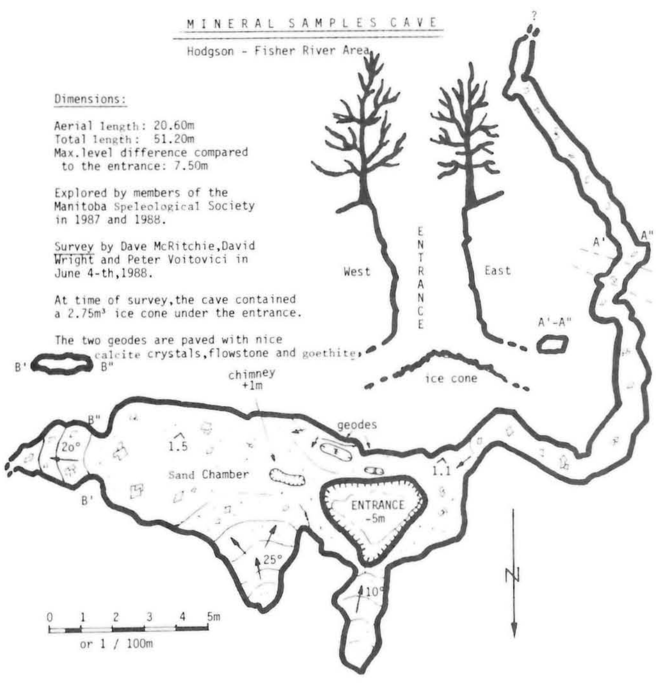


Figure GS-28-15: Caves, trenches and sinks of the Southern Interlake.







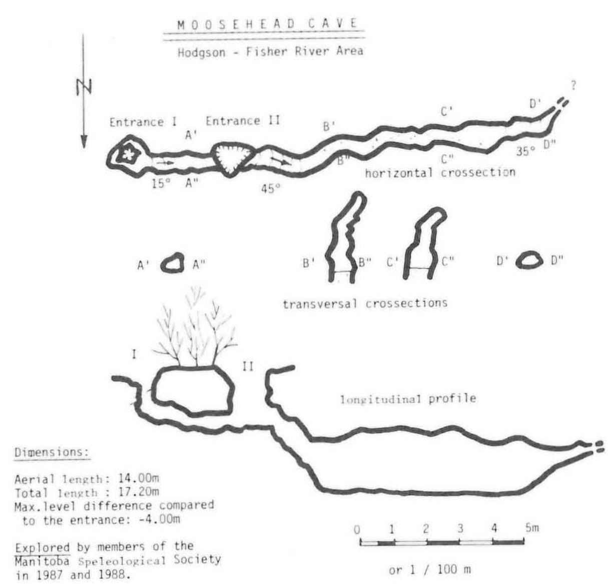


Figure GS-28-15: Caves, trenches and sinks of the Southern Interlake.

Figure GS-28-16: *Goethite-filled gashes (and calcitic cores) between breakdown blocks in Bat's Cave north of Dallas.*

Figure GS-28-17: *Cockscomb drapery in "climatic chamber", Bat's Cave north of Dallas.*

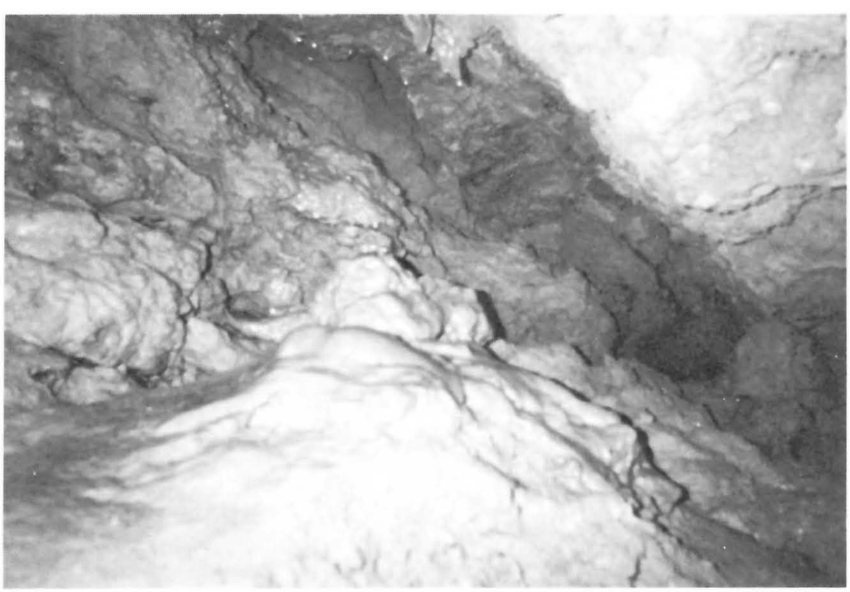


Figure GS-28-18: *Incipient stalagmite protuberances — Bat's Cave, north of Dallas.*

m wide and up to 30 m long are common in the area, and there is a fine example near Chatfield. However, many have been successfully filled by the local farmers.

Just west of Sylvan **Roadside Pit One** and **Roadside Pit Two** are more examples of enlarged joints. Both entrances are vertical pitches about 4 m and 5 m deep, respectively with basal passages opened out along the bedding plane, joint boundaries. A boulder and mud choke is currently being excavated, providing clear passage down from the east sink into the inner chamber of the west sink. There is evidence of standing water in a mud line at about 1 m. The entrance cuts through three well defined bedding planes, but there is apparently little stratigraphic difference. The cavity has broadened out below a chert-bearing band, the nodules of which hang prominently from the roof of the chamber.

At Broad Valley there is an excellent example of sinkhole development. The **Devil's Hole** is between 10 and 15 m in diameter and over 4 m deep. There is a decided overhang and the walls are smooth with long phreatic tubes extending into the rock. Later frost action has caused shattering, but the large breakdown blocks in the base are of the same stratigraphic units as at ground level. These is no evidence of material from the wall in the base.

Although numerous other sinks and small caves have been reported from the Sylvan, Inwood, Narcisse and Garson areas over the years, extensive reclamation of the land and related agricultural activities have in many localities resulted in the filling of surface entrances to protect livestock and equipment.

Cavities in bedrock carbonates are also frequently recorded in drill hole records from as far south as the city of Winnipeg. However, thick overburden in the Red River Valley precludes surface examination of these features.

Consequently the greatest potential for karst studies and discovering new caves appears to lie in the northern, less settled regions, and it is likely that this is where the future efforts of the SSM will be directed.

It has also long been recognized that the Interlake carbonates exhibit many of the attributes of Paleozoic formations in Tennessee and the Mississippi River Valley that contain major lead and zinc deposits. In this context hydrological studies may well play a key role in directing the focus of future exploration programs based on stream water and sediment geochemistry.

GLOSSARY:

Breakdown: Mechanical fracturing of the carbonate beds that make up the cave roof and walls, producing a rough jumble of angular rock fragments. Variations: Block breakdown; Slab breakdown; Chip breakdown.

Clints: Surface feature. A raised segment of rock bounded by corroded joints/bedding planes.

Doline: Generally circular or oval closed surface depression — dish, bowl-shaped, conical or cylindrical.

Estavelle: A streamsink that inverts during flooding and discharges water instead of draining.

Gours: Dams of calcite formed in streamways or on sloping surfaces. Running water containing excess CO_2 gives off more of this into the atmosphere when it flows over a lip, than when it is ponded. More calcite deposition occurs and builds up into a dam. Like many other cave features gours can be small (less than 1 cm) or large (5 m plus).

Grikes: Solution-enlarged joints.

Kamenitza: Solution basins (5-80 cm in diameter and 2-30 cm deep), with circular or oval outlines, flat bottoms, and rounded to overhanging edges.

Karren: Rounded solution runnels of many different types. Generally form dendritic to subparallel grooves on a karst pavement.

Karst: General name for limestone scenery and its typical landforms. In the Manitoba context, applies equally well to dolomites and dolomitic limestones of the Interlake.

Phreas: Permanent water-filled zone in a cave. Phreatic caves are caves formed below the water table.

Polje: Large closed and sometimes elongate flat bottomed valleys or depressions which flood during the wet season.

Ponor: The place where a sinking stream goes underground. Synonymous with Swallow hole, Swallet, or active Shakehole.

Shakehole: Crater left by collapse of soil — boulder clay — non-limestone caprock. The size is generally related to the thickness of the cover over the limestone.

Vadose: Refers to conditions obtaining when free-flowing streams, with an air-space above, erode downwards.

Zanjones: (Zan-hoe-nee): Solution feature of the humid tropics, zanjones are long vertical walled trenches ranging in width from a few centimetres to many metres and in depth from about 1-4 m. Zanjones occur as parallel trenches oriented generally in one direction and are found only in localities with thin bedded, brittle limestone.

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GS-29 SUBSURFACE PRECAMBRIAN GEOLOGY OF THE PAS-GRAND RAPIDS AREA

by C.R. McGregor

The Precambrian basement in west central Manitoba, south of Flin Flon-Wabowden, is in part overlain by Paleozoic strata and in part by Quaternary overburden (Fig. GS-29-1). NTS areas 63J, 63F and 63G are being compiled and will complement that of 63K compiled at a scale of 1:250 000 by the Geological Survey of Canada (Project Cormorant). The area includes the Churchill and Superior provinces and the Churchill-Superior Boundary Zone (Fig. GS-29-1). The geological interpretations are based on diamond drill hole data, aeromagnetic signatures, gravity patterns, gradiometric data and other sources of information. Completion of these three maps is slated for the fall of 1989.

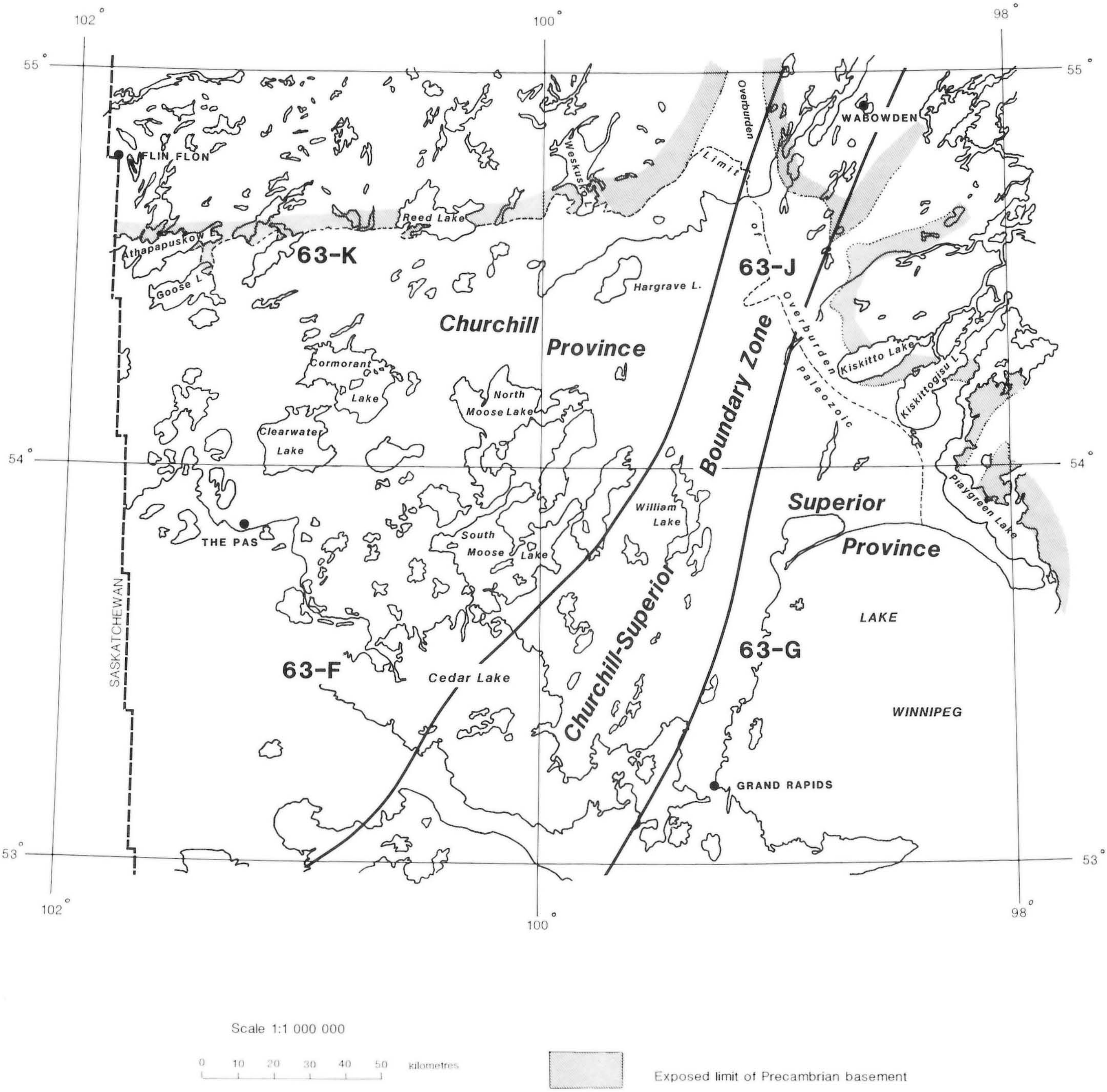

Figure GS-29-1: *Area of subsurface Precambrian geology compilation.*

GS-30 PLATINUM GROUP ELEMENTS INVESTIGATIONS

by P. Theyer

INTRODUCTION

Platinum group elements (PGE) are found primarily in mafic to ultramafic rocks, but are not restricted to these rocks since PGE can be mobilized in hydrothermal regimes and redeposited in a variety of host rocks (Stumpfl, 1974; McCallum et al., 1976). Mertie (1969) in his compendium of PGE deposits lists a total of twenty-three PGE occurrences in quartz veins and similar host rocks, preferentially associated with gold.

It is useful to remember when investigating older references of PGE occurrences that skepticism is required, since analyses for this group of elements were at best difficult to accomplish and frequently an inaccurate feat, especially when dealing with low concentrations in rock samples (Bloom, 1986). Modern determination techniques (Hoffman et al., 1978) have overcome these difficulties.

Platinum was reported to have been found in gold occurrences of the Wekusko Lake area. A sample from the McCafferty gold-bearing quartz veins was reported to have contained approximately 13 g/tonne platinum. Platinum has supposedly also been found in rocks at the workings of the Northern Manitoba Mining and Development Company, i.e. the Moose-Horn/Ballast mine (Canadian Mining Journal, v. 37, no. 22, 1916; Fig. GS-30-1). Follow-up work on these original analyses had either been unsuccessful or had not been done, since platinum occurrences are not mentioned in any of the subsequent geological investigations of this area (Alcock, 1917; Bruce, 1917; Alcock, 1920; Stockwell, 1937; Galley et al., 1985 and Galley et al., 1986).

GEOLOGICAL INVESTIGATIONS

Rock samples from the Moose-Horn/Ballast mine and the McCafferty vein and the Ferro Mine in the Wekusko Lake area (Fig. GS-30-1) and from the Mirage property in the Rice Lake greenstone belt (Fig. GS-30-1) were analyzed for Pt, Pd and Au. The analytical results and brief sample descriptions are given in Table GS-30-1.

Ferro Mine

This deposit consists of discontinuous pegmatitic to coarse crystalline quartz veins and lenses that locally contain muscovite. Sulphides occur either as sparsely disseminated pyrite and pyrrhotite or concentrated in veins and knots in some of the quartz veins. The host rock is a weakly foliated mafic volcanic rock with zones of intense localized shearing that have produced a black highly friable and brittle rock. Rock samples were collected from mine muck in the vicinity of the shaft and from rock powders stored in plastic bags in one of the abandoned buildings. The original sample number on the plastic bag is given in Table GS-30-1.

Moose-Horn/Ballast Mine

The mineralization in this deposit is reported to be in an approximately 15 to 60 cm thick quartz vein with abundant tourmaline, arsenopyrite, pyrite, chalcopyrite, galena, sphalerite, native gold and telluride that was tentatively identified as petzite.

On the surface, quartz occurs in discontinuous irregular lenses that are barren of sulphides, within a quartz-feldspar porphyry and a massive mafic rock.

McCafferty vein

This occurrence consists of an approximately 500 m long, northeast-striking (50°) quartz vein, up to 120 cm thick, hosted by a fracture zone transecting biotite-bearing dacite. The vein quartz and the northwestern wallrocks are essentially barren of sulphides, whereas the southeastern wallrocks are characterized by an approximately 1 m thick silicified hornblende- and biotite-bearing rock layer with 2-5% arsenopyrite.

Mirage

This gold occurrence, located in the Rice Lake greenstone belt of the southeastern Manitoba (Fig. GS-30-2), consists of an array of easterly striking quartz veins hosted by intermediate to mafic feldspar-phyric rocks mapped as anorthositic gabbro by Seneshen and Owens (1985). Individual quartz veins can exceed 90 m in length and attain up to 1 m thickness. The vein quartz is generally milky white but abundant admixed ankerite, iron oxide and wallrock inclusions frequently colours the quartz to red-brown hues. Sulphide mineralization consists of sparsely disseminated pyrite and pyrrhotite.

TABLE GS-30-1
CONCENTRATIONS OF Pt, Pd AND Au

Sample No.	Description	Pt	Pd	Au (ppb)	Locality
51-8-1	chip; vein quartz; barren	<10	<2	2	Mirage
51-8-2	chip; vein quartz; barren	<10	<2	4	Mirage
51-8-3	chip; vein quartz; barren	<10	10	43	Mirage
51-8-4	chip; vein quartz; 1% pyrite	20	300	6900	Mirage
51-8-11	grab; muck; 2% pyrite	<10	<2	180	Ferro
51-8-12	grab; muck; 2% pyrite	<10	110	1400	Ferro
51-8-13	powder; (S 2-40-10)	<10	<2	53	Ferro
51-8-14	powder; (S 2-25-10)	80	140	140	Ferro
51-8-15	powder; (S 1-51-5)	<10	<2	11	Ferro
51-8-16	powder; (S 2-41-5)	<10	<2	1500	Ferro
51-8-17		<10	<2	350	McCafferty
51-8-18		<10	<2	82	McCafferty
51-8-19		<10	<2	110	McCafferty
51-8-20		<10	6	810	McCafferty
52-8-21		30	<2	44	McCafferty
51-8-25	vein quartz; barren	<10	<2	180	Moose-Horn/Ballast
51-8-26	vein quartz; barren	<10	4	390	Moose-Horn/Ballast
51-8-27	vein quartz; barren	<10	<2	130	Moose-Horn/Ballast

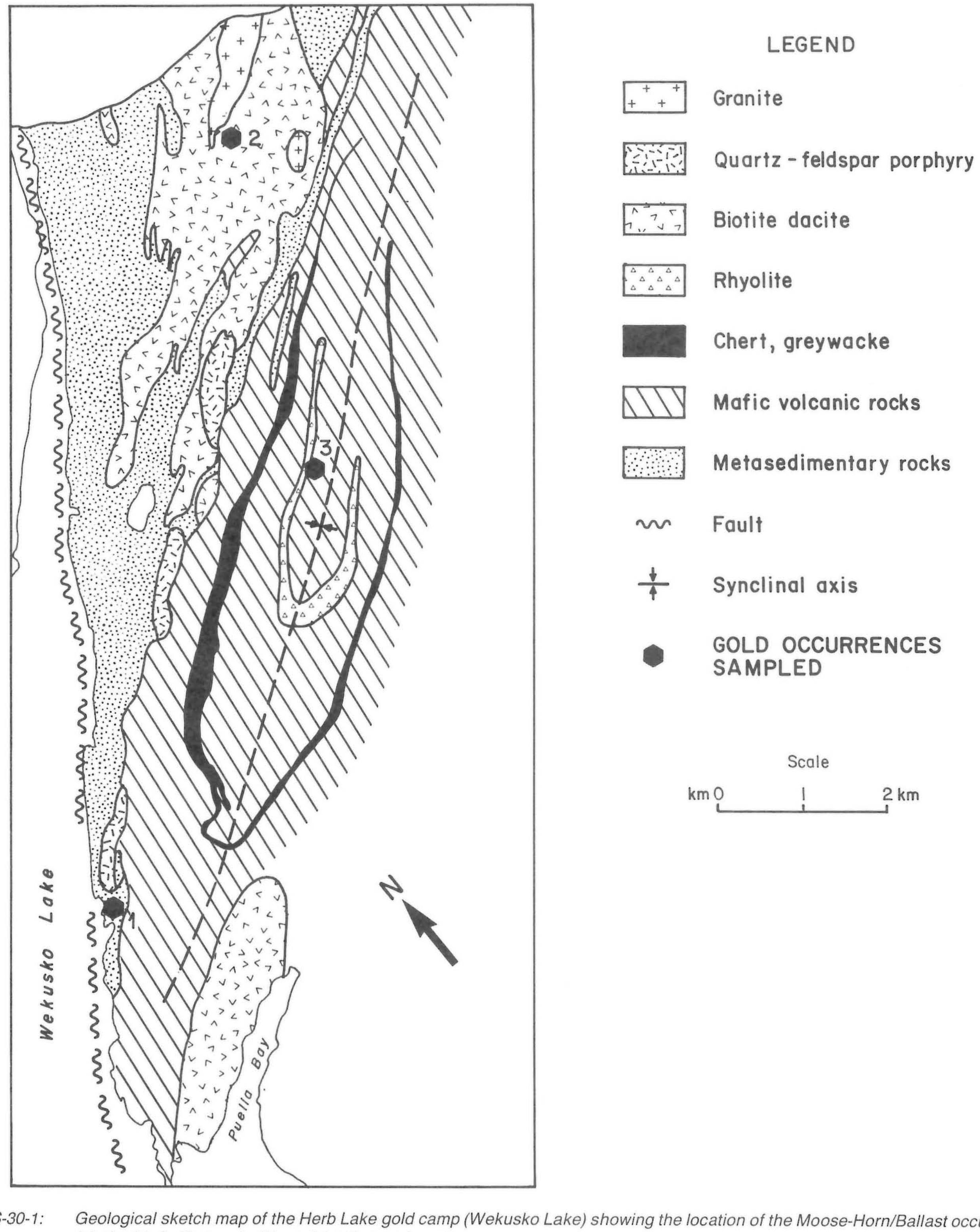

Figure GS-30-1: Geological sketch map of the Herb Lake gold camp (Wekusko Lake) showing the location of the Moose-Horn/Ballast occurrence (1), the McCafferty vein (2), and the Ferro mine (3).

CONCLUSIONS

Mirage occurrence

One of the four samples collected on this property (51-8-4) yielded anomalous concentrations of Au, Pd and, to a lesser degree, Pt. A second sample (51-8-3) exhibits slightly elevated concentrations of Pd and Au. These results warrant further investigation of this occurrence for PGE in sulphide-bearing quartz veins.

Ferro Mine

Two out of five samples collected at this mine yielded anomalous Au, Pt and/or Pd concentrations. These results warrant further investigation of this occurrence for PGE.

McCafferty vein and Moose-Horn/Ballast Mine

None of the eight samples collected on these properties yielded anomalous concentrations of Pt and/or Pd. It appears therefore that the analyses for these occurrence in 1916 (Canadian Mining Journal, v. 37, no. 22, 1916) were made either on unique rock specimens or were the result of analytical error.

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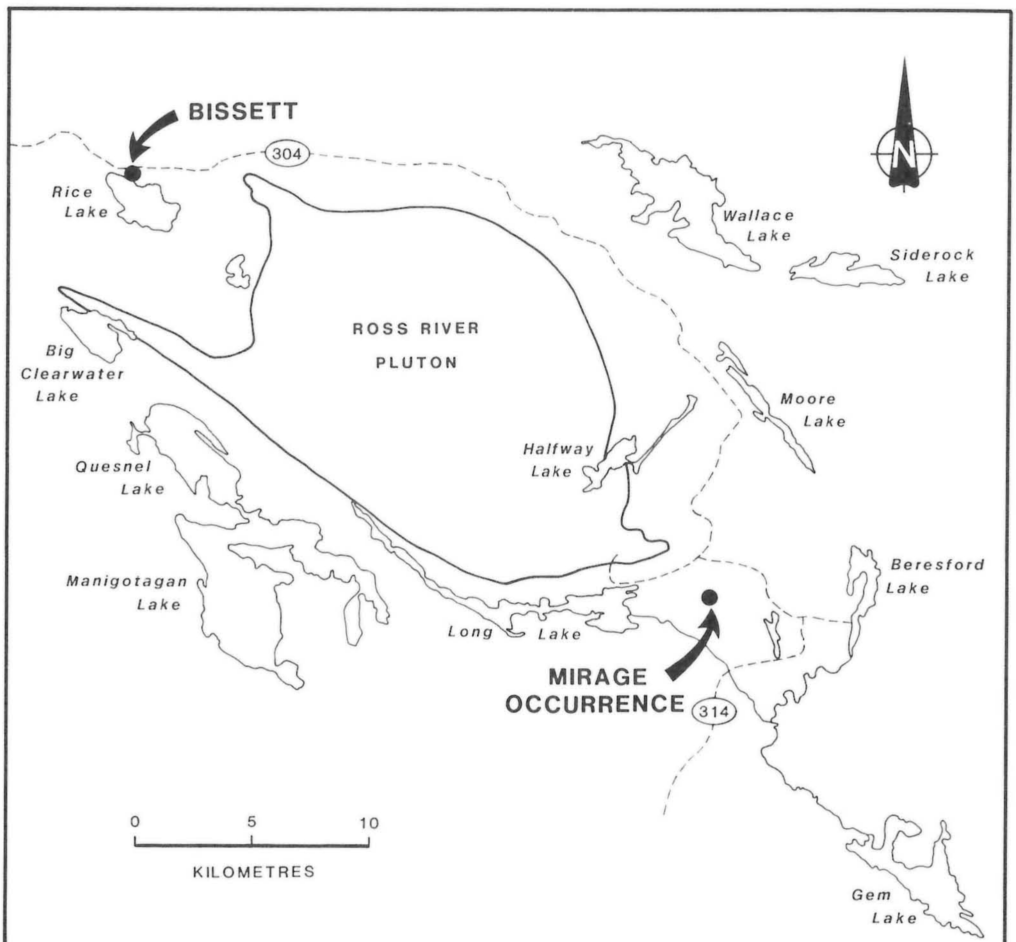

Figure GS-30-2: Sketch map showing the location of the Mirage gold occurrence (Rice Lake greenstone belt).

GS-31 TILL GEOCHEMISTRY IN NORTHERN MANTIOBA

by E. Nielsen and G. Gobert

Till sampling in the Darrol Lake area, south of Ruttan Mine, conducted in 1987 (Nielsen, 1987) was extended to the northeast to better determine the potential for gold mineralization in the area. In addition, a new till sampling program was initiated south of Kississing Lake, northeast of Flin Flon, as follow-up to the discovery of elevated copper and arsenic concentrations in till samples from that area (Kaszycki, pers. comm. 1988).

DARROL LAKE

The 23 overburden (4 littoral sand and 19 till) samples collected in 1987 were complemented by an additional 24 till samples collected this past summer (Fig. GS-31-1).

The results of visible gold grain counts on all 47 samples are shown in Figure GS-31-2. Twenty-eight gold grains were found in 18 of the 47 samples. With the exception of two delicate grains, all the gold grains are abraded indicating significant glacial transport from outside the sampling area. This conclusion is substantiated by the 'patchy' gold concentrations determined geochemically on the heavy mineral fraction (Fig. GS-31-3).

The abraded gold grains and the patchy distribution of visible gold and geochemical anomalies suggest the gold in these till samples is only background gold derived from extensive glacial erosion of volcanic and sedimentary rocks in the up-ice direction (Averill, 1988).

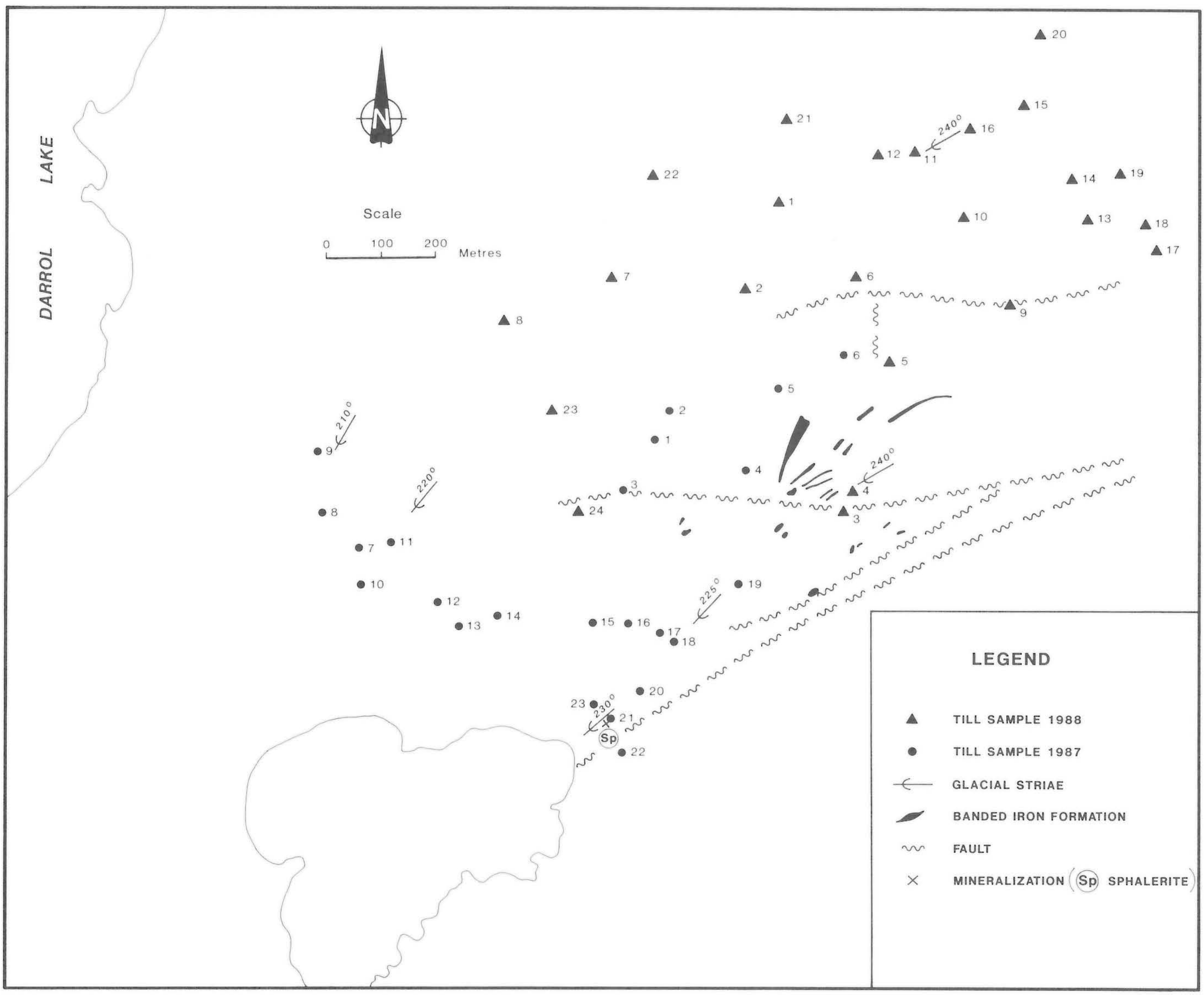

Figure GS-31-1: Till samples sites in the Darroll Lake area.

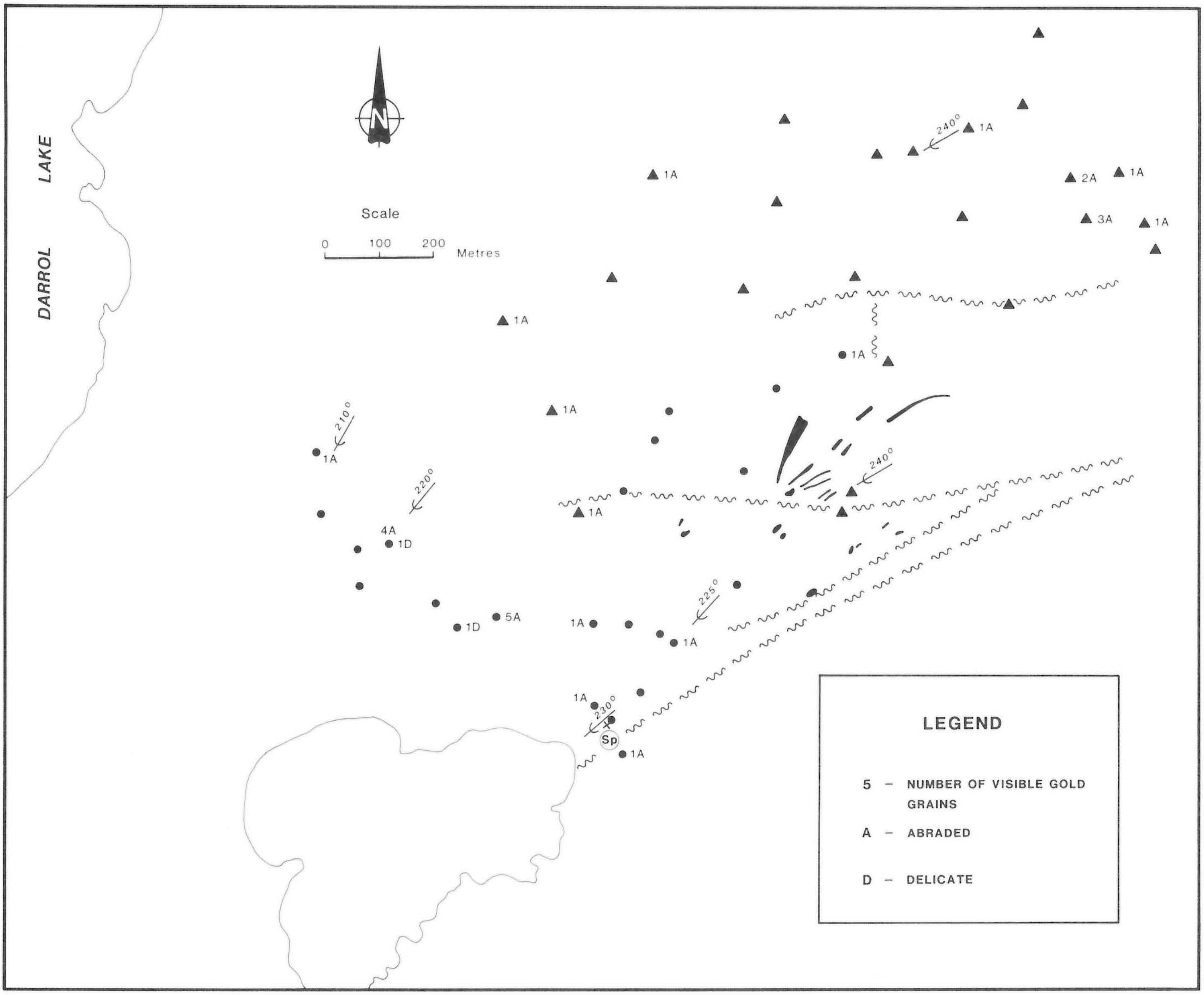

Figure GS-31-2: Distribution and characteristics of visible gold grains in the Darrol Lake area.

KISSISSING LAKE

A total of 50 till samples were collected along road traverses in the Deep South Bay-Duval Lake area, (Fig. GS-31-4), as follow-up to the multi-sample copper-arsenic anomaly mapped south of Kississing Lake by Kaszycki (pers. comm. 1988).

Of the 50 till samples collected, 26 samples contain a total of 59 visible gold grains. Except for five delicate grains the gold grains are all abraded indicating they have undergone extended glacial transport (Fig. GS-31-5).

Gold concentrations in the heavy mineral fraction range between values below the detection limit (5 ppb) to a high of 1676 ppb (Fig. GS-31-6).

Although the abraded nature and the widely scattered distribution of gold grains suggest this is background gold, they also indicate the potential for gold mineralization in the up-ice direction in the Kisseynew gneiss belt.

RECOMMENDATIONS:

Although till is thin or absent over the ridges east of Darrol Lake and Lake Agassiz clay and swamp is common in the low-lying areas, there are generally few bedrock outcrops. These conditions do not favour till sampling; humus or biogeochemical sampling might prove more rewarding.

South of Kississing Lake, shallow till is widespread above an elevation of about 320 m (1050 ft.) and may easily be sampled in hand-dug pits. Below approximately 320 m Lake Agassiz clay is common and till sampling may require a backhoe or a drill. However, as much of the Kisseynew area is above an elevation of 320 m, till sampling from shallow hand-dug holes is considered a viable method of determining mineral potential.

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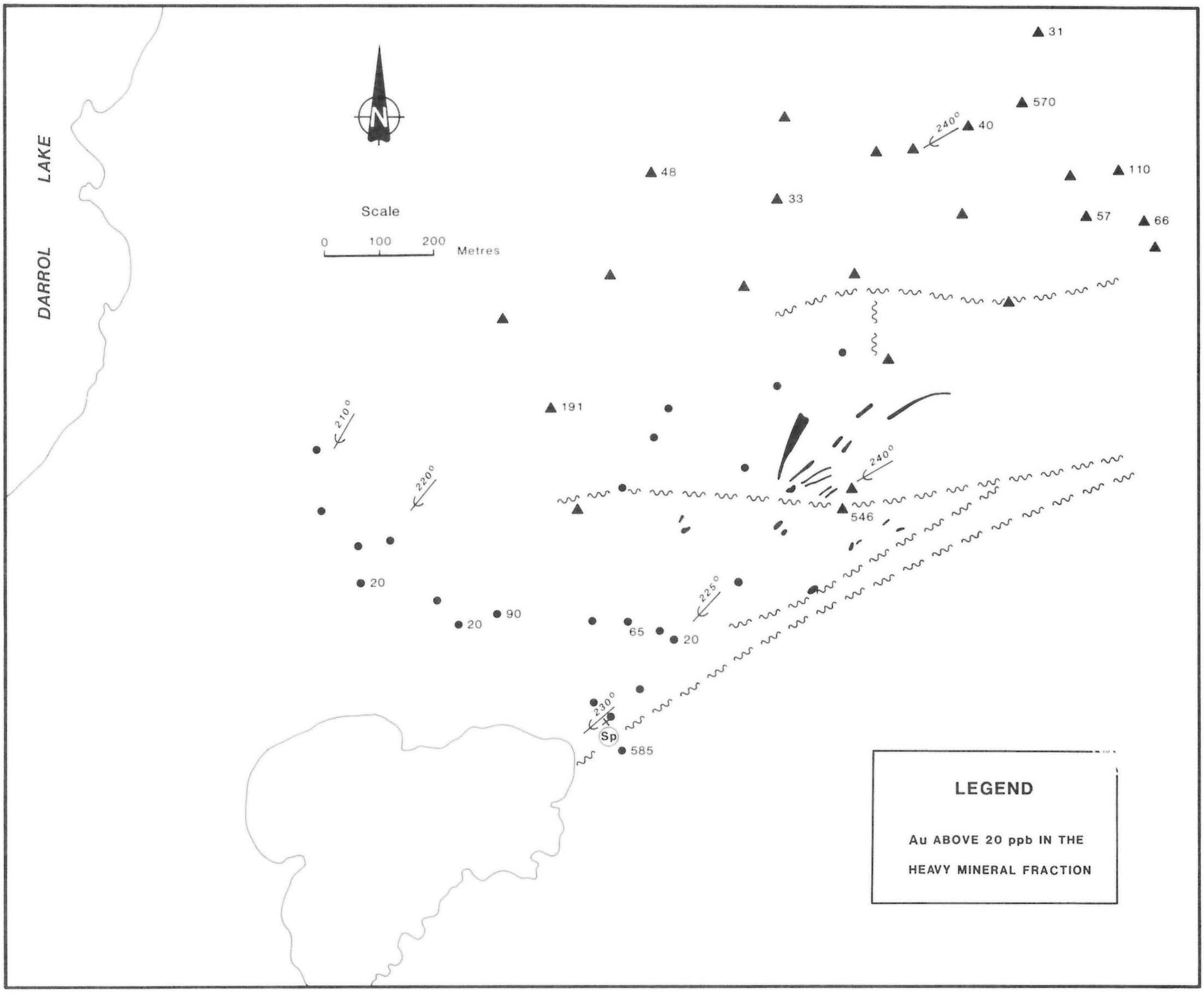


Figure GS-31-3: *Gold concentrations in the heavy mineral fraction (S.G. >2.96) above 20 ppb.*

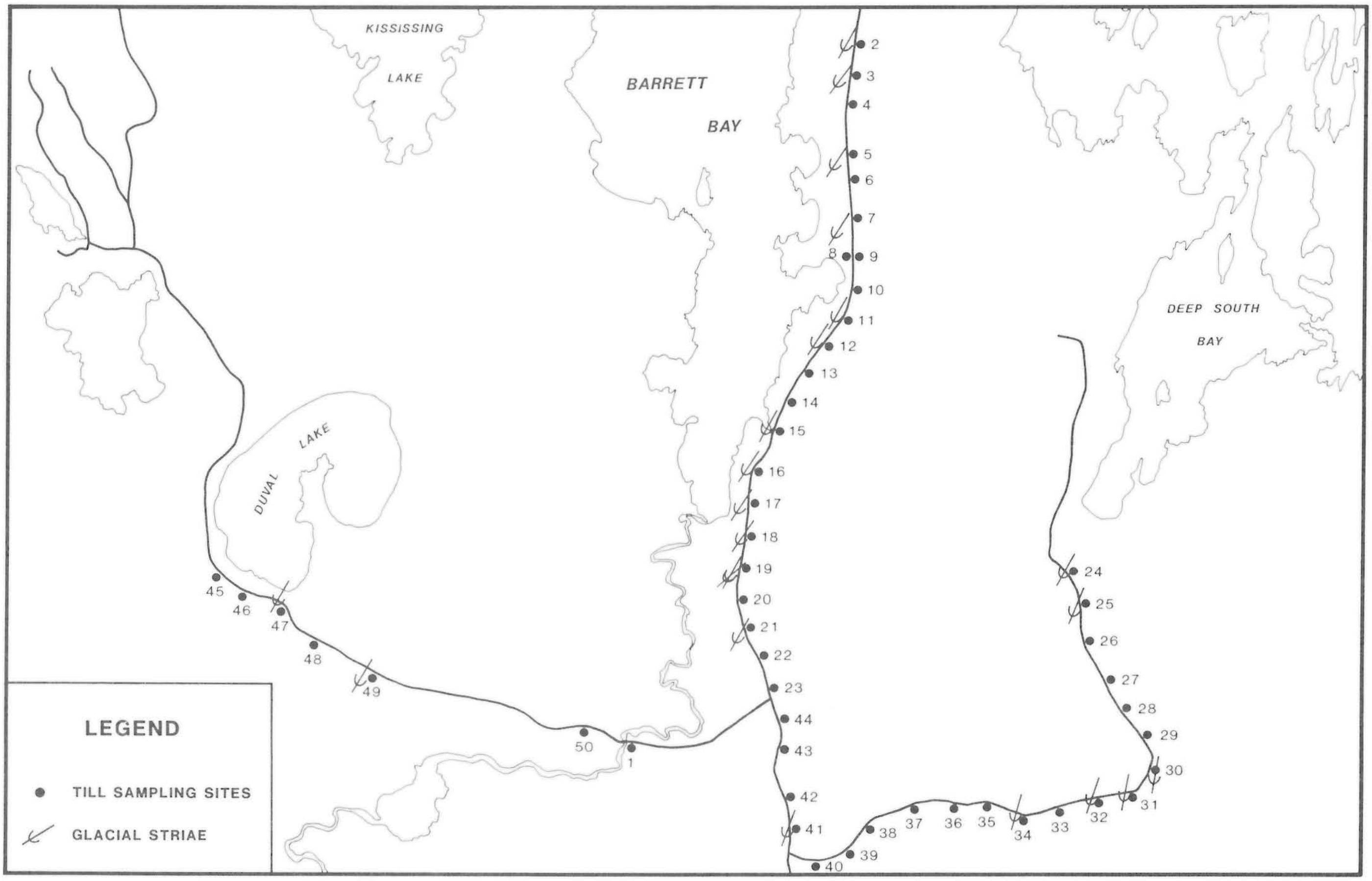


Figure GS-31-4: *Till sampling sites in the Deep South Bay — Duval Lake area.*

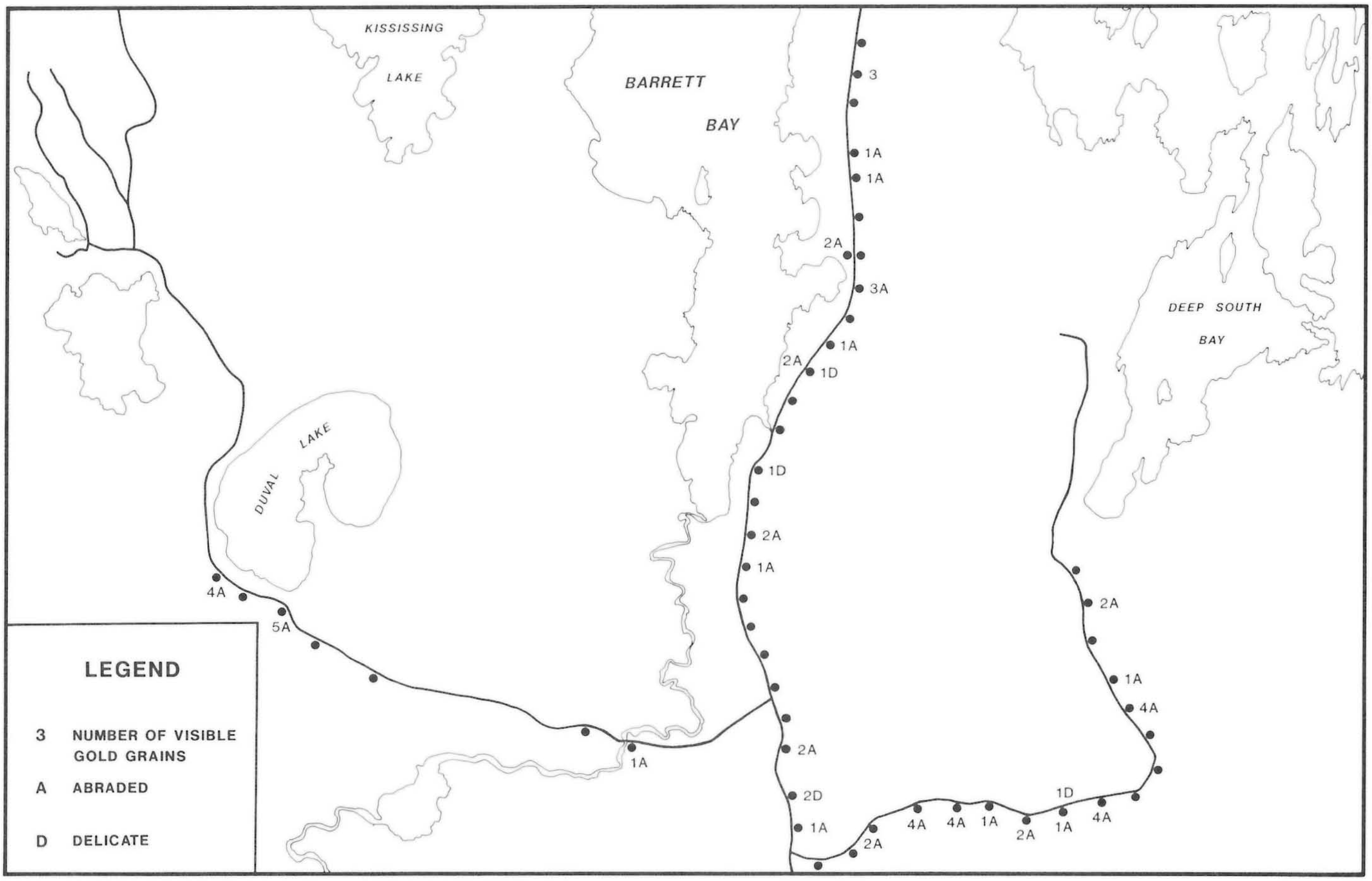


Figure GS-31-5: *Distribution and characteristics of visible gold grains in the Deep South Bay — Duval Lake area.*

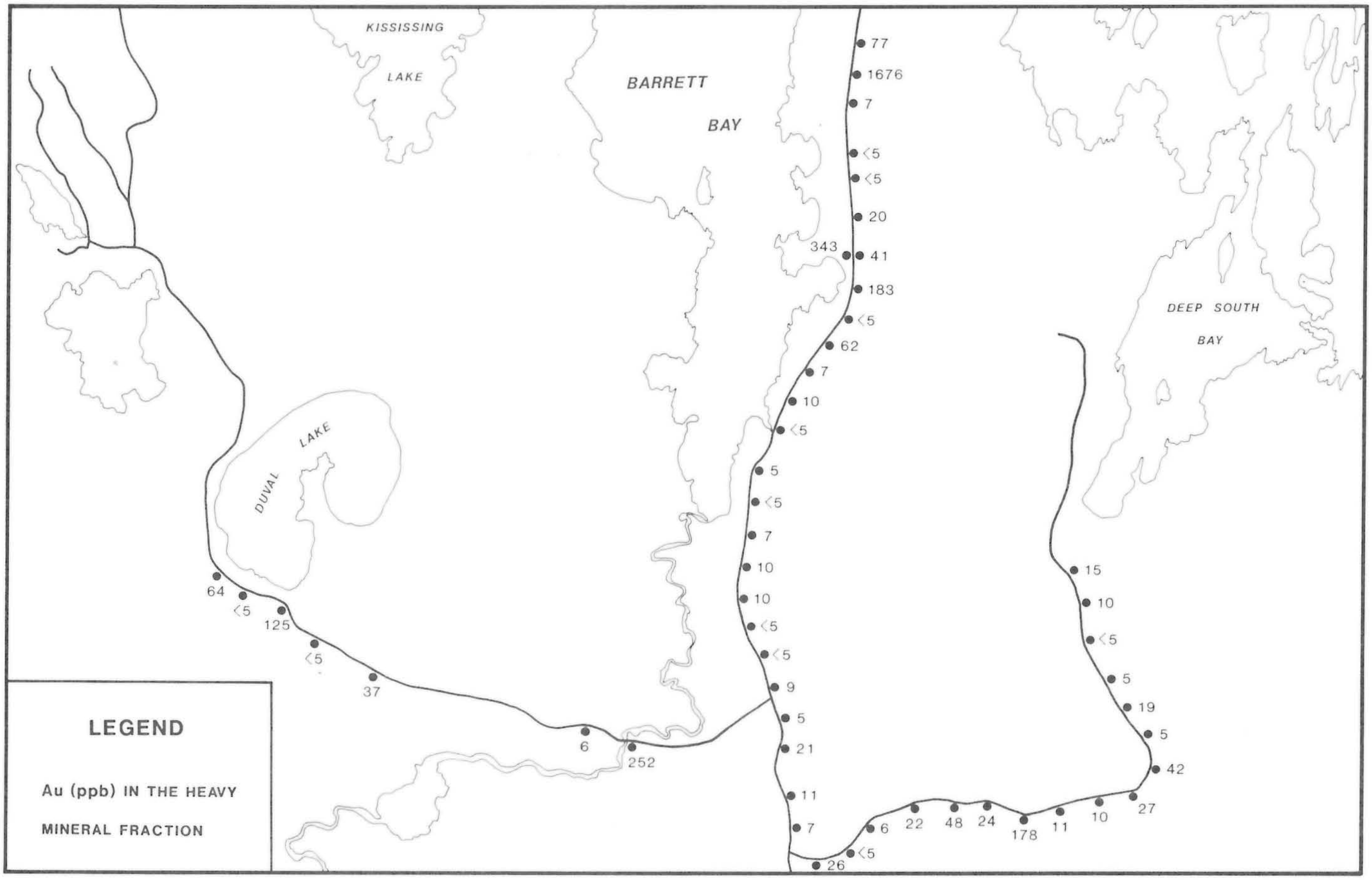
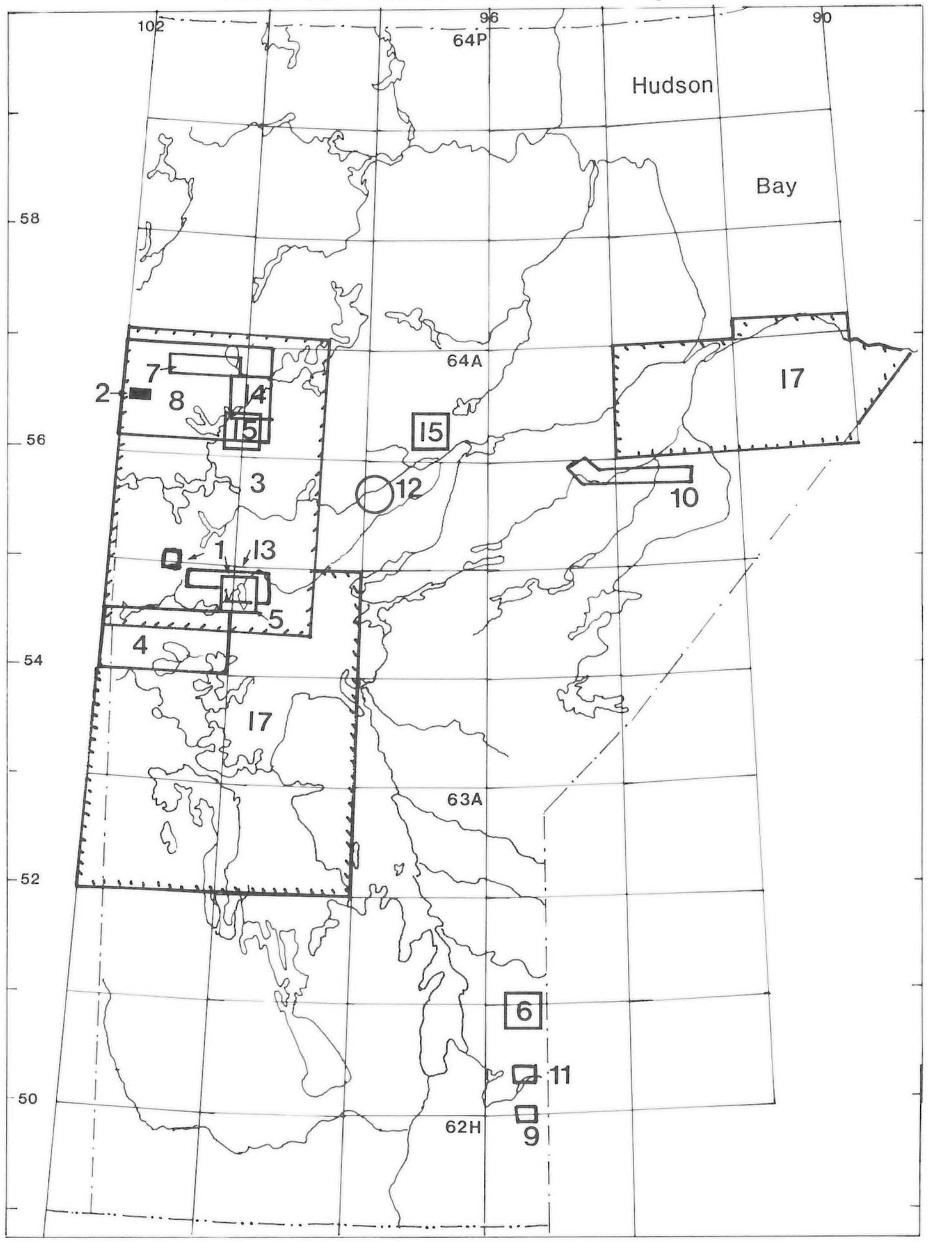


Figure GS-31-6: *Gold concentrations in the heavy mineral fraction (S.G. >2.96).*

FEDERAL MDA GEOSCIENCE PROGRAMS IN MANITOBA 1988-89

1988-89 Federal Geoscience Projects



1. Mineralized Alteration Zones (C.1.1.1)
2. Metamorphism: Lynn Lake (C.1.1.2)
3. Churchill Province Geochronology (C.1.1.3)
4. Sub-Phanerozoic Geology (C.1.2.1)
5. Flin Flon-Snow Lake Metallogeny (C.2.1.1)
6. Bissett Gold Study (C.2.1.2)
7. Agassiz Remote Sensing (C.2.1.3)
8. Churchill Mafic-Ultramafic Metallogeny (C.2.2.2)
9. Falcon Lake Study (C.2.2.3)
10. Fox River Sill (C.2.2.4)
11. Bird River Sill (C.2.2.5)
12. Thompson Structural Study (C.2.2.6)
13. Aeromagnetic Gradiometer (C.3.1.1)
14. Regional Lake Sediment and Water Geochemistry (C.4.1.1)
15. Drift Prospecting (C.4.1.2)
16. Surficial Geology Compilation (C.5.1.1)

Figure GSC-1: Location of Geological Survey of Canada field projects, 1988.

PROGRESS REPORT

by A.G. Galley

The 1988-89 fiscal year is the fifth and final of the 1984-89 Canada-Manitoba Mineral Development Agreement. For most of the project officers involved in the Agreement, this year is being taken up primarily by report preparation. In order to speed up the publication of the results of the various projects, most reports will first be brought out by March, 1989 as GSC open files. This will allow for quick dissemination of data and models derived from the five year program. Final reports will be published in the following year. In order to keep abreast of the upcoming publication of these open files and maps, it is suggested that interested parties request monthly GSC publication circulars be sent to them. These circulars are free, and adding your name to the circulation list merely requires a phone call to the GSC Publications Outlet. These monthly publication circulars list both GSC publications and papers that GSC personnel have published in outside journals, and include order forms for purchase of the internal publications. Copies of papers from outside journals can be obtained by writing to the author.

Geological Survey of Canada MDA projects were completed in the Lynn Lake-Rusty Lake, Flin Flon-Snow Lake, Thompson, Northeastern and Southeastern Superior regions. An airborne EM survey was completed under contract to Geoterrex in the Lynn Lake region, with the results to be published in the spring of 1989. Also in the Lynn Lake area, a study was completed evaluating the use of remotely-sensed data, in conjunction with geophysics and geochemistry, in detecting areas of high precious metal potential. Detailed lake water and sediment surveys and interpretive studies were completed over part of the Lynn Lake-Rusty Lake greenstone belt, with results outlining prospective areas for base and precious metal mineralization. Detailed drift prospecting programs for gold were continued in the Darrol Lake and Wheatcroft Lake regions.

In the Flin Flon-Snow Lake region, studies were completed on alteration associated with massive sulphide deposits and on the regional and detailed structural control of gold mineralization. Additional U-Pb data have assisted in reconstructing the geologic history of the Early Proterozoic rocks of this region. An airborne gradiometer survey was flown over portions of the belt between File and Wekusko lakes, completing coverage of the Manitoba portion of the belt.

In the Thompson region, field work was completed on the deformational history of the Thompson nickel deposits, a portion of which was done in cooperation with the Manitoba Geological Services Branch. In northeastern Manitoba, PGE studies on the Fox River Sill continued, with stratigraphic correlation being assisted through the interpretation of detailed geophysical surveys. Field checking was completed for the construction of 1:250 000 scale surficial geology maps north of the 52nd parallel. The lake sediment and water regional geochemical survey was published for east-central areas of the province.

In southeastern Manitoba, projects concerning the metallogeny of mafic-ultramafic intrusions were completed in the Bird River (chrome-PGE) and Falcon Lake (gold) areas. Gold-related structural and alteration studies of the region around the San Antonio Mine were completed, and structural studies around the Gunnar, Central Manitoba and Oro Grande gold deposits were continued. A cooperative GSC/GSB Quaternary project concerning gold in tills was continued in the Manigotagan region.

ABSTRACTS

GSC-1 Metamorphosed Alteration Zones (Project C.1.1.1) by E. Froese

E. Froese continued studies on the synvolcanic, massive sulphide-related alteration zones at Cook Lake and Wolverton Lake, near Snow Lake, Manitoba. Petrographic work is being complemented by electron probe analysis. This study will further define the relationship of the zonation within the alteration, and its relationship to base metal deposits. E. Zaleski is continuing her doctoral study at the University of Manitoba of the Linda massive sulphide zone near Snow Lake. Detailed investigations of the relationship between the sulphide lens and related footwall alteration zones, and of the sequence of deformation affecting these rocks, has contributed to the understanding of the region's complex structural and metamorphic history. Another alteration study is being completed by M. Leroux for a Master's degree at the University of Manitoba. The study is on garnet-anthophyllite rocks of the Star Lake area near Sherridon.

E. Froese and K. Ashton visited selected occurrences of altered rocks in the Sherridon area. The Sherridon Group at Sherridon, including carbonate and Fe-Mg amphibole-bearing rocks, were compared with a very similar sequence at Wildnest Lake, Saskatchewan. Because this sequence, according to work by K.E. Ashton, can be traced into Amisk Group rocks of the Flin Flon volcanic belt, some doubt is cast on the previously suggested correlation of Sherridon Group with Missi Group. The possibility should be considered that the sulphide deposits and altered rocks of the Sherridon Group are of Amisk age.

GSC-2 Geochronology in the Churchill Province (Project C.1.1.3) by T.M. Gordon

This Geological Survey of Canada — Manitoba Energy and Mines joint project was designed to: 1) establish the absolute timing of regional scale geological events in the Lynn Lake, Rusty Lake, Kisseynew, Flin Flon belts; and 2) provide controls for local stratigraphic and structural studies. Results of the first phase are published and in press, and are summarized in Figure GSC-2-1 and Table GSC-2-1. Work on particular problems is continuing.

Volcanic rocks in the Lynn Lake and Flin Flon belts were deposited at ca. 1900 Ma. (Fig. GSC-2-1a). The Cliff Lake pluton and Richard Lake tonalite are similar in age to the Amisk Group at Flin Flon suggesting that they were subvolcanic and hence possible heat sources for local

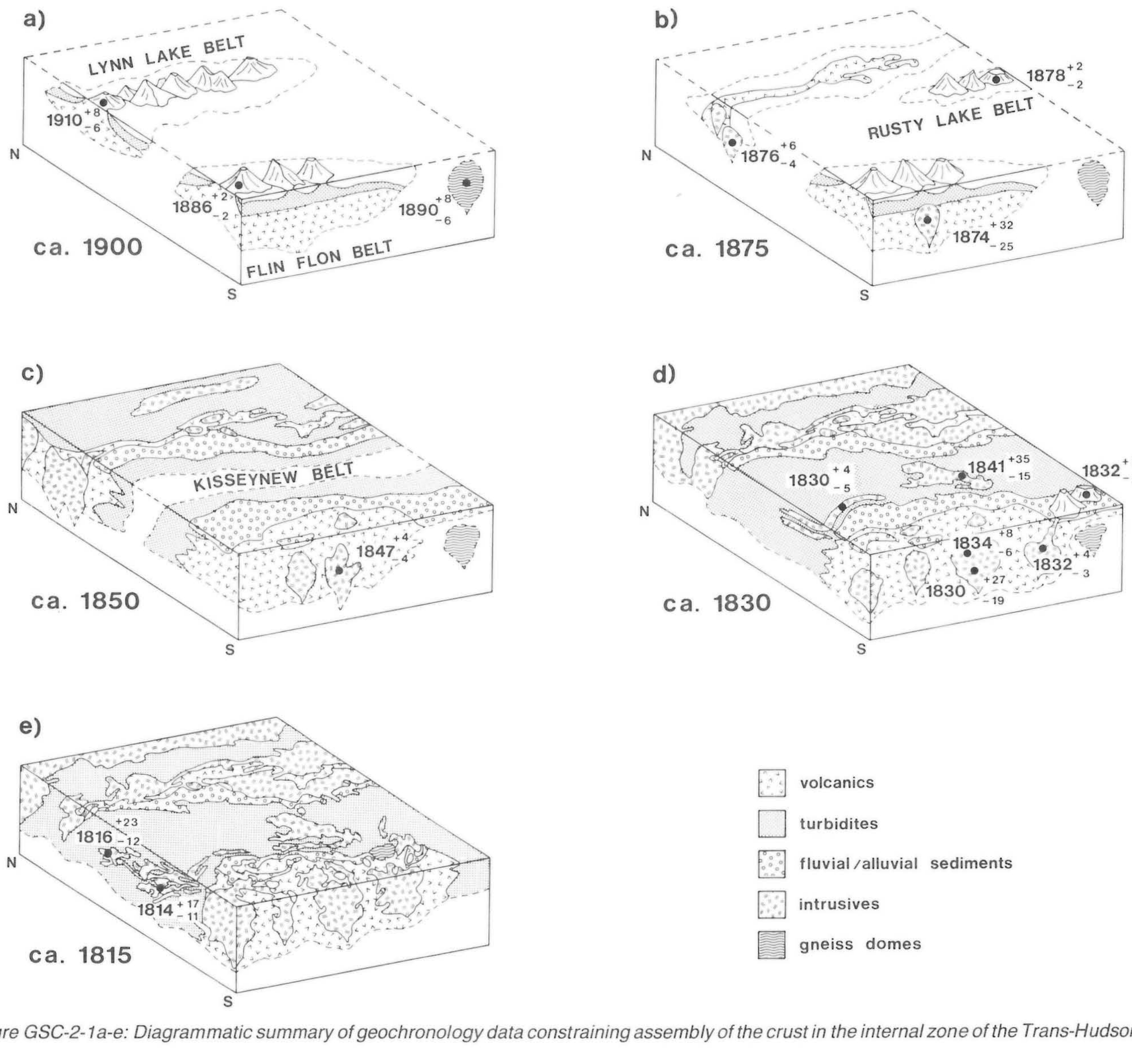


Figure GSC-2-1a-e: Diagrammatic summary of geochronology data constraining assembly of the crust in the internal zone of the Trans-Hudson Orogen.

TABLE GSC-2-1
SUMMARY OF GEOCHRONOLOGY RESULTS FROM THE CHURCHILL PROVINCE.

Unit, Localtiy	U-pb Age(s) (Ma)	Significance	References
		LYNN LAKE BELT	
Lynn Lake rhyolite, Wasekwan Group, Frances Lake	1915 +7/-6, 1910 +15/-10	from oldest sequence	Baldwin et al., 1987
Quartz diorite, pre-Sickle intrustions, Hughes Lake	1876 +8/-7	cuts folded Wasekwan, pre-Sickle	Baldwin et al., 1987
Tonalite, pre-Sickle intrusions, Norrie Lake	1876 +8/-6	cuts folded Wasekwan, pre-Sickle	Baldwin et al., 1987
		RUSTY LAKE BELT	
Rhyolite, Karsakuwigamak block, winter road	1878 +3/-3, 1874 +8/-7	from oldest sequence top of section	Baldwin et al., 1987
		FLIN FLON BELT	
Rhyolite crystal tuff, Amisk Group, Bear Lake fault block	1886 +2/-2	from oldest sequence	Syme et al., 1987; Gordon et al., 1987, in press
Cliff Lake pluton, Cliff Lake	1874 +32/-25	subvolcanic	Gordon et al., 1987, in press
Richard Lake tonalite, Snow Lake	1889 +8/-6	subvolcanic	Bailes et al., 1988
Lynx Lake pluton, Athapapuskow Lake	1847 +4/-4	cuts folded Amisk, faulted	Syme et al., 1987; Gordon et al., 1987, in press
Central plutonic complex, Cormorant Lake	1845 +10/-8	major intrusion	Blair et al., 1988
Ham Lake pluton, File Lake	1830 +27/-19	postdates D1, predates D2 and metamorphism	Gordon et al., 1987, in press
Chickadee rhyolite, Missi Group, Herb Lake	1832 +2/-2	youngest precrustal rocks, predates D1	Gordon et al., 1987, in press
Rex Lake plutonic complex, Wekusko Lake	1832 +4/-3	predates D2	Gordon et al., 1987, in press
Wekusko granite, Highway 392	1834 +8/-6	postdates D2?	Gordon et al., 1987, in press
		KISSEYNEW BELT	
Herblet Lake gneiss dome, Herblet Lake	1890 +8/-6	correlates with Amisk Group	Gordon et al., 1987, in press
Enderbite, File River	1830 +11/-5	oldest intrusions, predates metamorphism	Gordon et al., 1987, in press
Tonalite, Highrock Lake	1841 +35/-15	postdates enderbite, predates granodiorite	Gordon et al., 1987, in press
Granodiorite, Burntwood Lake	1814 +17/-11	anatectic, predates granite	Gordon et al., 1987, in press
Granite, Burntwood Lake	1816 +23/-12	anatectic, peak metamorphism	Gordon et al., 1987, in press

hydrothermal systems. The age of orthogneiss in the Herblet Lake gneiss dome supports the interpretation that the southern flank of the Kisseynew gneiss belt is a metamorphosed extension of the Flin Flon belt.

At ca. 1875 Ma. (Fig. GSC-2-1b) pre-Sickle granitoid rocks intruded the isoclinally folded Wasekwan Group in the Lynn Lake belt. Rhyolite in the Karsakuwigamak block in the Rusty Lake belt is comparable in age to these intrusions, demonstrating that the two volcanic belts have separate histories.

From ca. 1860-1845 Ma. (Fig. GSC-2-1c) widespread plutonism produced the Wathaman-Chipewyan batholith as well as the Lynn Lake pluton on Athapapuskow Lake, and the large central public complex in the Cormorant Lake area. Recent GSC work in Saskatchewan (Delaney et al., in process) shows that the uplift and erosion of the plutons resulted in the deposition of the Ourom Lake arkose near the end of this time period at 1850 $\pm$ 1 Ma.

Sills in the Kisseynew belt were emplaced at 1830 Ma, essentially synchronous with plutonism and Missi Group volcanism in the Snow Lake area (Fig. GSC-2-1d). the Missi Group age is significantly different from that of the Ourom Lake arkose, demonstrating that the various "arkose" sequences in the Churchill province cannot be considered time-equivalent.

The timing of regional metamorphism is established by the ages of anatectic rocks in the central Kisseynew belt at ca. 1815 Ma (Fig. GSC-2-1e). Metamorphism affects the Missi Group and postdates most folding, constraining the two major periods of deformation observed in the Flin Flon belt to 1830-1815 Ma.

The latest movement on northwest to northeast-trending faults juxtaposes rocks of different metamorphic grade, hence must be post-1815 Ma.

GSC-3 Project Cormorant: Interpretation of Sub-Paleozoic Geology South of Flin Flon-Snow Lake (Project C.1.2.1) by J.B. Dugal

The Geological Survey of Canada conducted a winter drilling project in the Clearwater — Moose Lakes area (Fig. GSC-3-1) to obtain information on Precambrian rocks occurring 86 to 100 m beneath a cover of overburden and Paleozoic dolomite and sandstone. The data, combined with information obtained from previous projects and aeromagnetic vertical gradient and total field surveys, will be used to compile a 1:250 000 scale map of the sub-Paleozoic geology of the Cormorant map sheet (NTS 63K).

Seven vertical AQ boreholes, totalling 762 m were drilled by the project in different magnetic domains as interpreted by Blair et al., (1988) from aeromagnetic total field surveys. Four of the holes were successfully drilled into Precambrian rocks. The remaining holes failed to penetrate the unstable sandstone formation at the base of the Paleozoic cover, or the upper sections of the Precambrian rocks, which are highly weathered in the study area. Geological logs (Table GSC-3-1) and a record of magnetic susceptibility measurements for the various rock types were produced to assist in the interpretation of the aeromagnetic surveys.

In June 1988, the core from 65 Manitoba Energy and Mines and 8 Geological Survey of Canada boreholes drilled in the Cormorant Lake area were re-examined. Magnetic susceptibility values for each rock and dip measurements for planar lithological features were recorded.

Recent aeromagnetic vertical gradient and total field surveys have been completed for most of the Project Cormorant area (NTS 63K) under the Federal/Provincial Northlands and Interim Agreements and as part of a 1984-89 Canada-Manitoba Mineral Development Agreement. A list of the areas covered and the date/projected dates of release are presented in Table GSC-3-2.

GSC-4 Flin Flon-Snow Lake Metallogeny (Project C.2.1.1) by A.G. Galley

The major portion of this fiscal year has been spent preparing the preliminary manuscript of the gold metallogeny of the southern Churchill Province, to be open filed by March 1989. This will include the results of studies of gold deposits and occurrences in the Snow Lake-Wekusko Lake and Elbow Lake regions. A third study completed in the Flin Flon belt was in the Phantom Lake area, Saskatchewan.

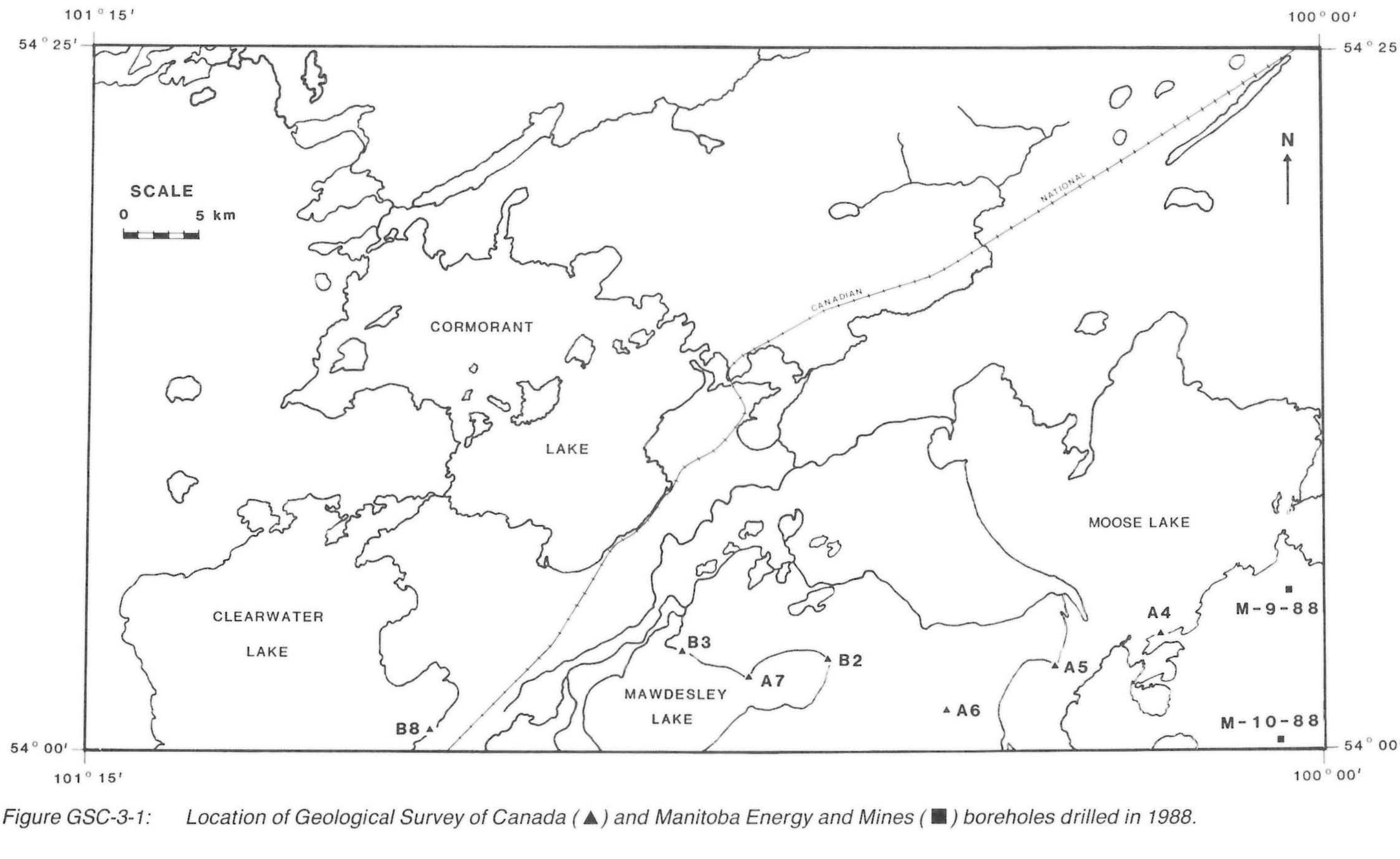


Figure GSC-3-1: Location of Geological Survey of Canada (▲) and Manitoba Energy and Mines (■) boreholes drilled in 1988.

TABLE GSC-3-1
1988 DRILL CORE DESCRIPTIONS

G.S.C.-A4

Depth (m)	Lithology
0.00-85.53	Calcareous dolomite.
85.53-87.71	Calcareous sandstone.
87.71-88.10	Argillaceous dolomitic sandstone.
88.10-91.15	Dolomitic sandstone/sandstone. Very poorly consolidated to unconsolidated.
91.15 (EOH)	Hole abandoned in unconsolidated sandstone.

G.S.C.-A5

Depth (m)	Lithology
0.00-16.35	Overburden.
16.35-86.17	Calcareous dolomite.
86.17-86.65	Calcareous sandstone.
86.65-96.54	Zone of core loss. Recovered 10 cm of highly weathered argillaceous (kaolinite) sandstone.
96.54-96.70	Highly weathered quartz-clay-rich gneiss. Dip of gneissosity 48-55°.
96.70 (EOH)	Hole abandoned due to continuous caving in the unconsolidated sandstone formation.

G.S.C.-A6

Depth (m)	Lithology
0.00-2.90	Overburden.
2.90-91.65	Calcareous dolomite.
91.65-99.00	Calcareous sandstone. The lower 6 m of core was not recovered.
99.00-99.44	Moderately to highly weathered gabbro/diorite.
99.44-129.95	Medium grained gabbro/diorite with several sections of fine grained gabbro. Several granitic and feldspar-rich dykes ($<$ 2 cm wide) cut the core at 40-60° to the core axis. The unit is weakly to moderately magnetic. Several small patches contain up to 15% magnetite.
129.95 (EOH)	

G.S.C.-A7

Depth (m)	Lithology
0.00-34.85	Overburden.
34.85-86.45	Calcareous dolomite.
86.45-87.20	Calcareous sandstone.
87.20-93.55	Zone of core loss. Recovered 22 cm of highly weathered argillaceous sandstone.
93.55-94.45	Highly weathered reddish brown argillaceous gneiss.
94.45-95.36	Moderately to highly altered argillaceous gneiss.
95.36-106.00	Medium grained mesocratic biotite-hornblende gneiss. Dip of gneissosity: 55-70°.
106.00 (EOH)	

G.S.C.-B2

Depth (m)	Lithology
0.00-24.00	Overburden.
24.00-89.86	Calcareous dolomite.
89.86-90.58	Calcareous sandstone.
90.58-96.55	Zone of core loss.
96.55-97.80	Highly weathered argillaceous sandstone. 84 cm core loss.
97.80-99.15	Highly to moderately weathered feldspar porphyry. Matrix consists of pyrite (15%) and quartz.
99.15-99.40	Medium grained granitic dyke.
99.40-102.50	Highly to moderatley altered chloritized argillaceous fine grained mesocratic gneiss.
102.50-116.83	Fine grained mesocratic biotite-amphibole gneiss. Dip of gneissosity: 50-70°. Weakly to moderately magnetic from 108.80 to 115.60 m.
116.83-117.90	Medium grained granitic gneiss. Dip of gneissosity: 48-50°.
117.90 (EOH)	

G.S.C.-B3

Depth (m)	Lithology
0.00-28.35	Overburden.
28.35-79.17	Calcareous sandstone.
79.17- 86.05	Zone of core loss. Recovered 20 cm of loose sand.
86.05-90.65	Highly to moderately altered medium grained granitic gneiss. Gneissosity dips from 68° at the top of the unit to 20° in the lower sections. Several coarse grained granitic dykes cut the core at 25-30° to the core axis. A few pyrite-rich dykes ($<$ 2 cm wide) cut the core at 45° to the core axis. The lower 2 cm is mafic rich consisting of mainly biotite and chlorite.
90.65 (EOH)	

G.S.C.-B8

Depth (m)	Lithology
0.00-1.50	Overburden.
1.50-98.00	Dolomite.
98.00-99.65	Calcareous sandstone/sandstone.
99.65-100.55	White highly weathered and friable argillaceous (kaolinite) Precambrian material.
100.55-103.85	Green to yellowish green, highly weathered medium grained amphibolite. Core loss of 1.45 m.
103.85-106.20	Medium grained amphibolite.
106.20-106.95	Medium grained hornblende tonalite gneiss.
106.95-111.02	Medium grained amphibolite. Lithium muscovite pegmatites occur at 107.20-107.32 and 108.33-108.68 m. Several thin quartz veins also crosscut the amphibolite.
111.02-112.10	Medium grained hornblende tonalite gneiss. Dip of gneissosity: 25°.
112.10-113.42	Medium grained hornblende tonalite gneiss with 2-3% garnet.
113.42-113.82	Quartz-feldspar pegmatite.
113.82-117.57	Mainly medium grained amphibolite with sections of medium grained tonalite gneiss.
117.57-121.55	Medium grained hornblende tonalite gneiss with 2-3% garnet.
121.55-125.35	Medium grained hornblende tonalite to diorite gneiss. Dip of gneissosity: 20-30°. A lithium muscovite pegmatite occurs from 122.75 to 122.85 m.
125.35-130.15	Medium grained hornblende tonalite gneiss with 2-3% garnet. A lithium muscovite pegmatite occurs at 129.55-129.85 m.
130.15 (EOH)	

TABLE GSC-3-2
AEROMAGNETIC VERTICAL GRADIENT AND TOTAL FIELD SURVEYS IN THE PROJECT CORMORANT AREA

Area	Survey Operations	Published/Released	
Yawningstone Lake	1980-1982	1983	
Iskwasum Lake	1980-1982	1983	
Egg Lake	1980-1982	1983	
Cranberry Portage	1980-1982	1983	
Naosap Lake	1980-1982	1983	1:50 000
Goose Lake	1980-1982	1983	colour compilations
Schist Lake	1980-1982	1983	
Flin Flon	1980-1982	1983	
McClarty Lake	1982	1984	
Reed Lake	1982	1984	
Nokomis Sherridon	1985	1987	1:20 000. Black and white contour maps. The
Flin Flon and Root Lake area (Namew Lake)	1985	1987	1:50 000 colour compilations are scheduled for release in Nov.-Dec. 1988.
Moose Lake North	1985		The 1:20 000 black and white contour maps are scheduled
Moose Lake South	1986		for release in Oct.-Nov. 1988. The 1:50 000 colour comp-
Elbow Lake	1986		ilations are scheduled for release in Nov.-Dec. 1988.

The investigations in the Snow Lake area included the completion of a 1:5000 scale map of the area centred on the Nor Acme Mine (GSC Open File 1700), and a detailed study of the alteration associated with this deposit. A constructed down-plunge projection of the area supports the hypothesis that the faults containing the major gold occurrences in the area originally formed as listric, or splay faults off the McLeod Road Thrust Fault. Gold mineralization was emplaced during late reactivation of these faults, which took place during or after the "Threehouse Phase" of folding. The plunge of the gold zones parallels the stong F1 downdip mineral lineation and clast elongation that is characteristic of the rocks in the Snow Lake region. Whereas at Snow Lake, this involves a moderate plunge to the northeast, north of the town the plunge of the F1 lineation and that of gold zones such as Zennco's Squall Lake Zone and Snow Lake Mines Birch Lake Zone shallows aprroaching the Squall Lake and Herblet Lake gneiss domes. The association of gold mineralization with other faults in the region, such as the Berry Creek and Crowduck Bay, also supports the role of major lineaments in the deposition of gold.

Five weeks was spent mapping a portion of the open pit exposing the Chisel Lake massive sulphide deposit. One week of this period involved cooperative mapping with Al Bailes of the Manitoba Geological Services Branch.

GSC-5 Structural and Alteration Studies, Bissett Area (Project C.2.1.2) by K.H. Poulsen

During the 1988 season four components of the project were advanced:

1) Rex Brommecker, supervised by K.H. Poulsen and C.J. Hodgson, completed 1:2500 scale mapping in the vicinity of the Gunnar Mine. The mapping emphasized structural relationships which will be further analyzed as part of an M.Sc. thesis at Queen's University. A preliminary analysis of the data shows that at least three generations of structures are recorded in the rocks of this area.
   - D_1: cleavage and local folds oriented subparallel to primary layering
   - D_2: strongly developed northwest-striking cleavage axial planar to large upright folds
   - D_3: crenulation and kink bands oriented approximately east-northeast.

2) L. Diamond, Carleton University, continued his study of fluid inclusions and carbonate alteration in the San Antonio and Gunnar areas. Vein quartz containing high proportions of CO_2 was identified in the field using a technique of crushing fluid inclusions. Preliminary data show that this method may be a useful, practical tool for distinguishing veins formed in auriferous, CO_2-rich environments from those that are not. L. Diamond also noted the temporal association of vein depositon and lamprophyre dyke emplacement at the Gunnar deposit: a single lamprophyre dyke cuts one quartz vein but in turn is cut by another vein.

3) A team of visiting scientists from the People's Republic of China participated in three weeks field work at the Central Manitoba and Oro Grande gold deposits. Mapping at 1:1000 scale revealed that the Wadhope gabbro is texturally and compositonally layered, and is subdivisible into basal equigranular mafic gabbro and upper granophyric and pegmatoid layers, with minor modal quartz; fractures, shear zones and veins are developed to the greatest extent in the upper layers.

4) The study of the structure and alteration at the San Antonio Mine is near completion. D.E. Ames successfully completed an M.Sc. thesis at Carleton University, under the supervision of J.M. Franklin and E. Froese, entitled "Stratigraphy and Alteration of Gabbroic Rocks near the San Antonio Mine in the Rice Lake Area, Southeastern Manitoba". The thesis includes a 1:5000 scale geology map of the sequence hosting the gold deposit. An investigation of the variations in mineralogy and textures within the gabbro isolated the gold-bearing veins and associated alteration to the leucogabbroic portion of the sill. The presence of paragonite in the gold-related alteration has not been recognized in many other gold deposits to date. A plot of fCO_2 vs. $aK+/H+$ was useful in explaining the sequence of alteration assemblages associated with the deposit. S. Lau and W. Brisbin of the University of Manitoba completed preliminary analysis of strain in rocks adjacent to the San Antonio deposit. The data show that the rocks of this area have undergone varying proportions of flattening and stretching, with the stretching direction parallel to the overall plunge of the San Antonio deposit.

GSC-6 Agassiz Remote Sensing (Project C.2.1.3) by A.N. Rencz

The Geological Survey of Canada, under the scientific authority of A.N. Rencz, tendered a contract to Dr. Wooil Moon at University of Manitoba to investigate the application of digital data sets for the Agassiz Metallotect, Lynn Lake. Manitoba. The project concentrated on application of airborne remotely sensed data (MEIS- multi-detector electro-optical imaging scanner) and its relationship to ground-based geochemical and biogeochemical data. The project also investigated airborne geophysical data and satellite data from LANDSAT MSS.

A final report has been submitted, the content of which will be open filed by the Geological Survey of Canada.

GSC-7 Metallogeny of Mafic-Ultramafic Rocks, Flin Flon-Snow Lake (Project C.2.2.1) by R.F.J. Scoates

J. Young and L. Ayres, with the University of Manitoba, have submitted their final report on the petrology and internal stratigraphy of the Iskwasum, Mikanagan, Jackfish, Reed Lake and Chisel Lake mafic-ultramafic plutons. Analyses are still being carried out on the PGM potential of units within the Reed Lake complex.

This report will be open filed by the Geological Survey of Canada by April, 1989.

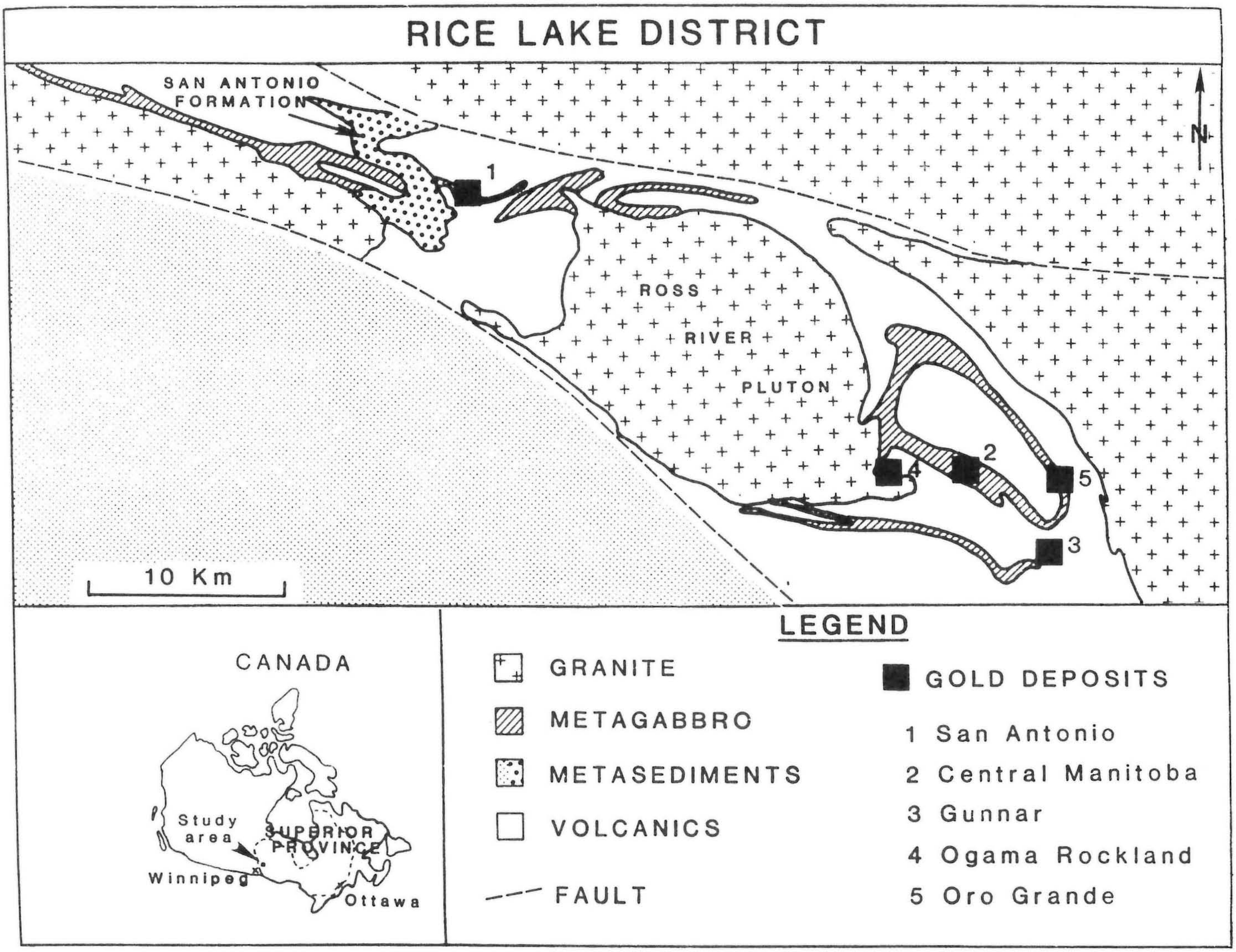


Figure GSC-5-1: Geology and gold deposits, Bissett area.

GSC-8 Metallogeny of Mafic-Ultramafic Rocks, Northern Churchill (Project C.2.2.2)
by L.J. Hulbert

Research for the period from March 31 to September 26, 1988 was confined to detailed mineralogical and geochemical studies on a number of intrusions from the Lynn Lake greenstone belt. Further detailed electron microprobe analyses have been conducted on the Fe-Ti-V mineralization and enclosing host rocks of the Tow Lake intrusion. The Fe-Ti-V mineralization occurs in the form of titaniferous magnetite and ilmenite in thick magnetite-orthopyroxene-plagioclase cumulates and magnetite cumulates. The titaniferous magnetite contains 0.58-5.2 wt. % TiO_2 and 0.86-1.40 wt. % V_2O_3 in solid solution. It was found that the lower the Ti content in solid solution the higher the corresponding vanadium content. The most important source of Ti in the samples is present in the form of ilmenite. Ilmenite was found to be the high titanium variety with values in the 51.67-52.99 wt. % TiO_2 range, with V_2O_3 contents ranging from 0.39-0.89 wt. %. Fortunately, the Cr_2O_3 contents of the associated Ti-magnetite is low, 0.0-0.20 wt. %, a metallurgically desirable feature of exploitable Fe-Ti-V oxide mineralization. The surrounding rock contains plagioclase that ranges from An (53-47) and orthopyroxene from En (65-61). Reaction olivine, forming between orthopyroxene and magnetite, was found to have a compositional range of forsterite (57.5-55). These chemical features suggest that this Fe-Ti-V-rich oxide layer is very similar to the magnetite layers in the basal portion of the Upper Zone of the Bushveld Complex. The main magnetite layer is exploited for V, Fe and Ti.

Detailed sampling for Pt, Pd, Au and Rh analyses across the width of the intrusion indicates that all samples contain levels less than the detection limits for Pt (1 ppb), Pd (2 ppb) and Rh (2 ppb). The highest gold value was 3 ppb. Analyses for Se, As, Te, Sb, Br, and Ge on these same samples also suggested very low levels of precious metals. Similar analyses to those above were conducted on samples from the Fraser Lake Complex and the Sickle Lake intrusion. New analyses of the mineralized samples from Fraser Lake confirm the previous low levels. Eight new ICP-MS analyses suggest a mean value of approximately 4 ppb for Pt, Pd and Au for well mineralized samples. The palladium values ranged from 2-15 ppb. Twenty analyzed unmineralized samples from the Sickle Lake intrusion suggest a mean of 8 ppb for palladium and platinum and 4 ppb for gold. Sporadic values as high as 63 ppb for Pt and 50 ppb for Pd were obtained. The values associated with the Sickle Lake intrusion are anomalous relative to all the other intrusions in the area. However, it still remains clear that the sulphide mineralized and unmineralized basic and ultrabasic intrusions in the Lynn Lake greenstone belt have anomalously low levels of platinum group elements.

Analyses of basalts (for PGE by stable isotope dilution ICP-MS) from the Magrath, Barrington, Tod, Hughes, Miskwa, Cockeram and Hughes lakes areas of the Lynn Lake greenstone belt, as well as Division B and D of the Northern Belt, suggest that these basaltic volcanic rocks have very high levels of platinum and palladium. Not only are these levels anomalous for volcanic rocks on a world scale, but they also contain greater values than the unmineralized and weakly mineralized mafic-ultramafic intrusions in the Lynn Lake greenstone belt. It is believed that the high levels of Pt and Pd in the associated volcanics suggests a rather fertile mantle source for the first stage of partial melting and coeval volcanics. However, second stage (the mafic-ultramafic intrusions) partial melts derived from the same source are PGE-poor because they are being derived from an area that has already been depleted in PGE.

GSC-9 Metallogeny of Mafic-Ultramafic Rocks, Falcon Lake Igneous Complex
(Project C.2.2.3)
by P.A. Tirschmann and N.M. Halden

The following is a description of the progress made on the third and last portion of a study of the metallogeny of the Falcon Lake Igneous Complex, the first two being on the internal stratigraphy and the gold mineralization associated with the complex. The relationship between small, zoned, late kinematic intrusions and gold mineralization is of interest with respect to possibility of the gold being magmatic. This study is part of a program by the Geological Survey of Canada, which includes the Star Lake and Phantom Lake igneous complexes in Saskatchewan.

Major and trace element geochemical analysis has been completed on 151 whole-rock specimens from the Falcon Lake complex. REE analyses have been obtained on 15 samples representative of gabbro to quartz monzonite compositions. Electron microprobe analyses are also available for plagioclase, pyroxene, amphibolite, K-feldspar and oxides from the major intrusive phases.

The fractionation history of the complex, although reflecting a single liquid line for descent of the majority of its later history, was probably more complex during the earlier phases of gabbro intrusion. The An contents of plagioclase from gabbros 2 and 4 vary between 60 and 69, for gabbros 1 and 3 they vary between 31 and 49, there being an obvious compositional hiatus between 50 and 60. Whole rock trace element compositions for gabbros 1 and 2 would suggest that they are more primitive than gabbros 3 and 4. It is possible that there were two main magmatic pulses, both gabbroic in composition, that underwent similar fractionation histories.

Gabbro 2 tends to be anomalous in composition when compared with other gabbroic phases. Some rocks contain up to 4 wt. % K_2O and Sr levels can be as high as 1700 ppm. Although they could not be considered truly "highly potassic", many of the analyses have MgO contents in excess of 3 wt. % and K_2O/Na_2O ratios in excess of 1.

Analyses of the mafic phases reveal that they are often zoned, having Ca-pyroxene cores rimmed with calcic amphibole. This would suggest that at least some of the gabbro had fractionated an early pyroxene. The origin of the later amphibole overgrowth could be related to greenschist facies metamorphism; the possibility, however, that it could represent fluctuations of P H_2O within the magma chamber cannot be discounted at this stage.

Petrographic studies have revealed some unusual mineralogical relationships. One such example can be observed at the contact between anorthositic layers and oxide layers in some of the later gabbro phases. It takes the form of oxide (probably magnetite) and apatite layers in contact with the anorthositic layers, adjacent to the apatite layers. There are skeletal growths of radiating amphibole. This texture suggests an unusual reaction that may have taken place within the magma during crystallization; this will be the subject of further microprobe studies.

GSC-10 Metallogeny of Mafic-Ultramafic Rocks, Fox River Sill
(Project C.2.2.4)
by P.L. Schwann and R.F.J. Scoates

Research on the petrology, geochemistry, stratigraphy and platinum-group element (PGE) mineralization of the upper 25 m of the Lower Central Layered Zone (LCLZ) and the lower 600 m of the Upper Central Layered Zone (UCLZ) stratigraphy of the Fox River Sill (FRS) was continued by Pamela Schwann, who is completing her M.Sc. thesis at Carleton University under the supervision of R.F.J. Scoates (GSC) and D.H. Watkinson (Carleton University). Three intervals, the Lower, Middle and Upper Mineralized Intervals, contain PGE mineralization (PGE 100 ppb) which is predominantly associated with sulphide-bearing pyroxenites. The Lower interval is 80 m thick and consists of finely interlayered rhythmic sequences of thin dunite and peridotite layers capped by thicker olivine clinopyroxenite layers. The Middle Interval is 50 m thick and occurs in a sequence of cyclic units composed of thin peridotite layers overlain by thick, sulphide-bearing, medium-coarse grained olivine clinopyroxenites. Cyclic units are not always completely developed. The Upper Interval occurs within sulphide-bearing hornblende-olivine pyroxenite. The pyroxenite is 9 m thick with PGE mineralization contained within the coarse grained upper 5 m.

Statistical analyses of PGE and elements of base metal sulphide (BMS) affinity (Cu, Ni, S) and As, Te, Sb, and Bi were used to infer the geochemical association of PGE. There is a moderately positive correlation among PGE and BMS in the 89 mineralized samples, notably concentrations and absolute S abundances are poorly correlated. There is no correlation between PGE and As, Te, Sb, Bi or Cr.

S isotopes of 11 mineralized samples within the 600 m study interval yielded heavy S isotope values. A follow-up S isotope study initiated this past spring by O.R. Eckstrand (GSC) and carried out by the University of Calgary participants R. Krouse and I.L. Grinenko (USSR) confirmed the heavy nature of the S isotope signature of the Fox River Sill. Values within the UCLZ 600 m study interval range from +0.7 to +12.4 per mil, generally becoming increasingly lighter with increasingly stratigraphic height. LCLZ samples have the heaviest S signature (+16 to +18 per mil).

GSC-11 Metallogeny of Mafic-Ultramafic Rocks, Bird River Sill
(Project C.2.2.5)
by R.F.J. Scoates

Field work on the Bird River Sill was devoted to completing detailed mapping of the Chrome Property area. These maps will be open filed at 1:100, 1:200, and 1:1000 scales by April, 1989.

Sampling was dedicated to completing a sequence of stratigraphically related samples through both the Ultramafic and Mafic Series. Petrological and geochemical investigations are proceeding.

GSC-12 Metallogeny of Mafic-Ultramafic Rocks, Thompson Belt
(Project C.2.2.6)
by O.R. Eckstrand

The progress on this project is described in this publication under the title:

GS-21 Thompson Nickel Belt Project — Pipe Pit Mine
(part of 63 O/8NE)
by W. Bleeker and J.J. Macek)

W. Bleeker is completing a study of the structural and metamorphic history of the geology in the region of the Thompson nickel orebodies under the supervision of P. Williams at the University of New Brunswick.

GS-13 Aeromagnetic Gradiometer/VLF and EM Surveys
(Project C.3.1.1)
by E.E. Ready

An airborne electromagnetic survey of the region west of Lynn Lake was completed under contract by Geoterrex in April 1988. Publication of the final product is expected in 1989.

An aeromagnetic gradiometer/VLF survey of the region north of the Paleozoic margin between File Lake and Wekusko Lake (parts of 63K/13 and 14) was completed by Kenting Earth Sciences during the summer of 1988.

GSC-14 Geochemical Surveys
(Project C.4.1.1)
by R. Schmitt and P.W.B. Friske

The geochemical surveys in 1988 involved regional, detailed and interpretive programs. Regional lake sediment and water geochemical results from a survey conducted in 1987 over 21 600 km^2 of central Manitoba (63H/NE, 63-I, 63P/SE) were released as GSC Open File 1641 in July. The open file includes data from 1698 sites, representing an average of one sample per 12.7 km^2. Lake sediments were analyzed for Zn, Cu, Pb, Ni, Co, Ag, Mn, Cd, Fe, Mo, V, As, Hg, U, LOI, Sb and Au. Lake waters were analyzed for U, F, Ca, Mg, alkalinity and pH.

The results of a detailed lake sediment and water infill survey carried out in August 1987 over part of the Lynn Lake and Rusty Lake greenstone belt and adjacent granitoid terrain are being prepared for release as a GSC Open File in late 1988. The survey outlines prospective areas for base and precious metal mineralization and provides data for evaluating lake sediment geochemical data in areas influenced by carbonate-rich till. The results of the infill geochemical survey will be integrated with an evaluation of geochemical, geological and geophysical data for map sheets 64B and 64C that is currently underway.

In August, R. Schmitt completed detailed multi-media geochemical sampling in the vicinity of Foster Lake (64C/10). The results of sampling to date indicate a complex process of gold mobilization from bedrock sources along the Johnson Shear Zone into surficial sediments, vegetation, ground and surface waters and lake sediments. Preliminary results were presented as part of a poster display at the Prospecting in Areas of Glaciated Terrain (PAGT) Conference in Halifax (September 1988). This study forms part of an M.Sc. study on gold mobilization into lake sediments being undertaken by R. Schmitt at University of Ottawa under the direction of E.M. Cameron.

GSC-15 Drift Prospecting: Northwestern Manitoba
(Project C.4.1.2)
by C.A Kaszycki

During June 1987, detailed sampling was carried out in the Darrol Lake area south of Ruttan Mine. Two samples in this area collected during regional sampling in 1987 contained extremely large concentrations of Au in the heavy mineral fraction of the till, and follow-up work was undertaken to assess the significance and reproducibility of these anomalies. Thirty till samples were collected over an area of approximately 3 km^2. Preliminary results indicate that over 50% of these samples contain visible gold in the heavy mineral fraction, although Au concentrations are significantly less than those indicated by the original anomalies. Results of this investigation will be presented at the Manitoba Meeting with Industry in November.

Results of the drift prospecting program were presented in a number of oral and poster presentations. The study of gold and arsenic in till at Wheatcroft Lake was presented at the GSC Forum in January and at the Prospectors and Developers Annual Meeting in March. In February, presentations summarizing regional till composition and interpretation of geochemical anomalies in the Lynn Lake-Leaf Rapids area were given at the CIM branch meetings in Flin Flon and Thompson. This talk was presented also at the Prospectors and Developers Annual Meeting in March. In May a summary of Late Wisconsinan ice flow history in northwestern Manitoba was presented at the Geological Association of Canada Annual Meeting in St. John's, Newfoundland.

Preparation of the final project report is well underway. Compilation of the regional geochemical data base is complete and data will be released as a single open file report this fall. Surficial mapping (1:100 000 scale) for NTS 64B,C,F,G and 63N has been completed and maps will be released as individual open file reports this fall. Compilation of the surficial geology for the entire region (1:250 000 scale) is nearing completion and will be released as a B-series map as part of the final project report. Master's theses examining a gold-arsenic anomaly at Wheatcroft Lake, and the acid neutralizing capacity of carbonate till on the Shield terrane of northwestern Manitoba are scheduled for completion this fall.

GSC-16 Surficial Geology Atlas Compilation, Manitoba — north of 52°
(Project C.5.1.1)
by M.D. Clarke

Under the supervision of Martin Clarke (GSC), regional mapping of surficial geology continues in areas of Manitoba previously unmapped at scales of 1:250 000 or larger. Recent work has concentrated on mapping from aerial photographs and thematic mapper imagery in the area north and east of Shamattawa in the Hudson Bay Lowland. Information acquired during the 1987 field season has, in part, led to the GSC open file publication of surficial geology maps at 1:250 000 scale in the vicinity of the mineral-rich Flin Flon-Snow Lake greenstone belt. This series of four maps will later be published at 1:250 000 as part of the atlas compilation project.

Current status of the project includes the recent publication at 1:250 000 scale of surficial geology maps of Stull Lake (53K), Oxford House (53L), and Norway House (63H). These maps include an inset map of potential aggregate resources. Printing of maps at similar scale for Gods River (63A) is expected to be completed by March 1989. Furthermore, mapping and drafting of six additional maps: Deer Lake (53D), Kaskattama River-Black Duck River-Cape Tatnam (54 B,A,G), Sturgeon Lake-Thorne River (53 O,J), Swan Lake (63C), The Pas (63F), and Cormorant Lake (63K) has been completed and publication is expected before July 1989.

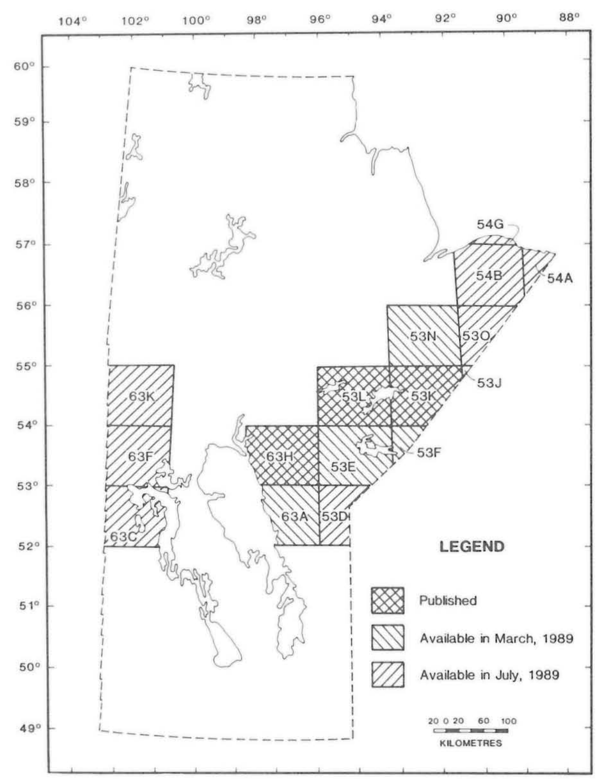


Figure GSC-6-1: Status of surficial geology atlas compilations.

GSC-17 ALTERATION ZONES, STRUCTURE, AND METAMORPHISM OF THE LAURIE LAKE AREA: (SUMMARY OF A CANADA — MANITOBA MINERAL DEVELOPMENT PROJECT)

by S.L. Jackson[1]

INTRODUCTION

The Laurie Lake area (Fig. GSC-17-1) in northern Manitoba contains Early Proterozoic rocks of the Churchill Province that belong to both the Lynn Lake metavolcanic belt and the Kisseynew metasedimentary belt (Milligan, 1960; Gilbert, et al., 1980). This area focussed on the structure and metamorphism of this area. However, mapping during the course of the study also established the presence of some previously unrecognized alteration zones. Such zones are known to be associated with sulphide deposits (e.g. the Fox Mine and the Lar deposit) and, because of their potential economic significance, are discussed below. Data, observations and conclusions of this study have been documented in detail by Jackson and Gordon (1985, 1986) and Jackson (1988). Some of the principal results are outlined below.

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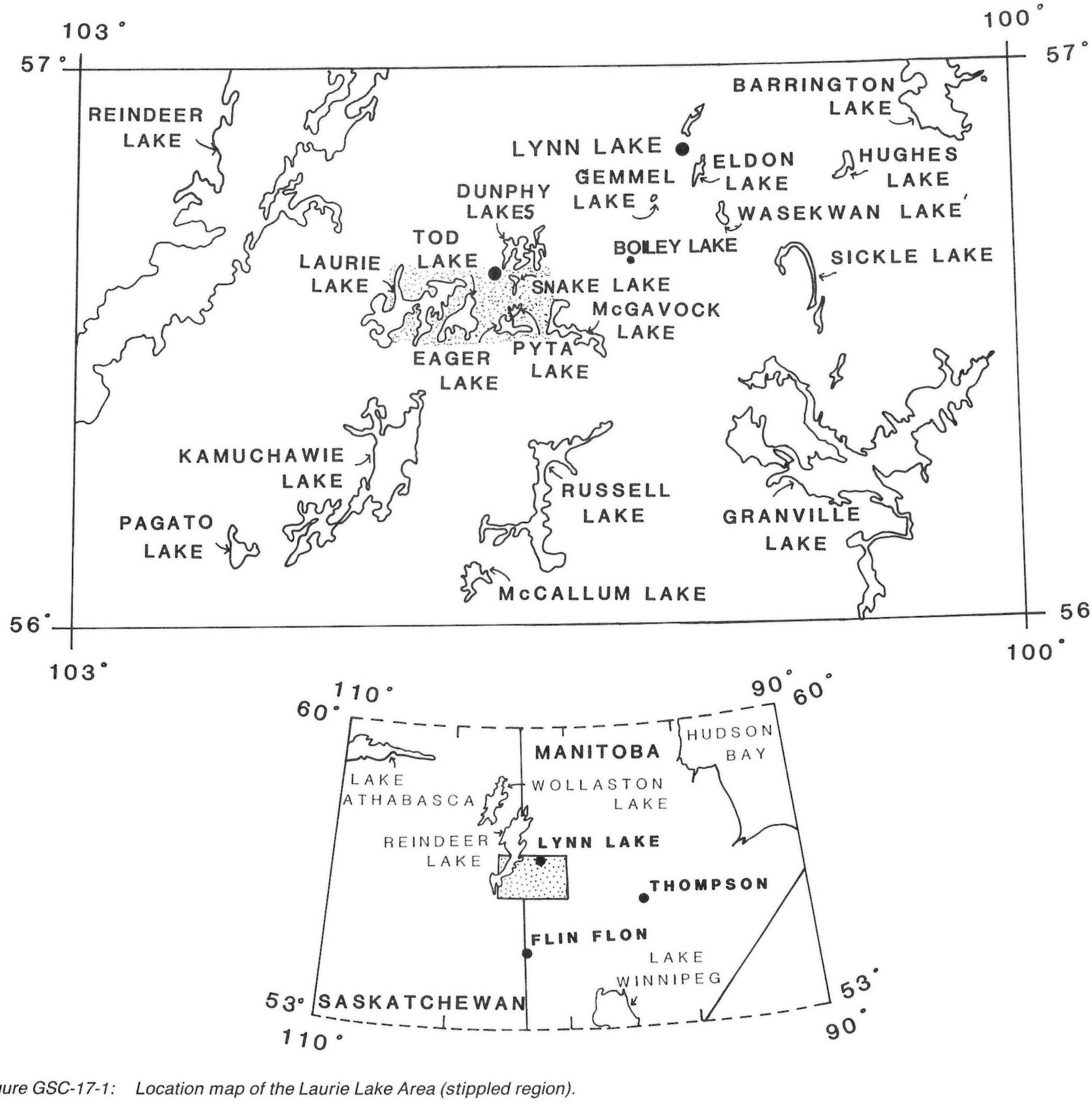


Figure GSC-17-1: Location map of the Laurie Lake Area (stippled region).

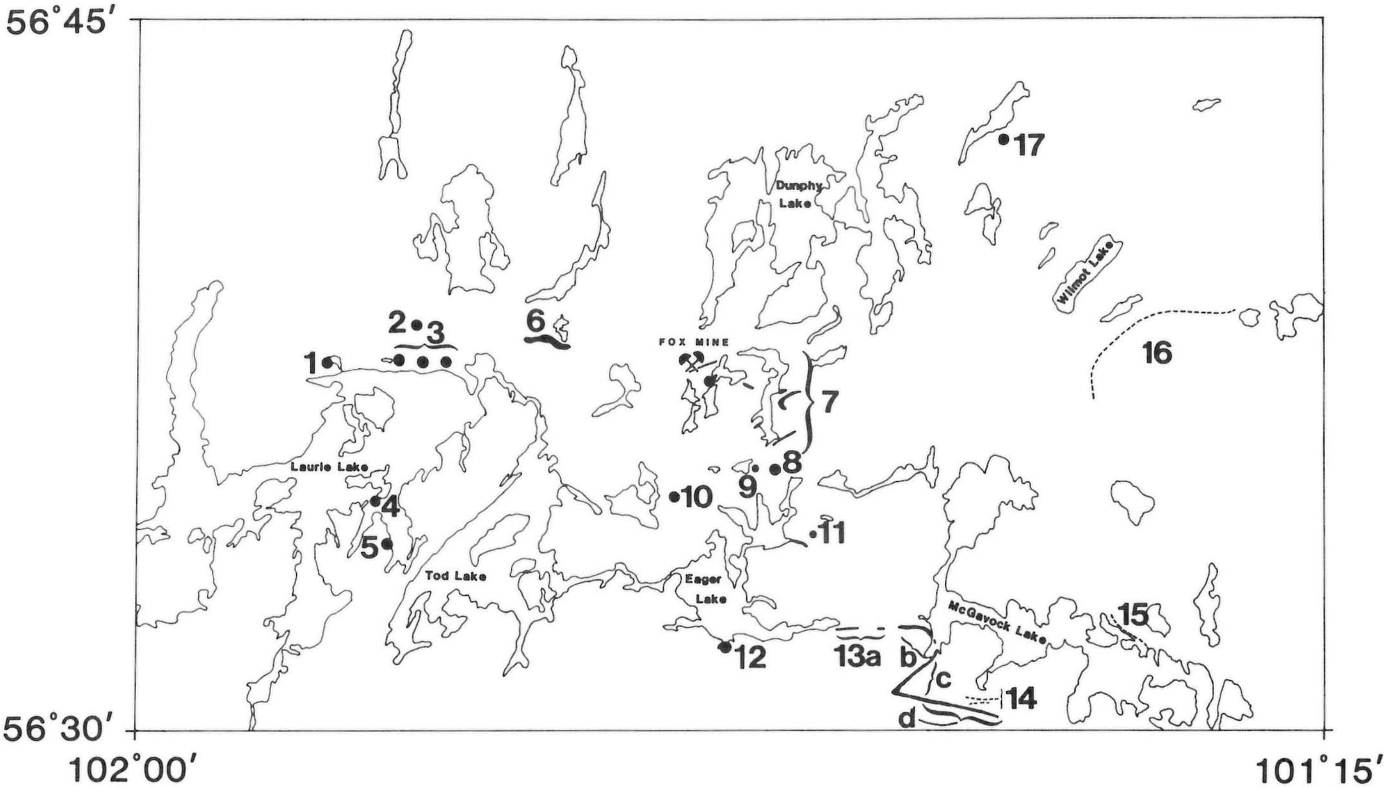


Figure GSC-17-2: Metamorphosed Alteration Zones of the Laurie Lake Area. Table 1 lists references to works on some of these zones. Zones not previously recognized are briefly described below.
Zone 4: Rock types within the immediate area include: aluminous metasediments, quartzofeldspathic metasediments, mafic to ultramafic metavolcanic rocks, and pillowed mafic metavolcanic rocks. The metamorphosed alteration occurs as: patchy cummingtonite and/or garnet-rich regions in amphibolite; regions of cummingtonite-garnet-sulphide and gedrite-garnet-sulphide within pillowed mafic metavolcanic rocks; and sillimanite-rich patches that transect bedding in metasediments. Previous work in the area is indicated by the presence of drill holes, cut lines and trenching.
Zone 5: This zone is approximately 25 m thick and occurs within amphibolites which include: diopside-plagioclase and hornblende-plagioclase banded amphibolite; hornblende-rich amphibolite; and massive to weakly foliated garnet amphibolite. Alteration is represented by garnet-gedrite-cordierite-, gedrite-garnet-tourmaline-, and cummingtonite-plagioclase-quartz-rich rocks.
Zone 8: Stanton (1949) mapped these rocks as "garnet-actinolite-cordierite-quartz-plagioclase gneiss". Other zones similarly mapped by Stanton (1949) are now known to be alteration zones (e.g. New Fox Alteration Zone; Barham, 1987); therefore this locality probably represents an alteration zone.
Zone 9: Small zones of cummingtonite-rich amphibolite.
Zone 10: Previously mapped by Stanton (1949) as "garnet-actinolite-cordierite-quartz-plagioclase gneiss". The writer examined this locality and found gedrite-rich rocks with garnet and cordierite. Associated rocks include: amphibolites, garnet-hornblende siltstones, and quartzofeldspathic sediments.
Zone 12: This zone extends at least 20 m inland to the east. North of the zone are mylonitized granitic gneisses and south of it are potassic-calcareous sediments. The zone is approximately 20 m wide. The alteration consists of plagioclase-cummingtonite ($\pm$ garnet)-, hornblende-garnet-cummingtonite-, and gedrite-rich rocks. A small gossan and some sulphide enclosed in large garnets are present.
Zone 16: This was mapped by Oliver (1952) as a unit containing hornblende, garnet and cordierite. It may represent an alteration zone because some rocks mapped as such by Oliver have been shown to be alteration zones.

METAMORPHOSED ALTERATION ZONES (METAMORPHOSED "FEMGAL" ROCKS)

This rock type is known to local geologists as "alteration", "alteration zone", or "metamorphosed alteration" because its chemical composition does not correspond to that of any common rock type (e.g. Eskola, 1914; Tilley and Fleet, 1930; Froese, 1969). These rocks are enriched in Fe and/or Mg, and Al (hence the acronym FEMGAL) and depleted in Ca, Na and K relative to unaltered protolith rocks (e.g. Eskola, 1914; Tilley and Fleet, 1930). Coexisting metamorphic minerals that reflect the unusual composition include various combinations of cordierite, gedrite, garnet, cummingtonite, sillimanite, staurolite, hornblende, plagioclase, magnetite, sulphides, and quartz. Biotite, if present, is the only K-bearing mineral. The distribution of these rocks is shown in Figure GSC-17-2 (see references in Table GSC-17-1).

One of the zones recognized in this study, south of Eager Lake (Zone 13, Fig. GSC-17-2), is the largest known metamorphosed alteration zone in the Lynn Lake area. A sketch map of a portion of this zone is provided in Figure GSC-17-3. The captions to Figures GSC-17-2 and -3 contain more information on these rocks and rocks associated with them.

The metamorphosed FEMGAL rocks are classified into two groups. The first group consists of those zones associated with mafic to intermediate metavolcanic rocks and aluminous K-poor metasediments (Zones 17 and 1-10 of Fig. GSC-17-2). The second group consists of those zones associated with high-grade Sickle metasediments and minor metavolcanic rocks and amphibolites (Zones 11-14, Fig. GSC-17-2).

Primary volcanic features and/or progression from unaltered metavolcanic rocks to Crd-Ged-bearing rocks are observed in 1 (Elliott and Appleyard, 1985), 4 (this study; see caption to Fig. GSC-17-2), and

TABLE GSC-17-1:

ALTERATION ZONES OF THE LAURIE LAKE AREA

Location #	Name	Reference
(Fig. GSC-17-2)		
1*	Lar	Mustard (1974)
		Elliott (1984)
2*	Gran	Stewart and Brewar (1984)
3	no name	Mustard (1974)
4*	no name	this study
		Stewart and Brewar (1984)
5	no name	this study
6*	New Fox	Stanton (1949)
		Stewart and Brewar (1984)
		Barham and Froese (1986)
7*	Fox Mine/	Stanton (1949)
	Snake Lake region	Olson (1984)
8	no name	Stanton (1949)
9	no name	this study
10	no name	Stanton (1949)
		this study
11	no name	this study
12	no name	this study
13	Eager McGavock	
13a		this study
13b		Stanton (1949)
		this study
13c		Stanton (1949)
13d		Oliver (1952)
14**		Gilbert et al. (1980)
15**		Gilbert et al. (1980)
16***		Oliver (1952)
17*		Ferreira and Baldwin (1984)

* Sherritt Gordon Mines Ltd. discovered and/or worked on zones 1, 2, 3, 6, 7 and 17.

** Zones 14 and 15 are reported as garnetiferous amphibolite; however, the writer found 13b to be alteration-zone rock and thus 14 and 15 should be examined in the light of this new interpretation.

*** Mapped by Oliver (1952) as garnet-hornblende-cordierite-rocks this unit also may be an alteration zone.

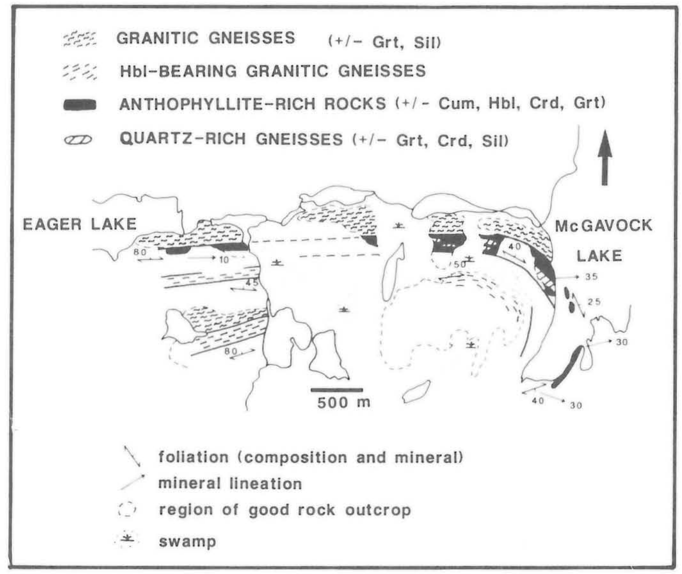


Figure GSC-17-3: The Eager-McGavock Lake Alteration Zone. Near southwest McGavock Lake, Stanton (1949) mapped rocks containing garnet, "actinolite", and cordierite (Zone 13b and 13c of Fig. GSC-17-2). Oliver (1952) delineated a zone (13d of Fig. GSC-17-2) of rocks, continuous with those mapped by Stanton, containing "hornblende", garnet, and cordierite. Mapping during this study revealed that these rocks are cordierite-gedrite rocks. Two main types of alteration are present: 1) gedrite-rich zones with rocks containing: gedrite-garnet-cordierite, gedrite-garnet-cummingtonite, hornblende-cummingtonite-garnet; 2) quartz-rich gneisses including different proportions of sillimanite, garnet and cordierite. This alteration zone may be the largest in the Lynn Lake region. Additional mapping should be carried out to determine the extent of this zone and whether or not massive sulphides are associated with it.

6 (Barham, 1987) and the Fox Mine area. One interpretation, consistent with the available data from zones 1-10, of metamorphosed FEMGAL rocks intimately associated with metavolcanic rocks is that they represent metamorphosed chlorite-quartz $\pm$ clay zones that developed in situ during pre-metamorphic alteration of the volcanic and associated rocks (e.g. Tilley and Fleet, 1930; Froese, 1969; Barham, 1987; Zone 6 of Fig. GSC-17-2).

The metamorphosed FEMGAL rocks south of Eager Lake are laterally continuous and occur in a high-grade predominantly metasedimentary succession with amphibolites and metavolcanic rocks. Mineral assemblages within this zone (see caption to Fig. GSC-17-3) are similar to those of the first group of FEMGAL rocks. Therefore, this zone is also interpreted as a metamorphosed chlorite-quartz $\pm$ clay horizon. The presence of metavolcanic rocks may indicate that this zone also formed by in situ hydrothermal alteration; however, identification of structures and/or textures proving such an origin was not possible owing to the high-grade and high-strain state of the rocks. The lateral continuity of the zone may indicate that the original chlorite-quartz $\pm$ clay material was deposited as a layer, perhaps as reworked, previously altered material or as volcanic ash deposited and altered in water.

STRUCTURAL GEOLOGY

The area is divisible into four main lithostructural domains (Fig. GSC-17-4). Domain 1, consisting largely of metavolcanic rocks and metagreywacke, contains steep-dipping relatively smooth-trending layer-parallel foliations and steep-plunging lineations. Domain 2, consisting chiefly of Sickle Group metasediments, contains east-northeast-trending, gently plunging folds of a conglomerate layer that is overturned to the south. In the southern part of Domain 2 is a map-scale fold of sheath geometry that opens downwards to the north and plunges approximately east-northeast. Domain 3, consists of highly attenuated, moderately northeast-plunging cylinder-shaped folds of migmatized Wasekwan Group and Sickle Group metasediments. Domain 4 is underlain largely by tonalite intrusions having north-dipping foliations. Domain boundaries are marked by structural discontinuities.

Two major episodes of deformation can account for the observed structural geology. One episode resulted in development of a transpositional foliation and the other resulted in the deformation of the transposed layering and foliation into the present map pattern. The second deformation involved south-southwest- to south-directed ductile thrusting, after the development of the layer-parallel foliation, of the Lynn Lake Metavol-

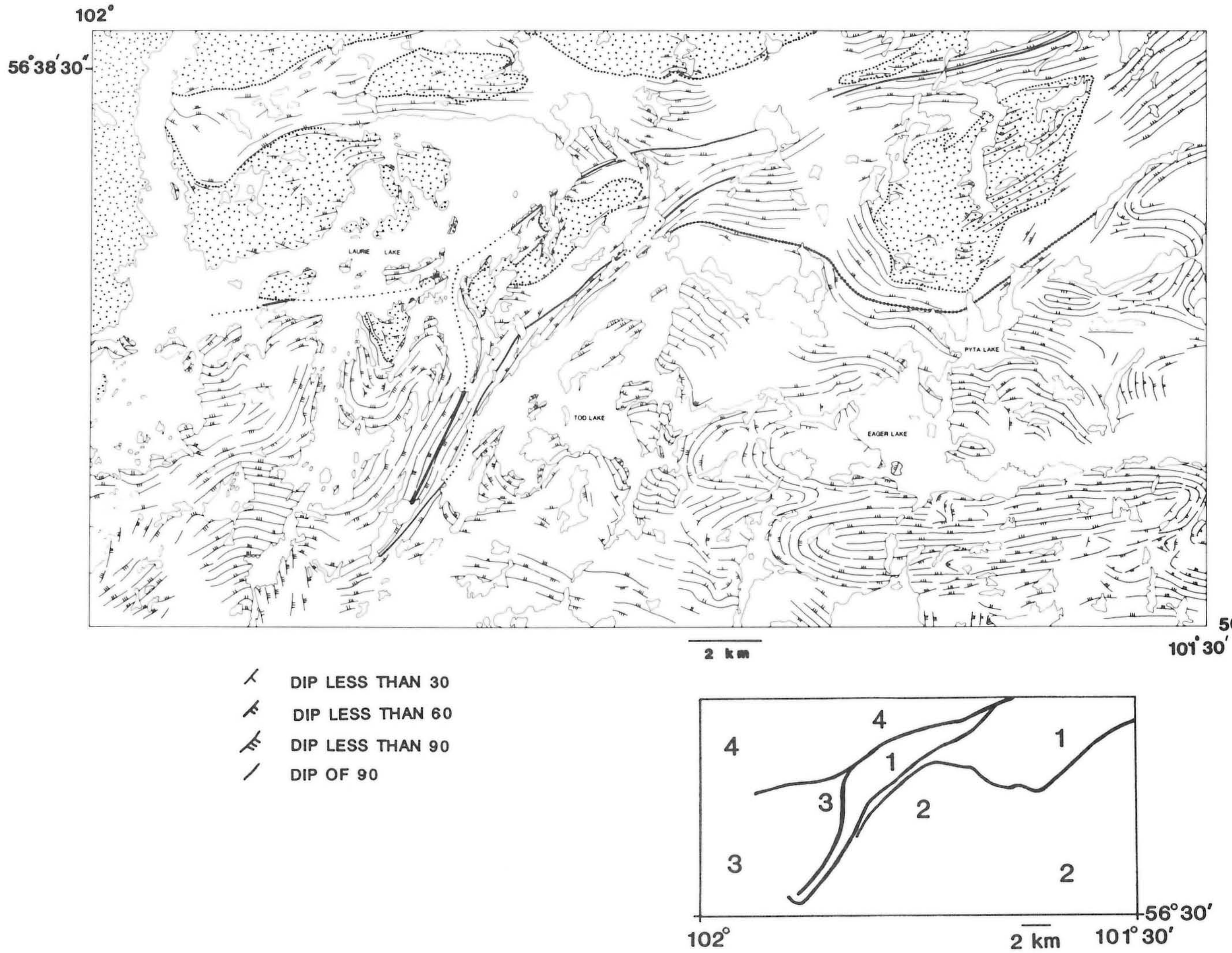


Figure GSC-17-4: Structural domains of the Laurie Lake Area. Small diagram (lower right) identifies the domains. Large diagram is a contoured foliation map of layer-parallel foliation. Thick lines represent faults; unconnected dots represent extrapolation of faults; dotted line represents the metavolcanic belt — metasedimentary belt boundary. Stippled regions represent intrusive rocks.

canic Belt over the adjacent Kisseynew metasedimentary gneiss belt. Metamorphism was synchronous with, but outlasted the main deformations.

METAMORHISM

A regional metamorphic gradient is preserved within the Laurie Lake area. In response to increasing degree of metamorphism the most significant changes were:

1. in K-feldspar-bearing quartzofeldspathic rocks,
   i) sillimanite appeared
   ii) granitic leucosomes appeared and increased in abundance

2. in K-poor aluminous metasediment and metamorphosed alteration zones, staurolite-bearing rocks gave way to garnet-cordierite-sillimanite-bearing rocks

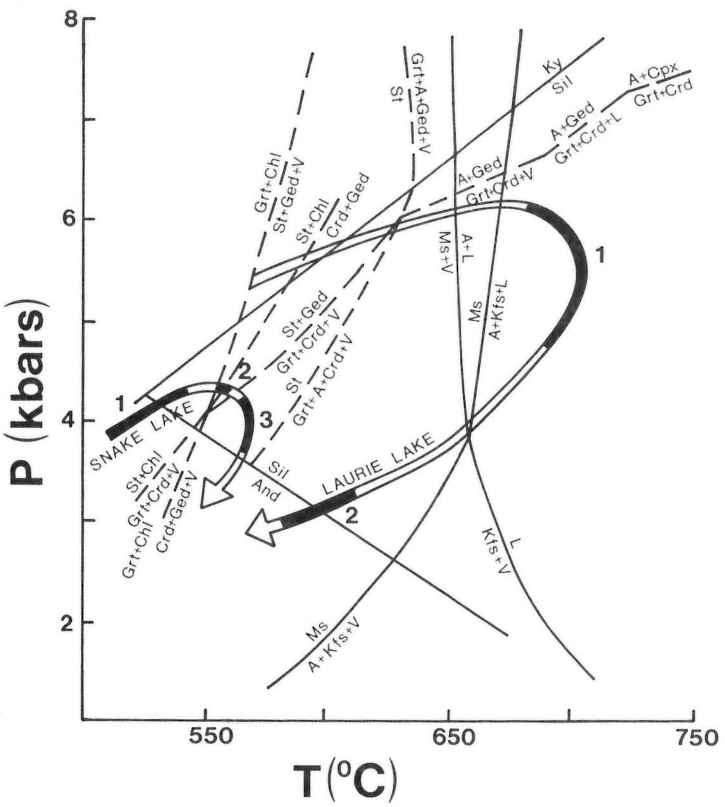
3. in K-poor aluminous metasediments quartz-plagioclase leucosomes appeared and increased in abundance.

Application of linear programming demonstrates tnat garnet-staurolite-biotite-, garnet-biotite-sillimanite-, and garnet-biotite-sillimanite-cordierite-bearing metasediments can be related by mass balance equations. Therefore, the differing mineral assemblages are due to differing degrees of metamorphism.

Calculated physical conditions of metamorphism (575-750° C at 5-6 kb), the distribution of Fe and Mg between coexisting silicates, and evaluation of an equilibrium involving ferropargasite, almandine, grunerite, plagioclase and quartz indicate that the preserved metamorphic gradient is due to variable temperature of metamorphism at uniform pressure.

Interpretation of mineral assemblages and non-equilibrium textures indicates that rocks from the Laurie Lake area followed relatively shallow P-T trajectories (Fig. GSC-17-5). Highly elevated thermal gradients during tectonic loading are believed to be responsible for the determined trajectories.

Consideration of calculated geothermal gradients, P-T calculations, and geochronological data indicates that the high-temperature moderate-pressure conditions of metamorphism could not have been attained without an additional heat supply and/or internal heat generation above the model values and/or a more efficient transfer of heat from lower- to mid-crustal levels (see Gordon, in press). It is postulated that plutons, derived from the lower-crust in response to crustal thickening and emplaced at the mid- to upper-crust, accelerated the rise in the geothermal gradient at mid- to upper-crustal levels.



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GSC-18 COULD THE SHERRIDON GROUP AT SHERRIDON BE A HIGH-GRADE EQUIVALENT OF THE AMISK GROUP?

by K.E. Ashton[1] and E. Froese[2]

The stratigraphic subdivision of the Kisseynew gneisses and the deduction of precursors present a continuing challenge. This note is concerned with the stratigraphic status and origin of a sequence of rocks in the vicinity of Sherridon and a similar suite in the Wildnest Lake area. Bateman and Harrison (1946) introduced the term Sherridon Group for a sequence of quartz-rich gneisses and amphibolites. Robertson (1953) modified this definition to include calc-silicate rocks and impure marble, and Froese and Goetz (1981) additionally included biotite-garnet schist interlayered with quartz-rich gneiss. The quartz-rich gneiss encloses sulphide bodies and lenses of altered rocks characterized by the assemblages cordierite-anthophyllite-garnet and cummingtonite-garnet.

Bateman and Harrison (1946) indirectly compared the Sherridon Group and the Missi Group by noting that both resemble a sequence of rocks at Weldon Bay. Later, Bailes (1971) proposed a correlation between the Sherridon Group and Missi Group. Froese and Goetz (1981), however, pointed out some difficulties with this lithological correlation. In contrast to the Missi Group at Flin Flon, the suite of rocks contained within the Sherridon structure includes prominent layers of amphibolite, abundant calc-silicate rocks and impure marble, and biotite-garnet schist. Furthermore, conglomerate, which is characteristic of the Missi Group, has not been recognized at Sherridon.

Recent work in the Wildnest Lake area, Saskatchewan, has led to the recognition of a suite of Kisseynew gneisses which are strikingly similar to those of the Sherridon Group in the vicinity of Sherridon, but which have been assigned to the Amisk Group (Ashton et al., 1986, 1987). Quartz-rich gneisses at Wildnest Lake are associated with amphibolite, calc-silicate rocks, impure marble and graphitic biotite-garnet gneiss. Cummingtonite-garnet rocks are common in the quartz-rich gneisses and some sulphide occurrences are known, such as the Schotts Lake Cu-Zn deposit (Pearson, 1986). The quartz-rich gneisses, with a range of 67-77% SiO_2 (based on 19 samples, unpublished), have been interpreted as felsic volcanic and volcaniclastic rocks and the amphibolites as mafic volcanic rocks. A highly variable carbonate content in rocks of a large compositional range suggests that the calc-silicate rocks originated by carbonatization of felsic and mafic volcanic rocks prior to metamorphism. A further concentration of carbonate during deformation and metamorphism is suggested by the common presence of the most carbonate-rich rocks (the impure marbles) in the hinge zones of folds. The graphitic biotite-garnet gneisses are regarded as metamorphosed greywackes and the cummingtonite-garnet rocks as products of Fe-Mg metasomatism. The local presence of sillimanite in the quartz-rich gneisses has also been attributed to alteration and is considered comparable to the widespread occurrence of aluminous minerals in altered felsic volcanic rocks at Snow Lake described by Bailes et al. (1987). These geological observations in the Wildnest Lake area cast some doubt on the correlation between the Sherridon Group in the vicinity of Sherridon and the Missi Group (Ashton et al., 1986). The possibility must be considered that the Sherridon Group, like the Wildnest Lake suite, is largely of volcanic origin and is equivalent to a part of the Amisk Group.

The interpretation of the quartz-rich gneisses at Sherridon as sedimentary was stated as a matter of course by Bateman and Harrison (1946), Robertson (1953) and Froese and Goetz (1981), reflecting the earlier view that the Kisseynew gneisses, in general, are a sedimentary succession (Bruce, 1918; Wright, 1929). Some of the amphibolites interlayered with the quartz-rich gneisses, however, have been regarded as volcanic in origin (Bateman and Harrison, 1946; Froese and Goetz, 1981). The calc-silicate rocks and impure marbles represent a wide range of compositions and could readily be interpreted as products of carbonatization of volcanic rocks. In 1988, graphite was observed in the biotite-garnet schist interlayered with the quartz-rich gneisses. Greywacke is a very plausible precursor for the schist. Two possible objections might be raised regarding the interpretation of the quartz-rich gneisses as felsic volcanic rocks: the siliceous nature of the gneisses and their large areal extent. Froese and Goetz (1981) reported an average composition of 25 samples of quartz-rich gneiss as 74.39% SiO_2; the range is 70-78%. A few other samples have SiO_2 contents of 79-82% (unpublished). These values do not, however, preclude a volcanic origin, since a range of 68-83% SiO_2 has been obtained for 26 samples of felsic volcanic rocks from the Flin Flon area (pers. comm., E.C. Syme, 1988). The potential objection dealing with a possible volume problem is also invalid. The Kisseynew gneisses are generally regarded as representing metamorphosed equivalents of rocks of the Flin Flon — Snow Lake volcanic belt (Byers and Dahlstrom, 1954; Bailes, 1971). When structural complexities are taken into account, the areal extent of quartz-rich gneisses at Sherridon is quite similar to exposures of felsic volcanic rocks in the Amisk Lake (Byers and Dahlstrom, 1954), Snow Lake (Froese and Moore, 1980) and Weldon Bay (Froese, 1984) areas.

The authors greatly benefited from discussions with R.R. MacQuarrie and W. Bleeker during the early stages of this work.

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MINES BRANCH
EXPLORATION SERVICES AND
AGGREGATE RESOURCES

ES-1 MANITOBA'S PRECAMBRIAN DRILL CORE COLLECTION PROGRAM

by D.E. Prouse

INTRODUCTION AND HISTORY

Prior to 1970, drill core was collected by the Mines Branch largely as an aid to specific research projects. In the early 1970s, a small-scale core collection program was started in order to assist exploration companies and prospectors throughout Manitoba. The construction of core sheds in The Pas (1972), Thompson (1973) and Lynn Lake (1974) allowed for a more concerted effort towards core collection and as a result the small-scale core collection program has evolved into the present day Precambrian Core Library System. The acquisition of storage space at the Geological Services Branch rock laboratory in Winnipeg in 1980 meant all major greenstone belts in the province had some form of core storage facility.

Between 1971 and 1977, the Resident Geologist in The Pas was responsible for the core collection program. By 1977, when this position was discontinued, 72 600 metres of core had been collected. From 1978 to 1982, 16 000 metres of core was collected by various members of the Department or delivered by exploration companies. By the end of 1982, 88 600 metres of core had been collected; however, due to a limited staff during the 1970s, much of this core was not properly inventoried or organized.

In January 1983, the province's core program was reactivated. Accomplishments achieved by the Thompson Job Creation Program and departmental staff during the summer field season and throughout 1983 resulted in the addition of 24 329 metres of core to the provincial core library system. Most efforts were directed towards the Lynn Lake and The Pas libraries. These facilities underwent major reorganizations as a result of core racking and inventory standardization. In April, 1984, the Government of Canada and the Manitoba Government finalized the Mineral Development Agreement. A portion of the funds available under the five-year term of the Agreement has been allocated to the provincial core libraries program.

The 1984 program was highlighted by the construction of a new wing on the core library in The Pas. This addition expanded the capacity of the library by 300% or 109 049 metres. In 1984, twenty core collections resulted in the addition of 26 169 metres of core.

The 1985 program had two specific objectives. The first, was the reorganization and selective reduction of specific holdings. The second objective was to compile a master file system for all holdings within the libraries. Drill logs, collar locations and other pertinent data were gathered as a prelude to computerization.

The 1986 program consisted of expanding storage capacity in Thompson and Lynn Lake, inventory reorganization, and continued work on the master file system. In Thompson, new inside and outside rack construction increased storage capacity by 30 413 metres (Fig. ES-1-1). At Lynn Lake, the construction of two outside racks increased library capacity by 18 507 metres or 31%. Inventory organizational efforts consisted of selective core reduction, updating library inventory records and core box relabelling using new computer generated tags.

A primary objective of the 1987 program was to develop a computer based master inventory of the northern libraries drill core holdings. By the end of the 1987 field season approximately 70% of the inventories from The Pas, Thompson and Lynn Lake had been entered into computer files. Other duties consisted of selective core reduction and relabelling. At the Lynn Lake facility efforts to improve building site drainage and general building and site maintenance were undertaken.

Since 1984, significant increases in requests for service and, especially, library utilization have been recorded (Fig. ES-1-2), but during fiscal year 1987-88, a disappointing drop in terms of library usage was experienced. However, an increase in general inquiries about core storage by the exploration industry and the public suggests that people are still genuinely interested in using the core storage system.

Since 1983, a noteworthy spinoff of the Provincial Core Libraries Program has been the participation of community oriented job training programs in library building improvement and expansion projects. For example, in previous years, The Pas Human Resources Opportunity Centre has been involved in the construction and assembly of modular core racking. During 1987 and 1988, they manufactured core boxes for use by the provincial drill core collection program.

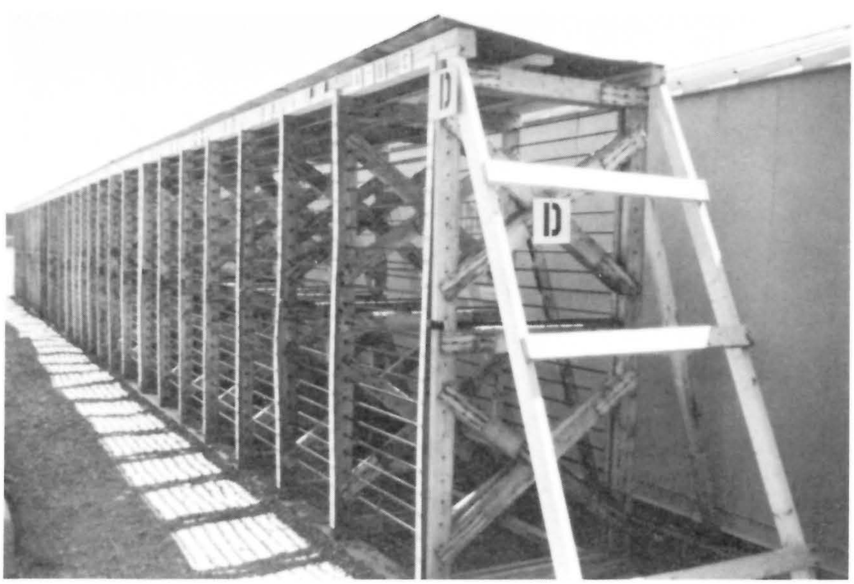

Figure ES-1-1: *Outside core racks, Thompson.*

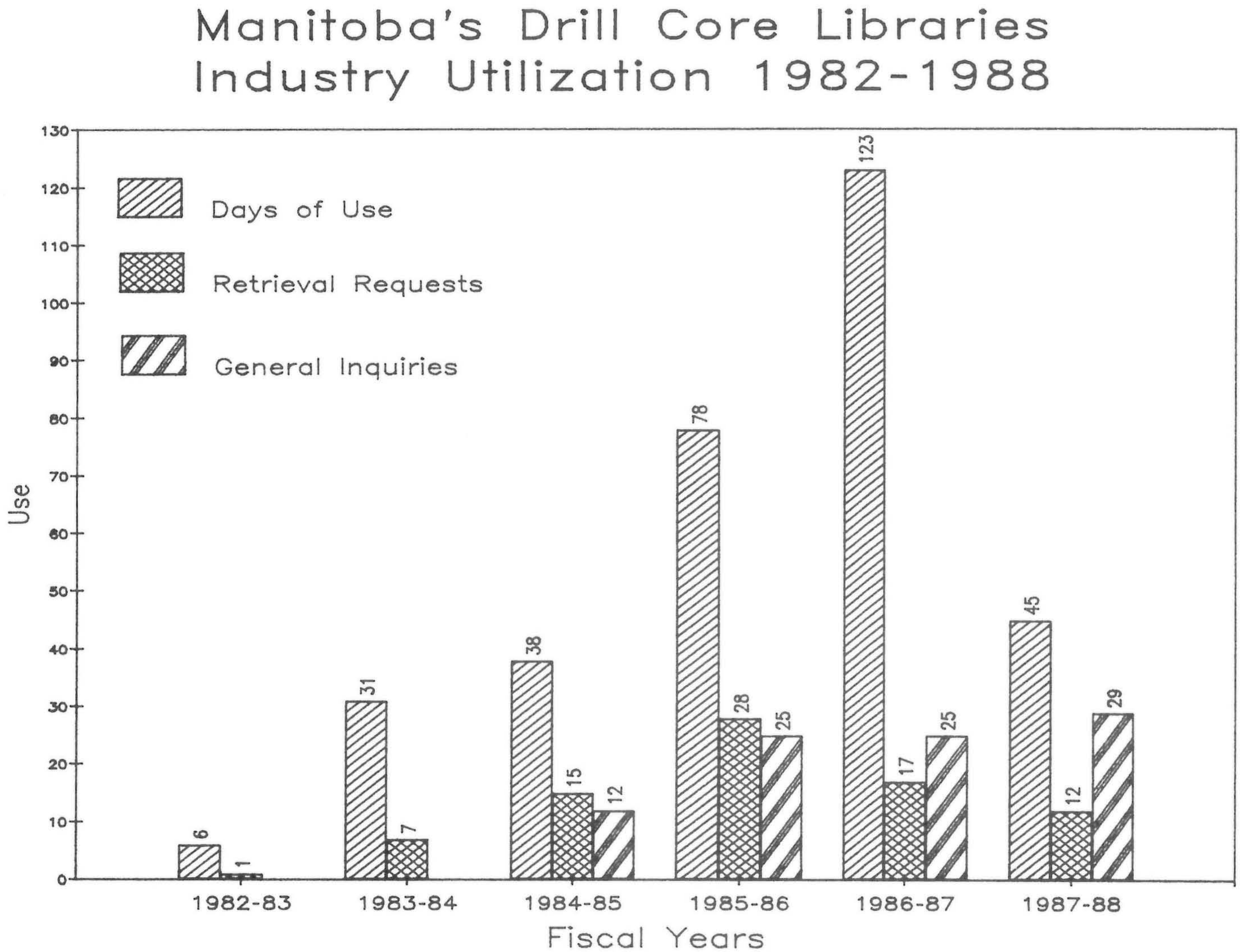

Figure ES-1-2: *Use of core libraries system.*

1988 Program

This year's and last year's programs, the last 2 years of the Mineral Agreement, were scaled down to nearly maintenance levels because the bulk of the expansion work was completed in the first 3 years of the Agreement. Also, in the fall of 1987 the Special Projects Geologist position was vacated and responsibility for the drill core program was shifted to the new Resident Geologist position in The Pas. At the same time the Drill Core Geologist position was discontinued, leaving only one person to work in the drill core program.

A primary objective this year has been to begin gathering all pertinent data to prepare an open file listing of all core holdings in the Precambrian Drill Core Library System. Another important objective was to complete the computer based master inventory of drill core holdings and to update the NTS master file system. In Winnipeg, a major concern was to save the core holdings that have for years been exposed to the elements at Brady Road. In July, the majority of this core was moved inside and a racking system for this core is to be set up as soon as space becomes available.

In The Pas library, 544 boxes or 3316 metres of core were selectively discarded from the inventory. Five government retrievals resulted in the addition of 539 boxes or 3286 metres of core (Fig. ES-1-3). New computer generated labels were applied to 1137 boxes of core and selective reboxing was carried out.

In Lynn Lake, 397 boxes of mislabelled drill core were discarded. One government retrieval resulted in the addition of 591 metres of core to this facility. In Thompson, one industry delivery of 376 boxes resulted in 2292 metres of core added to this library. Other duties consisted of reboxing 152 boxes of core and applying new computer lables to 528 core boxes.

In Winnipeg, one department retrieval resulted in the addition of 469 metres of core to this facility. Inventory reorganization and labelling was also carried out.

This fiscal year, drill core staff has thus far compiled 64 days of field work. As of September 1, 1988, six industry requests for collections, one department retrieval and one industry delivery has resulted in the addition of 6638 metres of core to the provincial core storage system. Library use for the current fiscal year (to date) has been 21 days during 12 visits.

Present Holdings in Core Libraries (Fig. ES-1-4)

The four libraries currently hold 173 430 metres of core.

(A) The Pas Library

Located in the Natural Resources Compound of Grace Lake, this library contains 69 375 metres of core collected from the Flin Flon — Snow Lake district. With an estimated capacity of 164 153 metres this facility is presently 42% full.

Figure ES-1-3: Government core retrieval, The Pas, August 1988.

Current holdings include:

Cominco: 3 projects, 13 holes, 1 554 m.
Dome Exploration: 1 project, 25 holes, 3 024 m.
Espina Copper: 2 projects, 33 holes, 1 487 m.
Granges Exploration: 26 projects, 221 holes, 13 100 m.
Hudson Bay Exploration: 42 projects, 228 holes, 21 378 m.
Manitoba Mineral Resources: 12 projects, 82 holes, 7 114 m.
Maverick Mountain Resources: 1 project, 110 holes, 10 284 m.
Alpha Mines, BP-Selco, L. Bunn, Camflo Mines, W.B. Dunlop, Imperial Oil, Inco, W.B. Kobar, Newmont Mining, Nor-Acme Gold Mines, Pronto Exploration, Red Earth Energy, Shell Canada Resources, and Thompson Brothers.

(B) Thompson Library

This library facility is located at the Burntwood River floatplane base. It has a capacity of 59 204 metres. With a current inventory of 31 266 metres this library is 53% full.

Current holdings include:

BP-Selco: 1 project, 7 holes, 1 728 m.
Canamax Resources: 27 projects, 202 holes, 11 869 m.
Cominco: 3 projects, 23 holes, 3 328 m.
Falconbridge Exploration: 3 projects, 14 holes, 2 573 m.
Granges Exploration: 3 projects, 8 holes, 3 085 m.
Hudson Bay Exploration: 2 projects, 6 holes, 2 067 m.
Noranda Exploration: 3 projects, 10 holes, 2 292m.
Nor-Acme Gold Mines: 1 project, 13 holes, 1 024 m.
Rio Algom Exploration: 1 project, 5 holes, 732 m.
Tantalum Mining Corporation: 2 projects, 12 holes, 987 m.
Inco, Manitoba Hydro, and Nufort Resources.

(C) Lynn Lake Library

This building, located near Parsons Airways floatplane base at Eldon Lake, contains 43 761 metres of drill core from the Lynn Lake greenstone belt, northern part of the Kisseynew basin and northern Manitoba in general. The current capacity of this facility is 77 468 m. and at present it is 56% full.

Current holdings include:

BP-Selco: 1 project, 17 holes, 1 426 m.
Falconbridge Exploration: 2 projects, 8 holes, 841 m.
Granges Exploration: 9 projects, 141 holes, 11 350 m.
Hudson Bay Exploration: 7 projects, 59 holes, 4 584 m.
Manitoba Mineral Resources: 18 projects, 204 holes, 16 233 m.
S.M.D.C.: 12 projects, 42 holes, 4 133 m.
Sherritt Gordon Mines: 3 projects, 15 holes, 2 002 m.
Cyprus Exploration, Denison Mines, Gigantes Exploration, Homestake Mineral Development Company, Keevil Mining Group, McIntyre Mines, Rock Ore Exploration, Shell Canada Resources, and Yukon Antimony.

D) Winnipeg

This library located at Brady Road holds 29 028 metres of drill core from south-eastern Manitoba. This facility has no racked storage at the present time, but efforts to alleviate this situation have begun. The core has been moved indoors and the construction of a racking system is to begin as soon as possible.

Current holdings include:

BP-Selco: 2 projects, 15 holes, 1 811 m.
Brinco: 1 project, 16 holes, 829 m.
Dumbarton Mines: 4 projects, 59 holes, 5 401 m.
Esso Minerals: 6 projects, 47 holes, 2 548 m.
Falconbridge Exploration: 5 projects, 52 holes, 7 680 m.
Manitoba Mineral Resources: 6 projects, 57 holes, 2 798 m.
Maskwa Nickel Chrome Mines: 2 projects, 11 holes, 695 m.
J. Donner, Exploration Operations Branch, Footloose Resources, Indian & Northern Affairs, S. Lesavage, Neepawa Iron Mines, Schmirf Exploration, Tantalum Mining Corporation and University of Manitoba.

How to Use the Core Libraries

The core libraries at The Pas, Lynn Lake and Thompson are now well organized for use by industry and the public. Well lighted, heated inspection rooms with core splitters are provided.

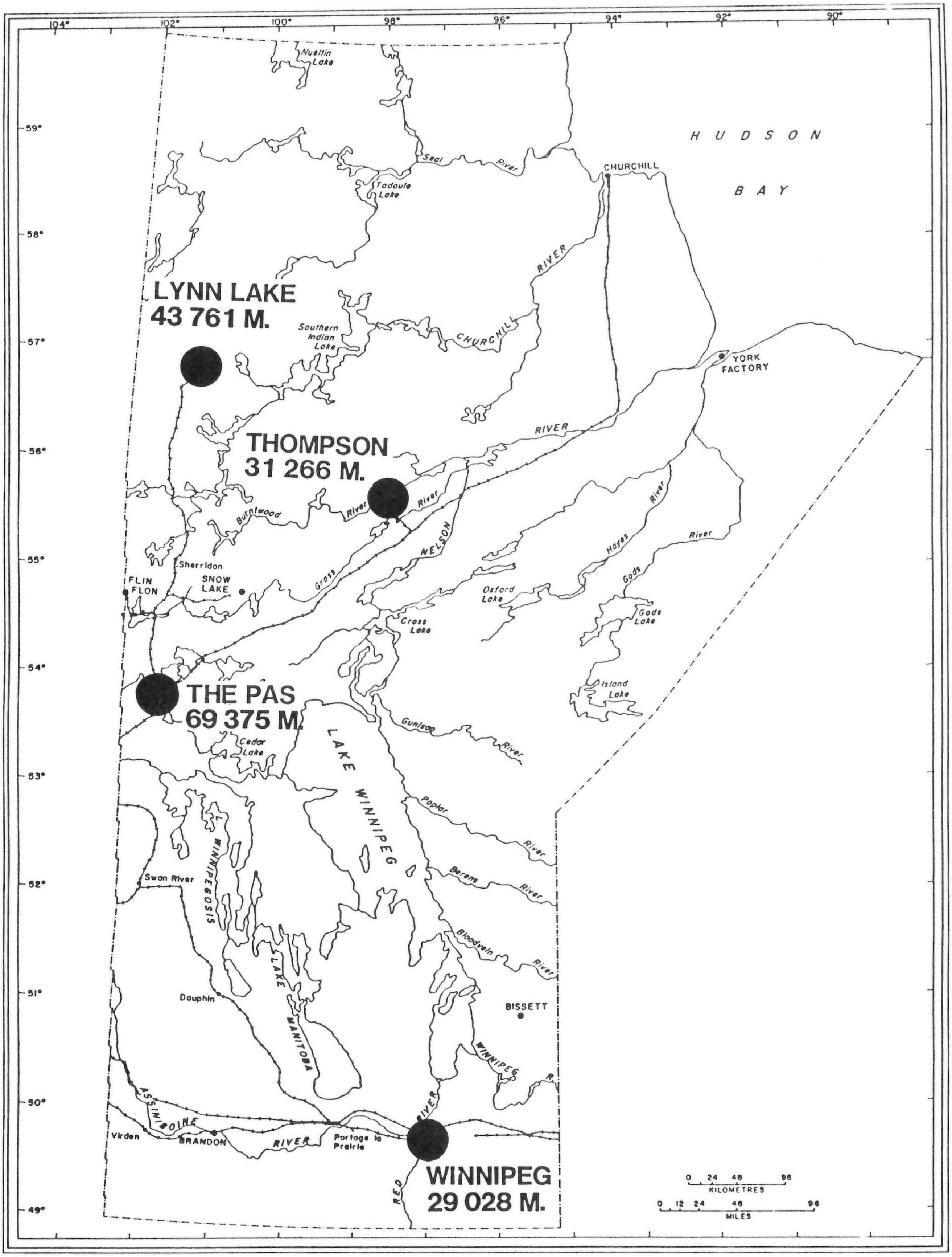

Figure ES-1-4: *Manitoba Core Library locations and present core holdings.*

None of the Department's core libraries are permanently manned, therefore all enquiries and permission for access must be made to:

D. Prouse, Resident Geologist
Mines Branch-Exploration Services Section
Manitoba Energy and Mines
Provincial Building, 3rd and Ross Avenue
The Pas, Manitoba R9A 1M4
Phone: (204) 623-6411 ext. 251

OR

B. Esposito, Assessment Geologist
Exploration Services Section
Manitoba Energy and Mines
555 — 330 Graham Avenue
Winnipeg, Manitoba R3C 4E3
Phone: (204) 945-6535

If necessary, arrangements will be made with appropriate local Government representatives in Lynn Lake and Thompson who have keys to the core libraries in their towns. These are:

Lynn Lake: Conservation Officer
Manitoba Natural Resources
675 Halstead Avenue
Lynn Lake, Manitoba R0B 0W0
Phone: (204) 356-2413

Thompson: W. Schumacker or W. Comaskey
Manitoba Environment and Workplace Safety and Health
Mines Inspection Branch
Provincial Building, 59 Elizabeth Drive
Thompson, Manitoba R8N 1X4
Phone: (204) 778-4411

NOTE: Do not contact these people directly; phone The Pas or the Winnipeg office first.

Access to confidential core is allowed only with written permission from the company which holds the ground. This written permission must be presented to the Resident Geologist or Assessment Geologist.

Core boxes placed in the library will be managed by drill core personnel. If sampling of core is desired, prior consideration and permission are required from the Resident Geologist in The Pas. When sampling is carried out the assays and pulps, if requested, must be forwarded to the Resident Geologist or Assessment Geologist. Quartering of previously sampled core **will not be permitted** in order to preserve the stratigraphy.

Library users must be prepared to physically handle the core boxes and return them to the racks.

The master file of drill logs and plans for non-confidential drill core holdings in the northern libraries is available for inspection in The Pas. Drill logs and plans for non-confidential drill core holdings for southeastern Manitoba are available for viewing in the Winnipeg office. For a more comprehensive outline of Manitoba's Precambrian Drill Core Libraries program, please refer to the bilingual brochure of the same title produced under the Mineral Development Agreement. This is available free of charge from the Winnipeg or The Pas office.

Acknowledgements

The author wishes to extend thanks to N. Banks for his diligent efforts and perseverance in making the summer program a success. Gratitude is also extended to all those in the Mines Branch and those from the Geological Services Branch laboratory for their assistance in moving the Brady Road core inside. The office staff in Winnipeg and The Pas also are acknowledged for their back-up assistance throughout the year.

ES-2 COMPILATION, PROMOTION AND EXPLORATION SERVICES (MDA PROJECT 5.9)

by J.D. Bamburak, L.E. Chackowsky and P. Athayde

INTRODUCTION

The Exploration Services Section of the Mines Branch has been involved in compilation, promotion and exploration services since 1979. The Mineral Development Agreement (MDA), signed in April 1984 by the Government of Canada and the Manitoba Government, increased staffing and funding and has allowed expansion of these services. This has resulted in: the Bibliography of Manitoba Geology project; the Manitoba Mineral Inventory project; and quality displays, reports and brochures.

COMPILATION

1. BIBLIOGRAPHY OF MANITOBA GEOLOGY

The bibliography compilation project began in April 1985, with the objectives of compiling a sorted listing and archival library of all geologic literature pertaining to the landmass of Manitoba, and to provide an online computerized storage and retrieval system (IBM "STAIRS" software) to allow bibliographic retrievals by author, year, title information, NTS and selected subject keywords.

By October 1986, 3600 citations of provincial and federal publications had been entered into the database. Open File Report OF86-1 "Bibliography of Manitoba Geology 1" (BMG-1) was printed and released in November. The continually updated STAIRS system was capable of searching the bibliography by author, year or title information.

By January 1988, 3285 more citations, mostly of journals, periodicals and theses, were added to the database. Early in 1988, Open File Report OF88-1 (BMG-2) was published as a supplement to BMG-1, in a similar format.

The STAIRS system was modified early in 1988 enabling bibliographic searching by NTS area (eg. 64C; 53K/15), and by subject keywords (descriptive terms that may not occur in the title of a citation). NTS data have been added to most of the federal and provincial publications cited in the database and work is well underway to add that data for serial literature, theses, etc. Subject keywords have been added to about 4000 citations from AGI's, GEOREF and GSC's GEOSCAN databases. The addition of NTS and subject keywords to the database will be used to generate NTS and subject indexes for future publications of the bibliography.

A geological paper, "Bibliography and NTS Index of the Geology of Manitoba" is scheduled to be printed by the end of the MDA, in March, 1989. It will arrange all (about 7000) citations in the database into an author-year sorted bibliography with each citation assigned an NTS area(s), and a reference number. The NTS index will refer back to the reference numbers of the citations. Also included will be a set of microfiche listing the citations refered to in the index, sorted by NTS area. Subject keywords will not be included.

2. MANITOBA MINERAL INVENTORY

A compilation of platinum occurrences/indications was started in November 1987 and should be available for distribution in the near future. P. Theyer of Geological Services provided many of the references for the platinum occurrences. References were also obtained using the STAIRS system of the Bibliography of Manitoba Geology.

The mineral inventory updates of Manitoba chromite, tantalum, lithium, beryllium, tin and scheelite deposits/occurrences were completed in August 1988 and cards are available. Brad Rumpel, a summer student, revised the silver deposits/occurrences in the mineral inventory file.

Updating of copper, zinc and nickel mineral inventory cards for the Flin Flon-Snow Lake greenstone belt commenced in September.

3. ASSESSMENT FILE

During the summer, a student updated, to the end of August, all map mylars in the assessment report index map series. These maps, at a scale of 1:31 680, show former mineral disposition outlines with five-digit accession numbers. The mylars are used for reproduction or as overlays on Mining Recording's claim maps.

Supplements to the "Index to Non-confidential Assessment Reports" (OF86-5) were produced in May and November.

4. INDEX MAP SERIES

The Section reproduces index data plotted on 1:1 000 000 scale mylars. Fourteen mylars show outlines of permits, exploration reservations and airborne geophysical surveys. Six mylars outline map areas of geoscientific publications. Aggregate Resources updated their maps showing aggregate and surficial map coverage.

PROMOTION

1. MONITORING EXPLORATION

During 1987-88, Exploration Services staff undertook 19 field trips; 87 person-days (excluding the drill core program) were spent in the field and many contacts were made with exploration personnel in on-going liaison and monitoring of exploration activity. From April to August 1988, an additional 12 field trips involving 44 person-days were made.

2. DISPLAYS

During the past year, the Section has produced displays depicting exploration activity and mining in the Province and services provided by the Department. Two major events were: the Annual Meeting with Industry in Winnipeg last November, and the Prospectors and Developers Convention in Toronto in March. Other events were the Manitoba School Career Symposia in Winnipeg (a joint display with The Mining Association of Manitoba), Brandon, Flin Flon and The Pas.

3. ARTICLES

"Mining in Manitoba", an educational publication, was written by Section staff and released in April, 1988. The report details the historical development of mining in the Province, summarizes the geological framework, discusses exploration and mining methods, reviews current operations and indicates potential development.

Staff wrote several articles describing the activities of exploration companies in the Province, including: "Mineral Exploration in Manitoba 1987" and "Manitoba Exploration Highlights" (revised in November 1987 and March 1988).

4. COMMITTEES

Two Section staff have served on the CIM Winnipeg Branch Executive and also on the Mineral Exploration Liaison Committee (MELC) during the year. The Head of the Section served as Manitoba's Co-Secretary to the Mineral Development Agreement Management Committee. One staff member served on the Map Catalog committee.

EXPLORATION SERVICES

1. PUBLICATION DISTRIBUTION

Exploration Services Section is responsible for release notices of new publications; the mailing list of over 600 customers; gift and exchange agreements; preliminary and index maps; Geological Survey of Canada open file reports; various published geophysical maps (aeromagnetic, gradiometer, total field, input, etc.); and for providing consultative services to the Info Centre. New releases of Minerals Division publications and Geological Survey of Canada open files are available from both The Pas Mining Recording and the Winnipeg Information Centre. Coordination is provided by Exploration Services Section.

Open File Reports (OF87-2, 87-6, 87-12 and 88-1); Bedrock Geology Compilation Maps for 52E, 52L and 53L; Aggregate Resources Compilation Maps for 52E, 52L, 62H, 62I, 62J and 62K; Mineral Deposit Report No.1 (63K/13SE) and the Geological Highway Map of Manitoba (French and English versions), produced under the Canada-Manitoba interim and current Mineral Development Agreements, were distributed following a notification process. (See 'List of Publications Released', this volume.)

The "Canada-Manitoba Mineral Development Agreement 1984-89, Sector 'A' Geoscientific Activities, Progress Report 1987-88" (Open File

Report OF88-2) was released in June 1988. This report reviews activities conducted in Manitoba by Manitoba Geological Services Branch, Exploration Services Section of the Mines Branch, and the Geological Survey of Canada during the 12-month period ending March 31, 1988, and outlines projects scheduled for implementation during 1988-89.

In January, the second edition of "The MDA News" was mailed to over 600 addresses on the publications mailing list.

2. BROCHURES

The following brochures were revised in November 1987 and March 1988:

a. "Staff and Functions of the Geological Services Branch";
b. "Staff and Duties of the Exploration Services Section";
c. "Mining and Exploration Companies in Manitoba"; and
d. "Selected Contractors and Consultants Serving the Exploration Industry in Manitoba."

In March 1988 a revised "Mineral and Exploration Services in Manitoba" brochure was released at the Prospectors and Developers Convention in Toronto.

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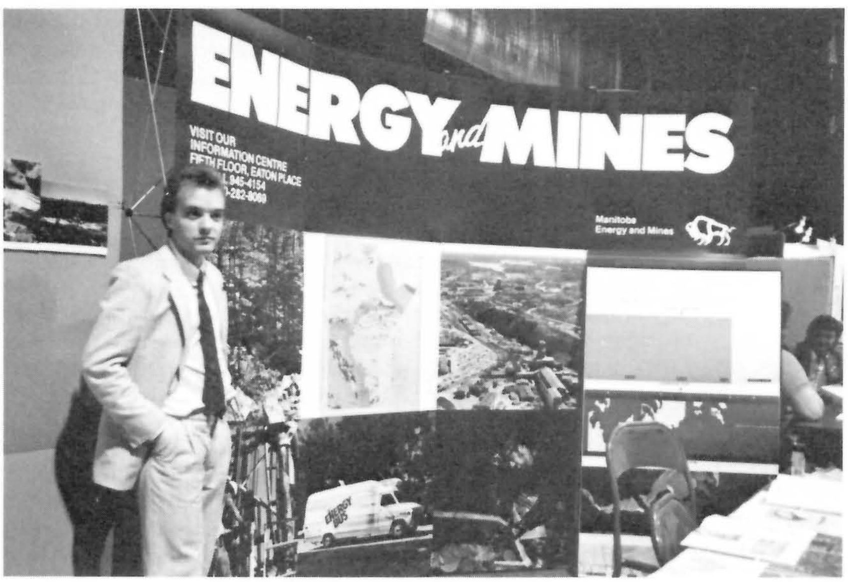

Figure ES-2-1: 1988 Careers symposium in Flin Flon.

AR-1 SURFICIAL GEOLOGY AND AGGREGATE RESOURCES OF THE SNOW LAKE AREA

by MaryAnn Mihychuk

INTRODUCTION

A surficial geology and aggregate inventory program was conducted in the Snow Lake area, NTS sheets 63J/12 and 13, and 63K/9 and 16 (Fig. AR-1-1). Regional surficial mapping was conducted to identify geologically favourable environments for aggregate deposits. The objectives of this year's field work were to:

1. define known aggregate deposits;
2. provide a data base for future land-use management; and
3. aid in evaluation of potential sites for new pits or quarries.

During the 1988 field season, 246 field stations were investigated and 109 samples collected. Preliminary maps and aggregate quality data including grain size and clast lithology are available through the Aggregate Resources Section, Mines Branch. Preliminary maps 1988SL-1 to 4 (Mihychuk, 1988), at a scale of 1:50 000, are being released at the same time as this report.

SURFICIAL GEOLOGY

Glaciolacustrine silts and clays related to glacial Lake Agassiz blanket most of the area. Precambrian bedrock highs protrude through the glaciolacustrine sediments and there is extensive swamp development in lowland areas. Nearshore sand and gravel deposits are found on the flanks of prominent topographic highs and as low relief beach ridges in

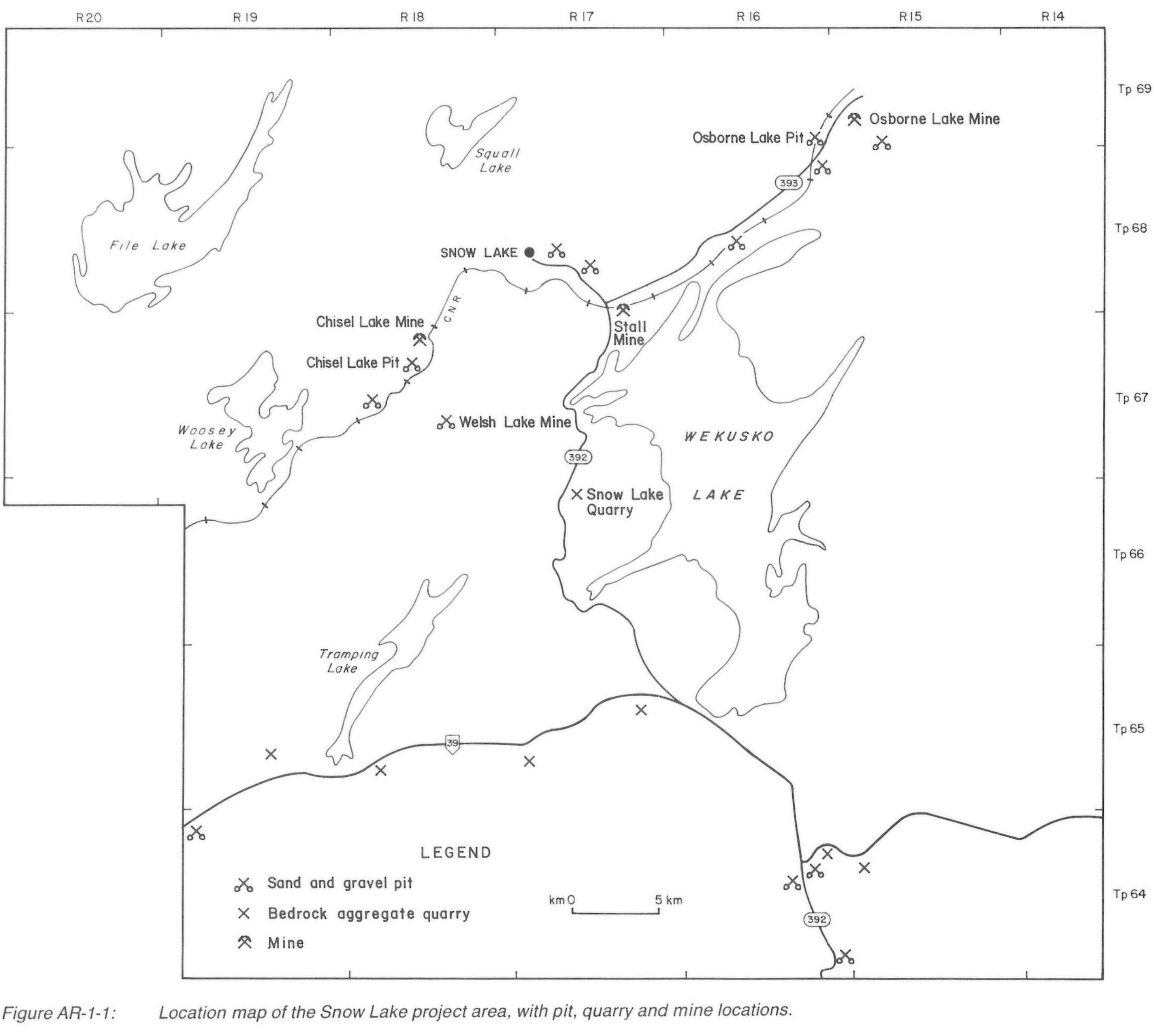

Figure AR-1-1: Location map of the Snow Lake project area, with pit, quarry and mine locations.

flat areas. Glaciofluvial and ice-contact sediments occur as isolated plains. Till was observed on the leeside of bedrock knolls. Glacial movements recorded as striations show three ice flow directions, 248°, 210° and 180° in order of oldest to youngest. The dominant ice flow direction in the study area is 210°.

BEDROCK GEOLOGY

The Precambrian-Paleozoic contact divides the study area in half. The northern portion is characteristic Shield terrane. Rock types consist of granitic and granitoid gneisses, metamorphosed volcanic and sedimentary units and highly altered metamorphic rocks. Structural features dominate the topography with minimal glacial modification. South of the contact the Paleozoic carbonates form a series of low relief escarpments usually north- or west-facing, and average 1-2 m in height.

AGGREGATE RESOURCES

Aggregate resources in the Snow Lake area occur in morainic, glaciofluvial and glaciolacustrine Quaternary deposits, and Paleozoic dolostone.

MORAINIC DEPOSITS

Morainic deposits are found at or near the ice margin. Deposits often exhibit rapid changes of sediment type and structural deformation. The Chisel Lake, Welsh Lake and Osborne Lake (Fig. AR-1-1) deposits show ice contact characteristics. Morainic deposits have the greatest resource potential for aggregate.

The Chisel Lake pit is located approximately 1.5 km southeast of the mine (SW 27 and SE 28-67-18W) and is the main source of aggregate for the mine. The deposit has been extensively quarried and is near depletion.

The Welsh Lake deposit (NW 11 and SW 14-67-18W) is about 6 km south of Chisel Mine. The deposit hosts the largest reserves in the Snow Lake area. Beach development is evident as a series of ridges on the west flank of the deposit. The deposit is generally very sandy; however, there are coarse sediments containing cobble-pebble gravel in the core of the deposit and in some of the beach ridges. There are two other deposits in the vicinity as evidenced by quarry mineral dispositions and personal communications; however, access to the deposits was not achieved during the past field season. These two deposits are probably associated with the Welsh Lake deposit in the form of a fairly major morainic zone.

The Osborne Lake pit (NW 36-68-16W) located on Provincial Road 393 contains over 3 m of cross-laminated fine to medium sand (Fig. AR-1-2). Approximately half of the reserves have been mined, even though the quality is considered very low.

A large sand and gravel plain was identified by Bailes (1980) on the west shore of File Lake. This deposit was not mapped during the past season for logistical reasons. The deposit appears to have good exploration potential and requires field investigations to determine aggregate quality and reserves.

GLACIOLACUSTRINE DEPOSITS

Nearshore and shoreline deposits developed during glacial Lake Agassiz have moderate to marginal aggregate resource potential. Some shoreline development was observed on the flanks of bedrock highs, usually on the south or west flank. Deposits are poorly developed, averaging less than 2 m in thickness, and are not continuous.

BEDROCK QUARRIES

Paleozoic dolostone is the only rock type used for aggregate in the study area. The relatively thin beds (10-40 cm) and rock hardness makes the dolostone extremely favourable for aggregate quarrying purposes. Crushed dolostone is the surface coat of all major roads in the area. The Snow Lake Quarry (33-66-17W) on Provincial Road 392 is situated in a Paleozoic outlier. This quarry was active during the past season and is the major source of crushed rock in the area. Reserves have been almost depleted. A new quarry was opened this year south of Highway 39 (SW 18-65-17W). Other quarries in the study area are depleted or have been inactive for several years.

SUMMARY

A summary of this year's field work is:

1. The Snow Lake area is rapidly reaching a critical shortage of aggregate reserves. Demand is expected to remain high with ongoing mineral development.
2. All easily accessible deposits have had some degree of mining. Deposits near demand areas (the community or mine sites) are near depletion or are depleted.

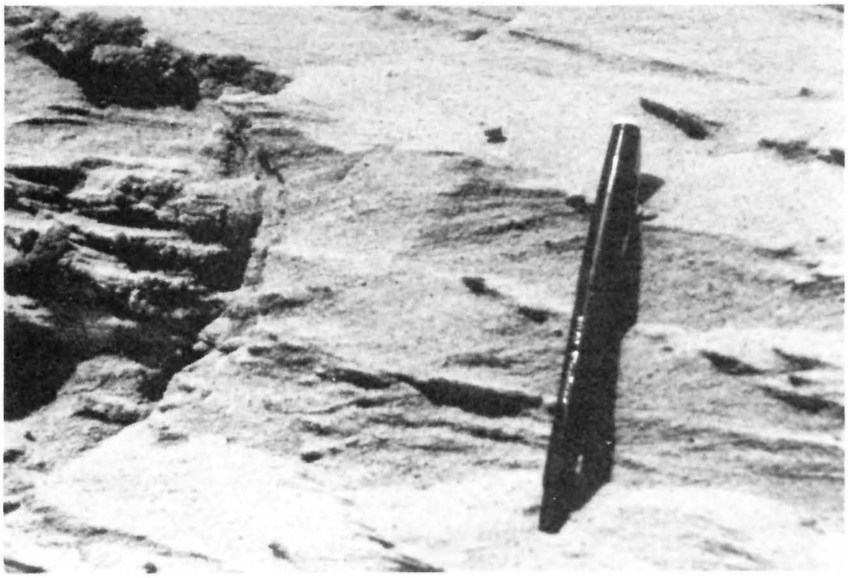

Figure AR-1-2: Cross-laminated fine sand and silt in the Osborne Lake sand pit.

3. The Welsh Lake deposit holds the greatest potential for meeting demand needs.
4. Conservation of remaining aggregate reserves is recommended through effective land-use management. Additionally, exploration is recommended to identify future supplies.
5. Exploration potential exists in the Welsh Lake morainic zone, the File Lake area, and the Lake Agassiz shoreline deposits on the flanks of structural highs.

CONCLUSION

Aggregate reserves in the Snow Lake area are very limited. Most deposits have been mined to depletion and remaining reserves are either minimal, inaccessible or a considerable distance from demand areas. Exploration is recommended to ensure present and future supplies.

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(November 24, 1987 — November 22, 1988

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Bannatyne, B.B.(1988): Dolomite resources of Southern Manitoba; Economic Geology Report ER85-1.	*
Cameron, H.D.M. (1988): Geology of the Eden Lake area; Geological Report GR 84-2.	$10.00
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Chackowsky, L.E. (1988): Bibliography of Manitoba, Geology 2 Open File Report OF88-1	5.00
Corkery, M.T.(Map Committee Chairman) (1987): Geological Highway Map of Manitoba; MDA Special Publication No. 1; scale 1:1 000 000	No charge
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Manitoba Energy and Mines, Aggregate Resources (1988):
Pointe du Bois, 52L, 1:250 000; Aggregate Resource Compilation Series AR88-1-5 5.00

Manitoba Energy and Mines, Minerals Division (1987):
Report of Field Activities 1987 5.00

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PRELIMINARY MAPS 1988

GEOLOGICAL SERVICES BRANCH

Geological Survey

		Scale
1988F-1	Schist Lake (Part of 63K/12) by E.C. Syme (Supersedes 1987F-1)	1:15 840
1988F-2	Bakers Narrows (Part of 63K/12) by E.C. Syme (Supersedes 1987F-2)	1:15 840
1988F-3	West Arm (Part of 63K/12) by E.C. Syme	1:15 840
1988F-4	Millwater (Part of 63K/12) by E.C. Syme	1:15 840
1988F-5	Tartan Lake-Embury Lake (Part of 63K/13) by H.P. Gilbert (Supersedes 1987F-3)	:15 840
1988K-1	Kissising Lake (63N/3) by D.C.P. Schledewitz	1:20 000
1988K-2	Batty Lake (63N/2 and part of 63N/1) by H.V. Zwanzig, P.G. Lenton, B.S. Miller, P. Elias and G. Arkos (Supersedes 1987K-3)	1:50 000
1988S-1	Chisel-Morgan Lakes (Part of 63K/16) by A.H. Bailes (Supersedes 1987S-1)	1:15 840
1988T-1 to T-8	Pipe Open Pit Mine (Part of 63-O/8NE) by W. Bleeker and J.J. Macek	1:400

Bedrock Geology Compilation Map Series, Preliminary Edition

	Kississing, NTS 63N by D. Kowerchuk	1:250 000

MINES BRANCH

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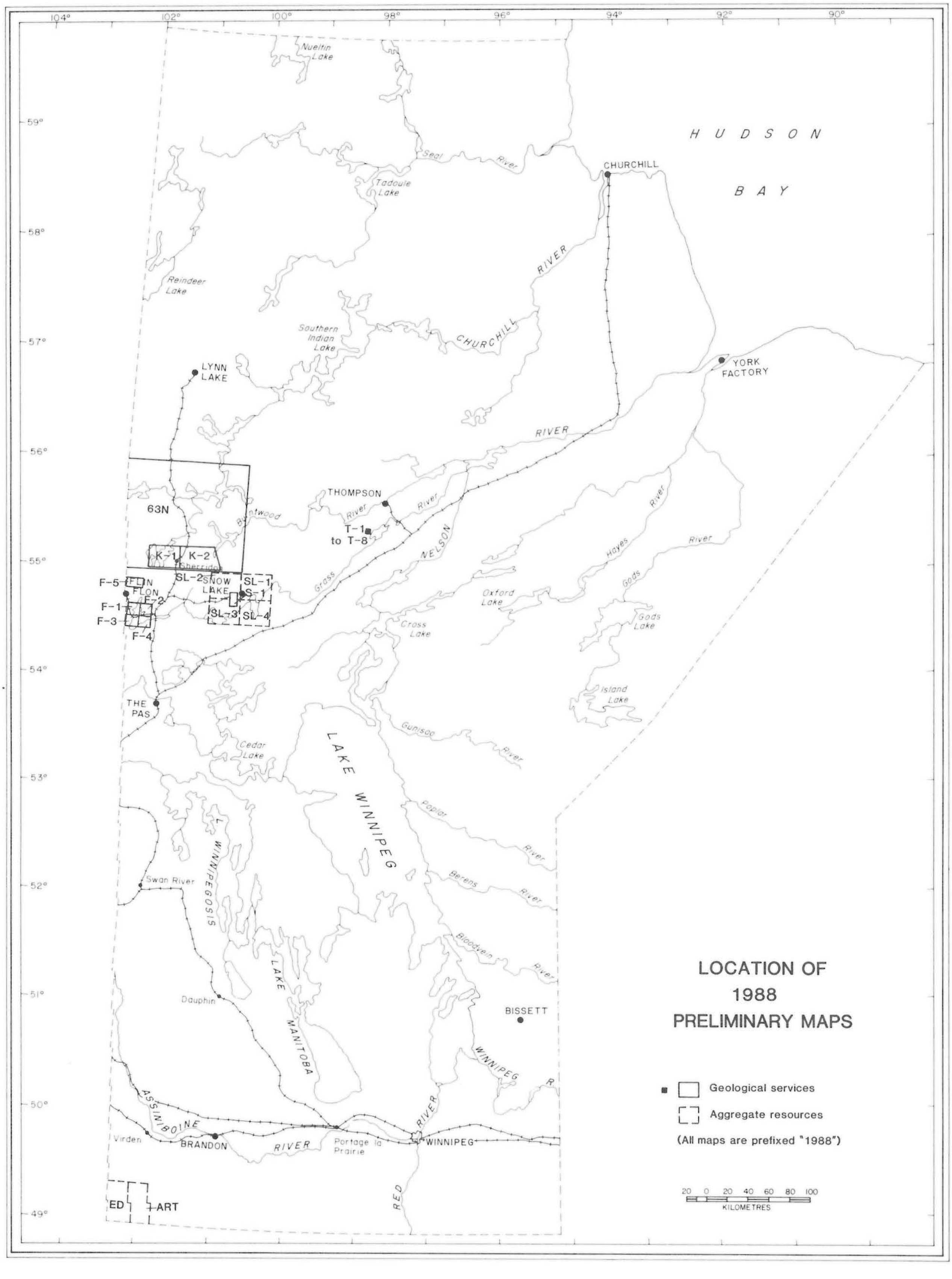
1988 SL-1	Surficial Geology and Aggregate Resources of Herb Lake (63J/13) by M.A. Mihychuk	1:50 000
1988 SL-2	Surficial Geology and Aggregate Resources of File Lake (63K/16) by M.A. Mihychuk	1:50 000
1988 SL-3	Surficial Geology and Aggregate Resources of Tramping Lake (63K/9) by M.A. Mihychuk	1:50 000
1988 SL-4	Surficial Geology and Aggregate Resources of Buzz Lake (63J/12) by M.A. Mihychuk	1:50 000
1988 E/A	Aggregate Deposits in the R.M. of Edward and R.M. of Arthur (Parts of 62F/2,3,6,7) by H. Groom	1:50 000



LOCATION OF
1988
PRELIMINARY MAPS
Geological services
Aggregate resources
(All maps are prefixed "1988")
KILOMETRES
HUDSON
BAY
CHURCHILL
YORK FACTORY
LYNN LAKE
THOMPSON
T-1 to T-8
63N
K-1
K-2
SL-1
SL-2
SL-3
SL-4
S-1
F-1
F-2
F-3
F-4
F-5
SNOW LAKE
FLIN FLON
THE PAS
LAKE WINNIPEG
BISSETT
WINNIPEG
BRANDON
Dauphin
Swan River
Virden
Portage la Prairie
ED
ART

LIST OF GEOLOGICAL STAFF AND AREAS OF CURRENT INVOLVEMENT

GEOLOGICAL SERVICES

POSITION	PERSONNEL	AREA OF CURRENT INVOLVMENT
Director	Dr. W.D. McRitchie	Manitoba
Geological Survey:		
Senior Precambrian Geologist	Dr. W. Weber	Manitoba
Precambrian Geologists	Dr. A.H. Bailes	Snow Lake
	H.D.M. Cameron	Cross Lake
	M.T. Corkery	Cross Lake-Northern Superior Province, Nelson and Churhill Rivers
	H.P. Gilbert	Tartan Lake, Island Lake, Barrington Lake
	P.G. Lenton	Cross Lake-Kisseynew gneissic belt — granite and pegmatite
	Dr. J.J. Macek	Thompson
	D.C.P. Schledewitz	North of 59°; Kississing Lake
	E.C. Syme	Flin Flon, Athapapuskow Lake
	Dr. H.V. Zwanzig	Churchill Province, Kisseynew belt, Lynn Lake
Mineralogist	C.R. McGregor	Mineralogy, Sub-Phanerozoic Precambrian
Geological Compiler (Atlas)	D. Kowerchuk	1:250 000 Precambrian compilation maps
Phanerozoic Geologist	Dr. H.R. McCabe	Southwest Manitoba and Interlake
Quaternary Geologist	Dr. E. Nielsen	Manitoba Pleistocene stratigraphy, basal till geochemistry
Mineral Investigations:		
Senior Mineral Deposit Geologist	Dr. G.H. Gale	Manitoba, specifically Flin Flon and Snow Lake
Mineral Deposit Geologists	Dr. D.A. Baldwin	Lynn Lake-Ruttan area
	Dr. P. Theyer	Southeast Manitoba: PGE investigations
	Dr. M.A.F. Fedikow	Snow Lake area and geochemistry
	O. Ostry	File Lake-Sherridon area
	D. Parbery	Mineral Deposit Geological Assistant
	K. Ferreira	Mineral Deposit Geological Assistant
Industrial Minerals Geologist	W.R. Gunter	Northern Manitoba
	B.E. Schmidtke	Southern Manitoba
Computerization	G.G. Conley	Stratigraphic data files
	D.R. Eccles	Mineral Deposit files
Editorial & Cartographic Services:		
Geological Editor	B.B. Bannatyne	

MINES BRANCH

POSITION	PERSONNEL	AREA OF CURRENT INVOLVEMENT
Director of Mines	W.A. Bardswich	Manitoba
Aggregate Resources:		
Section Head	R.V. Young	Aggregate inventory R.M. of Lorne; Manitoba
Geologist	G.L.D. Matile	Aggregate inventory L.G.D. of Piney
	H.D. Groom	Aggregate inventory R.M. of Edward and Arthur
	M.A. Mihychuk	Aggregate inventory Snow Lake Area
Mining Engineering:		
Resource Management Geologist	C.W. Jones	Aggregate resources management
Exploration Services:		
Section Head	W.D. Fogwill	Exploration activity in Manitoba
Assessment Geologist	B. Esposito	Assessment files
Resident Geologist, The Pas	D.E. Prouse	Exploration activity, drill core program
Staff Geophysicist	I.T. Hosain	Regional compilation of assessment data
Mineral Information Geologist	J.D. Bamburak	Publications, information
Compilation Geologist	L.E. Chackowsky	Indices to Manitoba geoscience data; bibliography
Mineral Inventory Geologist	P. Athayde	Mineral deposit data