Manitoba
Energy and Mines
Geological Services

Report of Activities 1992

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Manitoba
Energy and Mines
Geological Services

REPORT OF ACTIVITIES 1992

1992

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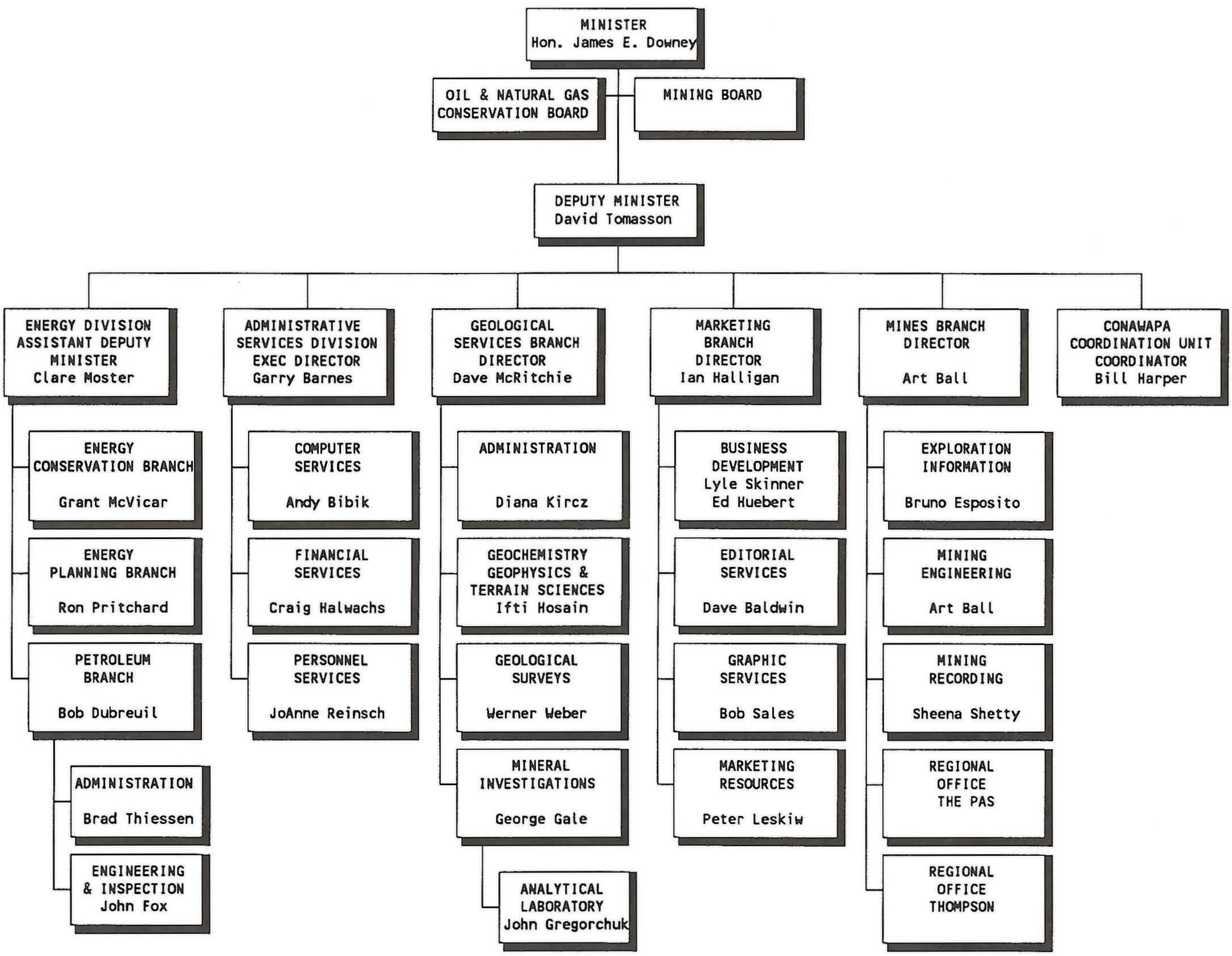
MANITOBA ENERGY AND MINES
DEPARTMENT OVERVIEW



OVERVIEW.C November, 1992

Deputy Premier
Minister of
Energy and Mines

Minister responsible for Manitoba Hydro

Room 333
Legislative Building
Winnipeg, Manitoba, CANADA
R3C 0V8

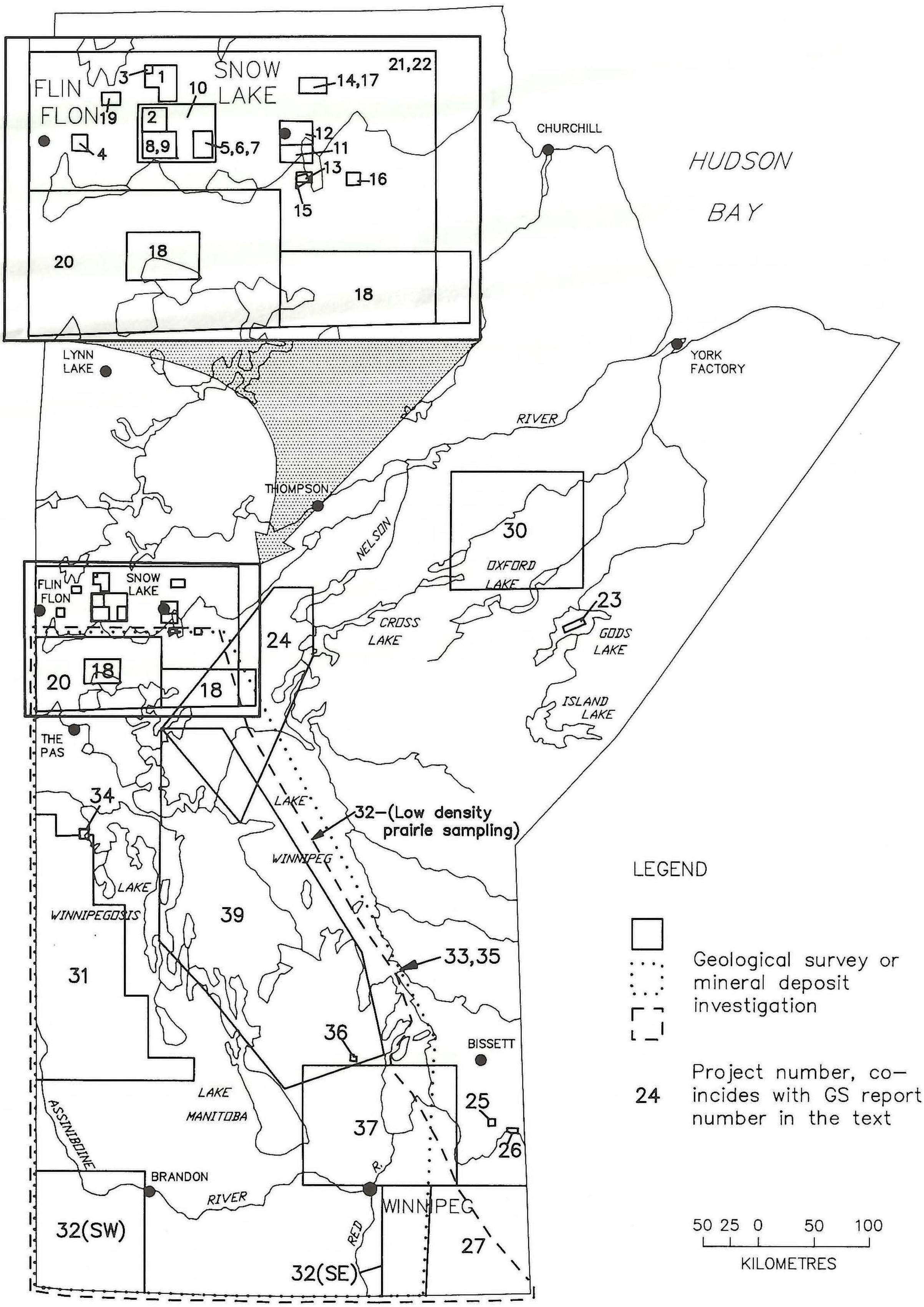
Manitoba is in the market for mining opportunities and future development initiatives. Our government recognizes Manitoba's many natural advantages and we are gearing up to build on our strengths by implementing a series of incentives and streamlining legislation to improve our competitive position.

I am excited by the great potential of our incentive programs and encouraged by the very positive feed back we are receiving from the mining industry.

Manitoba's advantages include excellent mineral potential. Large areas have yet to receive detailed prospecting and some areas have barely been touched by exploration activity. Geological information plays a key role in identifying areas with higher prospectivity and in assisting the private sector in the selection of new targets for more detailed evaluation and drilling.

I look forward to meeting with you at this year's Manitoba Mining and Minerals Convention to discuss future mining opportunities and I hope the information contained in this report directs you to new ventures that are both productive and profitable.

Honourable James Downey
Minister of Energy and Mines



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MANITOBA GENERAL

INTRODUCTORY REVIEW

by W.D. McRitchie

McRitchie, W.D., 1992: Introductory Review; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 1-3.

During 1992 constraints on budget allocations continued to limit the extent and duration of operations mounted by the provincial Geological Services Branch (GSB). However, this shortfall was in large part compensated by a build-up in the level of Geological Survey of Canada (GSC) contributions, through the new National Mapping Programs (NATMAP) in the Flin Flon region and southern Manitoba, as well as EXTECH and activities funded under the LITHOPROBE initiative. At current projections, the total geological survey program delivery in support of exploration in the region feeding the Flin Flon smelter, over the next four year period, will be almost three times that of a stand-alone effort by the provincial GSB. Provincial and federal contributions are both funded in part through the five year Canada/Manitoba Partnership Agreement on Mineral development (MDA), now in its third year. The GSB developed an in-depth, 10 year plan for continued program delivery in the Province.

Flin Flon-Snow Lake:

With a budget of $2.55 million dollars (MDA and provincial "A" base), the principal emphasis of GSB programming continued to be the Flin Flon/Snow Lake region, where multidisciplinary geological, geophysical and geochemical surveys, mineral deposit documentation and scout drilling, are being conducted in support of industry's exploration for new copper and zinc deposits. The NATMAP Shield Margin project (NASMAP) is now fully operational with contributions being made by the GSB, GSC and several universities. A three day workshop in Winnipeg and field tours in the Creighton, Flin Flon and Snow Lake regions, were convened at the beginning of the field season to coordinate operations in Manitoba with those in Saskatchewan. All information collected in this major cooperative effort conforms to mutually agreed to standards and classifications, the intent being to generate a minerals Geographic Information System for the region. Standardization of input parameters is also facilitating the rapid development of derivative maps and electronic databases. This year four full colour maps will be released at the Winnipeg Mining and Minerals Convention with 1:50 000 scale cross-boundary maps planned for early in 1993.

New geochronological data and structural investigations generated through MDA and NATMAP initiatives are also playing a critical role in the interpretation of seismic results that stem from last years LITHOPROBE operations. LITHOPROBE workshops were convened in Saskatoon (March), Regina (September), and Winnipeg (May, September); the fall meetings are aimed at developing manuscripts to present the initial interpretations of the processed seismic data, which is of outstanding quality.

Detailed mapping on the Baker Patton felsic complex revealed a stratigraphic link between newly-discovered mineralization at Leo Lake and lithologies at the old North Star Lake Mine.

1:5 000 mapping in the recently burned area northeast of Sherridon delineated local occurrences of hydrothermally altered rocks in the vicinity of the Jungle Lake massive sulphide deposit.

In the nearby Walton Lake area, 1:20 000 geological mapping focussed on high grade metamorphic rocks in the structural and stratigraphic transition zone between the Kisseynew gneiss belt and the Flin Flon volcanic belt. Rocks in the area were subdivided into four lithologically and stratigraphically distinct sequences that occur on top of each other as a stack of recumbent folds, and probable thrust slices. Each sequence contains an unique set of mineral occurrences and style of hydrothermal alteration. The recognition of Amisk Group equivalents in the Walton Lake nappe elevates the massive sulphide exploration potential of this region, as well as supporting the interpretation that the Sherridon Suite is also equivalent to the Amisk Group.

One hundred and eighty-five till samples collected from hand-dug pits in the Elbow Lake area, were submitted for geochemical analysis. Ice flow directions interpreted from dispersal trains indicate ice flow slightly west of south.

Gold and sulphide prospects in the North Star Lake and Elbow Lake areas were mapped as part of the ongoing documentation of mineral occurrences in the Flin Flon belt. A possible volcanogenic massive sulphide type alteration zone has been recognized in rhyolitic rocks in the Tee Lake area. A complex structural history has been recognized in the North Star Lake area where three phases of ductile deformation are followed by several brittle events.

The GSC initiated detailed mapping of the Reed Lake gabbro as follow-up to the regional study of mafic/ultramafic intrusions in the Flin Flon-Snow Lake mining district.

1:20 000 mapping in the Webb and Fay Lake area encountered mainly Amisk mafic volcanic and volcaniclastic rocks, intruded by fine grained gabbro sills, together with quartz-plagioclase porphyry dykes and sills. The Amisk rocks are overlain by Missi Group basal conglomerates and quartzofeldspathic paragneisses. Two large composite intrusions, the Echo Lake and Gauthier Lake plutons, underlie more than half the area. Both are cut by east-trending and north-trending faults and shear zones.

Mapping at Claw Lake defined a large, layered mafic/ultramafic complex with crosscutting phases of several ages. Mafic volcanic rocks at Elbow Lake can now be subdivided into both back-arc ocean floor and transitional types; this subdivision has important implications for base metal exploration in the area. Granitoid rocks display a wide range in composition and age. The Gant Lake batholith provide a transect that stitches the boundary between the Flin Flon and Kisseynew belts. Geochemical and isotopic work indicates all mapped granitoid units are calc-alkaline volcanic-arc granites derived from juvenile infracrustal sources.

1:20 000 mapping of greywacke, siltstone and mudstone on Wekusko Lake demonstrated the equivalency of these rocks with those that contain the Bur, Kobar/Ruby zinc-copper massive sulphide deposits to the northeast. This reinforces suggestions, arising from earlier work, that exploration should also anticipate the existence of sediment-hosted massive sulphides in this region.

Thirty-one core samples were collected to delineate the extent of geochemical haloes associated with the Bur Zone zinc-copper deposit. Initial results suggest the deposit is enriched in mercury and may therefore respond to a combination of mercury vapour and ground geophysical exploration techniques.

1:5 000 mapping of the Osborne deposit traced the host felsic pyroclastic rocks northeastward toward the northwest shore of Long Lake. This highly prospective horizon will continue to be the focus of future detailed mapping and geochemical sampling. Brief reconnaissance mapping and geochemical sampling programs were also conducted in the Watch Lake area, and over the Copper-Man zinc-copper deposit.

1:5 000 geological mapping by the GSC and GSB in the Kormans Lake area defined the presence of a major early fold closure that could result in repetition of the felsic rocks that host the Anderson and Stall Lake mines between Tramping and Morgan lakes.

Cormorant area and Nickel belt extension:

Elsewhere in the province, drill core from previous nickel exploration along the southwest extension of the Thompson belt, was relogged in an effort to identify occurrences of the lithologies diagnostic of the Ospwagan Group (thought to be the host for much of the nickel mineralization). Sub-Paleozoic basement geology has been reinterpreted, down the axis of the nickel belt, using the most recent interpretations, augmented by new drillhole information provided through the Branch's scout drilling program and nonclassified company information. Ten additional scout holes were drilled in the adjacent Cormorant area (NTS 63K), to ground-truth new interpretations of the airborne magnetic data conducted by Allan Spector and Associates under contract to the GSC. Further control was provided through high resolution gravity surveys sponsored by the GSC in the Spring of 1992. The usefulness of the gravity surveys has prompted proposals for additional coverage south of Snow Lake, and along the extension of the nickel belt.

North-central Manitoba:

Field operations in the north-central sector of the Province were limited to mapping the stratigraphy associated with gold mineralization on Elk and Jowsey islands, Gods Lake, and to a brief vegetation geochemical reconnaissance of the Little Stull Lake area, in cooperation with the GSC and Phelps Dodge.

Southeast Manitoba:

Hitherto unrecognized komatiitic rocks, intercalated with magnesian tholeiites and calc-alkaline metabasalts, have been identified by the GSC north and east of a major shear zone that runs through Moore and Beresford lakes. It has been suggested that the komatiites may be correlative with pre 2.8 Ga supracrustal rocks in the Red Lake belt to the east, and that the early shear zone may have played an important role in influencing the distribution of gold mineralization in the Rice Lake belt.

Quartz veins in the Bissett and Wallace Lake area were sampled and mapped to evaluate their potential as a source of lump silica. More than five tons of chromite ore was retrieved from the Chrome claims, Bird River Sill, and shipped to ORETECH for crushing and concentrating into a feedstock for metallurgical research being conducted at Laurentian University.

Detailed mapping of chromitite seams on the Page property showed that the stratigraphy, though discontinuous, is similar to that on the Chrome claims. Numerous faults disrupt the continuity of the chrome-bearing seams. A new sequence of chromitite layers, termed the Page Chromitite suite, was defined between the disrupted suite and the Lower Main.

In the nearby Bernic Lake region, additional pine bark and spruce needles were collected as part of a regional assessment of geochemical haloes associated with this district's rare-element pegmatites.

Southwestern Manitoba:

Work on the province's Paleozoic rocks focussed primarily on redefining formational boundaries in the Ordovician, and to a lesser extent the Silurian. This work is intended to promote the search for deep petroleum, in traps below those in the Mississippian and Amaranth formations. A large number of petroleum and mineral exploration drill cores were relogged, wireline logs re-examined, and new picks selected.

Additional information on Devonian reefs at The Bluff and Dawson Bay, and the stratigraphy of Silurian dolomites near The Pas was obtained from new holes drilled in these areas. The Bluff information, combined with earlier drillhole results, has been used to define the geometry and development of the reefs, the initiation of which appears to have been controlled by the northeast-trending basement structures in the Churchill/Superior Boundary zone. This work has also helped to develop guidelines for petroleum exploration elsewhere in the Williston Basin. A series of stratigraphic reference holes have been drilled over the last few years to aid subdivision and correlation of Silurian dolomite in the northern Interlake. This year the GSC logged one of the reference holes west of Buffalo Lake (Grand Rapids Uplands) and provide an array of geophysical parameters that include density, temperature, conductivity, resistivity, and gamma responses.

The GSB continued its' input into, and editorial comment toward, the development of the Atlas of the Western Canada Sedimentary Basin, now scheduled for release in early 1993. Field studies were confined to the ongoing examination of karst features in the Interlake. This work is also helping to refine the stratigraphic maps for the region as new marker beds are found in hitherto unexplored country.

Further stratigraphic information was generated through drilling and outcrop examinations in NTS area 62I, as part of an inventory of this region's industrial minerals; this included definition of potential new sources of granite dimension stone near Brightstone, Lac Du Bonnet.

Chemical analyses and laboratory tests of drill core from Fisher Branch dolomites near Sandridge, confirmed the high magnesium contents, low residues, and reserves required to qualify these rocks as a potential raw material source for magnesium metal production.

Several different geophysical instruments were used to improve the definition of buried kaolin-filled channels in the Sylvan area, near Riverton. The ground surveys were augmented with airborne VLF data collected by the GSC Skyvan.

Twenty-three drillholes were completed, and 100 surficial till samples collected in southeast Manitoba as part of the NATMAP Southern Prairies project. Initial results suggest the extent of greenstones in the basement is not as widespread as was originally inferred from interpretation of airborne magnetic data.

Work in the Virden area included drilling four holes, and 1:100 000 mapping of surficial deposits. Contributions to this project were also made by the University of Manitoba and the provincial Water Resources Branch.

Till and soil samples were collected from 225 sites in southern Manitoba to provide input to the GSC low density Prairie till/soil program. The samples will be processed to glean new data on glacial dispersion trends, to look for lamproite/kimberlite indicator minerals, and to provide geochemical information of value to environmental studies.

Manitoba General:

The Branch continued collaborative work with the Manitoba Mining Association, aimed at identifying candidate areas for designation as Endangered Spaces (ES). Several regions with apparently limited mineral development potential have now been identified, and a preliminary proposal tabled for the undertaking of resource assessments in those areas where the existing database is deemed to be inadequate for conducting appraisals of residual exploration potential. In parallel with these activities the Branch has also worked closely with other government agencies in providing mineral data for ES candidate areas in agro-Manitoba, Provincial Parks and Provincial Forests.

Numerous enquiries on mineral related matters were responded to throughout the year, both in Winnipeg and through the Flin Flon and Pas Regional Offices. These included property examinations and field tours held for the benefit of explorationists in the Flin Flon/Snow Lake and Thompson regions.

In addition to providing minerals information to several advisory and land-use committees, the Branch also provided input into the Master Minerals Strategy being developed for the Leaf Rapids region by Watts, Griffis and McOuat Limited.

The GSB maintains a number of electronic information files for internal use and for distribution to the public. Although on-line public access to the files is not currently available, selected datafiles, including raw field data, are periodically released on diskettes as interim reports.

The format of the annual open-house is to be expanded yet again this year, to include concurrent business and technical sessions, as well as the traditional core shack.

In addition to publishing several open files, and Mineral Deposit Series Reports, the Branch completed the 1:250 000 synoptic bedrock compilation for the Knee Lake area. Similar products covering NTS sheets 63K and 63J are also scheduled for production in fiscal 1992/1993.

As part of ongoing federal/provincial and interprovincial liaison activities, and on behalf of the Provincial Geologists Committee, a paper entitled "The role of the Provincial Geological Surveys, circa 2000" was presented to the International Conference of Geological Surveys in Ottawa (April 1992). The Branch also took part in a Strategic Planning Session with the GSC in Whitehorse, Yukon Territory, immediately following the Mines Ministers Conference in September.

Progress continues in consolidating the new core storage and expediting base at the old Centennial Mine site near Flin Flon. The Flin Flon Regional office is now fully functional with both a Regional and a Staff Geologist. Plans for establishing the Thompson Office are progressing, with an opening anticipated early in 1993.

GSC geophysical programs included a regional airborne gamma ray spectrometer/VLF/magnetometer survey of southeast Manitoba, phase II of the regional airborne magnetic surveys in the Dauphin area, and an extension of gradiometer surveys into NTS areas 63J/3 and 63J/4 south of Wekusko Lake. The Dauphin area surveys were funded in part with contributions from Cameco and Uranerz. Exclusivity rights will permit release of the data in June 1993.

September 29, 1992

GS-1 GEOLOGICAL INVESTIGATIONS IN THE WALTON LAKE - EVANS LAKE AREA (PARTS OF NTS 63N/2)

by H.V. Zwanzig

Zwanzig, H.V., 1992: Geological investigations in the Walton Lake-Evans Lake area (parts of NTS 63N/2); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 4-7.

INTRODUCTION

1:20 000 scale geological mapping was carried out in an 140 km^2 area on the south flank of the Kisseynew gneiss belt (Fig. GS-1-1) to upgrade the existing 1:50 000 scale coverage (Zwanzig 1984, 1988; Zwanzig and Lenton; 1987; Zwanzig and Schledewitz, in press). The focus of the work is on high grade metamorphic volcanic rocks in the structural and stratigraphic transition zone between the Kisseynew gneiss belt and the Flin Flon volcanic belt, and addresses remaining problems in lithostratigraphy, structure and mineral potential. The mapping takes advantage of the excellent exposures produced by the forest fire of 1989, and of new access provided by logging. This project is coordinated with the structural mapping by the University of New Brunswick, and VIBROSEIS surveys by the Geological Survey of Canada under the auspices of NATMAP and LITHOPROBE.

The major findings of this year's field work are the following:

1. large areas of metavolcanic rocks were recognized on the burnt over outcrops;
2. the effects of widespread hydrothermal alteration were documented;
3. unique assemblages of units with distinctive styles of alteration and mineralization define four major recumbent structures; and
4. pre-peak metamorphic thrust faults are inferred from the stratigraphic mapping.

Very able assistance was provided by E. Hunt and Z. Andegeorgs. Access to the private roads was allowed by REPAP Manitoba Ltd.

LITHOLOGY

Rocks in the area are subdivided into four sequences, each composed of a unique assemblage of lithologic units. These sequences are given from northwest (structural top) to southeast (structural base), and, in each sequence, the units are presented in stratigraphic order where possible, with the effects of complex folding removed (Table GS-1-1). Protoliths of the gneisses are indicated in brackets.

The sequences occur on top of each other as a stack of recumbent folds (small early developed nappes) and probable thrust slices. They were transported southwest, structurally telescoped during two phases of progressive deformation, and refolded during a third phase of deformation (Fig. GS-1-1). Contacts between sequences are inferred to be early faults and synclinal traces of early fold nappes (Fig. GS-1-1).

The origin of these sequence has been suggested (Zwanzig and Schledewitz, in press) to represent coeval depositional facies; (1) proximal to the Flin Flon volcanic belt, (2) a basin-margin facies, (3) deposits from the deeper part of a basin, and (4) another structural slice from the volcanic belt, newly documented in this report.

Table GS-1-1: Sequences of Lithologic Assemblages

(4) BATTY LAKE - MEAT LAKE SEQUENCE

Missi Group
- Pale grey gneiss ± epidote ± hornblende (metasandstone), local grey-pink gneiss with magnetite (meta-arkose), minor amphibolite
- Grey-green hornblende-bearing gneiss (metasandstone) with 1 to 5 m units of amphibolite (metabasalt, in part)

conformable contact (?)

Metagreywacke (Burntwood Metamorphic Suite)
- Grey, layered, biotite gneiss, generally garnet-bearing and graphitic
- Grey,rusty, hornblende-bearing graphitic biotite gneiss ± garnet in the lower part of the unit

concordant contact

Volcanic Arc Assemblage (Amisk Group)
- Thin interlayered amphibolite and felsic gneiss (mafic and felsic tuff)
- Amphibolite ± garnet, diopside (pillowed basalt in part), locally altered to calc-silicate rock
- Light grey felsic gneiss ± garnet ± hornblende, commonly with quartz eyes (5-20%, 1-5 mm) (intrusive and extrusive varieties generally indistinguishable), local felsic volcanic breccia commonly altered to calc-silicate rock, cordierite-garnet alteration-rock at the top of the unit where the upper amphibolite unit is absent; intruded by metagabbro partly altered to calc-silicate rock
- Biotite-garnet gneiss ± hornblende (low-grade Fe-Mg alteration rock) with rusty-weathering lenses and gossan layers (disseminated sulphide minerals), interlayered with garnetiferous felsic gneiss with rare quartz eyes (felsic volcanic, volcaniclastic and high-level intrusive rocks); local biotite-rich metasedimentary units
- Cordierite-garnet ± sillimanite ± hercynite ± anthophyllite gneiss (hydrothermal Fe-Mg alteration), with altered gabbro intrusions and in contact with the Batty Lake tonalite complex, which is altered at its margin.

intrusive contact

Batty Lake Tonalite Complex
- Gneissic quartz-rich tonalite

(3) GOHL LAKE SEQUENCE

Missi Group
- Light grey to pink gneiss (meta-arkose, local pebbly beds); minor metabasalt/tuff at the base
- Pale grey gneiss ± epidote ± hornblende (metasandstone)
- Grey-green hornblende-bearing gneiss (metasandstone) with 1 to 5 m units of amphibolite ± coarse plagioclase phenocrysts (metabasalt/tuff/diabase)

conformable(?) contact

Metagreywacke (Burntwood Metamorphic Suite)
- Grey, layered biotite gneiss, generally garnet-bearing and graphitic, locally muscovite bearing

fault(?) contact with sequences 1 and 2

(2) NOKOMIS LAKE - EVANS LAKE SEQUENCE

Missi Group
- Metasandstone ± epidote
- Amygdaloidal metabasalt; coarsely plagioclase phyric basalt/tuff/sills
- Grey-green hornblende-bearing metasandstone
- Basal metaconglomerate

unconformable(?) contact

Basin-margin Amphibolite Assemblage
- Interlayered fine grained felsic gneiss (tuff/chert) and amphibolite (basalt, in part)
- Amphibolite (pillowed flows and breccia)
- Mottled quartz-hornblende-plagioclase gneiss ± garnet
- Garnet amphibolite (silicate iron formation?)
- Altered (calc-silicate bearing) metagabbro

concordant contact

Metagreywacke (Burntwood Metamorphic Suite)

- Grey, layered biotite gneiss, generally garnet bearing and graphitic, hornblende bearing at the top

(1) MOODY LAKE - DRURY LAKES SEQUENCE

Missi Group

Moody Lake intrusive complex

- Ultramafic to granodioritic

- Amygdaloidal metabasalt coarsely plagioclase phyric basalt/tuff /sills, interlayered metasandstone

- Grey-green hornblende-epidote-bearing metasandstone

- intrusive contact

- Basal conglomerate/pebbly meta-arkose

unconformable contact

Volcanic Arc Assemblage (Amisk Group)

- Interlayered fine grained felsic gneiss (tuff?) and amphibolite
- Amphibolite ± garnet ± diopside (pillowed flows in part) intruded by differentiated, locally layered melagabbro-leucogabbro-quartz diorite-tonalite
- Volcaniclastic metagreywacke, minor amphibolite

intrusive contact

Spider Lake East - Drury Lakes Intrusive Complexes

The recognition that the lower part of sequence 4 belongs to the Amisk Group supports the suggestion (Ashton and Froese, 1988) that the Sherridon Group (which is very similar to sequence 4) is also part of the Amisk Group.

STRUCTURE

Sequence 1 is interpreted to occupy a para-autochthonous infrastructure that extends northeast underneath a stack of transported structural slices and small fold nappes. It occupies much of the Moody Lake dome, and forms the roof zone and a 1.5 km by 300 m enclave in the tonalites south of Evans Lake.

Sequence 2 extends for 5 km across the Evans Lake area in the inverted limb of a synclinal nappe. Units are truncated by an inferred fault. Sequence 3 is interpreted to have a thrust fault along the base. This fault is folded, and the Missi Group is cut off in the footwall, southwest of Moody Lake. The Burntwood Suite is cut off in the hanging wall along Moody Creek. The fault is inferred to be along a sharp contact between sequence 1 Amisk Group basalt and sequence 3 metagreywacke. The fault is intruded by gabbro and pegmatite. The two faults may join near the mouth of Moody Creek to form southerly directed imbrications with sequence 1 in the footwall (Fig. GS-1-1).

Sequence 4 occupies an anticlinal nappe (Walton Lake nappe) that extends across the Meat Lake area, east through Batty Lake and northwest through Walton Lake, and a parasitic synclinal recumbent fold (Limestone Creek syncline) west of the Batty Lake complex. Rocks in the nappe contain folded quartzose mobilizate, extensional shears, and widespread rolled garnet porphyroblasts with folded inclusion trails and asymmetric pressure shadows. These structures show consistent SSW transport of the hanging wall near the peak of metamorphism.

The fold-thrust stack was refolded by recumbent structures such as the Hayhurst Lake structure (Fig. GS-1-1) and north-northeast-trending upright structures such as the Meat Lake synform. The superposed folding also produced the heart-shaped interference pattern in the Missi Group of sequence 3, southwest of Evans Lake.

Metamorphic grade is upper amphibolite facies. The thermal peak of metamorphism followed development of the fold-stack. The best preserved, and apparently lowest-grade, rocks are in the large raft within tonalite in the infrastructure west of the Drury Lakes complex (Fig. GS-1-1). The most coarsely recrystallized rocks are in the core of the Walton Lake nappe.

ALTERATION AND MINERAL POTENTIAL

Hydrothermal alteration in the area was generally produced by Fe-Mg enrichment, which is expressed as coarse porphyroblasts of garnet, cordierite and anthophyllite (up to 4 cm). Carbonatization was weaker and produced finer grained calc-silicate minerals. Abundant quartz-rich metamorphic mobilizate may indicate silicification. All alteration predated the regional metamorphism, but occurred at different stratigraphic levels.

Low grade hydrothermal alteration was nearly ubiquitous below the stratigraphic level of the metagreywacke (Burntwood Suite) in the Batty Lake - Meat Lake sequence (4). Belts of intense Fe-Mg alteration in the felsic gneisses generally extend for about 5 km and are several metres to 500 m wide. These continue down into the margin of the Batty Lake tonalite complex. Common rusty-weathering lenses contain traces of sulphide minerals, and gossan zones are locally up to 2 m thick. Gabbro in sequence 4 contains calc-silicate minerals. The gabbro in the lower part of sequence 2 also shows carbonatization, and the stratigraphically overlying mottled plagioclase gneiss is interpreted to be altered as well. One spectacular alteration pipe cuts apparently unaltered ferrodiabase between the gabbro and the mottled gneiss. Several known gold occurrences are hosted in the mottled gneiss.

The potential for finding VMS deposits in the lower part of sequence 4 is considered to be high. These rocks were originally mapped as Sherridon Group, which contains VMS deposits (Robertson, 1953). Every rock type below the Missi Group in sequence 4 has a counterpart in the Sherridon Group, but the volcanic rocks are better exposed and better preserved, and alteration is even more prominent in sequence 4. In contrast, the volcanic and intrusive rocks in sequence 1 appear to be regionally unaltered, but contain a gold deposit (Puffy Lake), and a gold occurrence (Martell Lake, southeast of the area), that have associated alteration.

REFERENCES

Ashton, K.E. and Froese, E.

1988: Could the Sherridon Group at Sherridon be a high-grade equivalent of the Amisk Group?; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 183-184.

Robertson, D.S.

1953: Batty Lake map-area, Manitoba; Geological Survey of Canada, Memoir 271, 55p.

Zwanzig, H.V.

1984: Kisseynew Project: Lobstick Narrows - Cleunion Lake, Puffy Lake and Nokomis Lake areas; **in** Manitoba Energy and Mines, Mineral Resources, Report of Field Activities, 1984, p. 38-45.

1988: Kisseynew Project: Batty Lake region; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 49-52.

Zwanzig, H.V. and Lenton, P.G.

1987: Kisseynew Project: Limestone Point Lake - Star Lake areas; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1987, p. 55-64.

Zwanzig, H.V. and Schledewitz, D.C.P.

in press: Geology of the Kississing - Batty lakes area, Interim Report; Manitoba Energy and Mines, Minerals Division, Open File Report OF92-2.

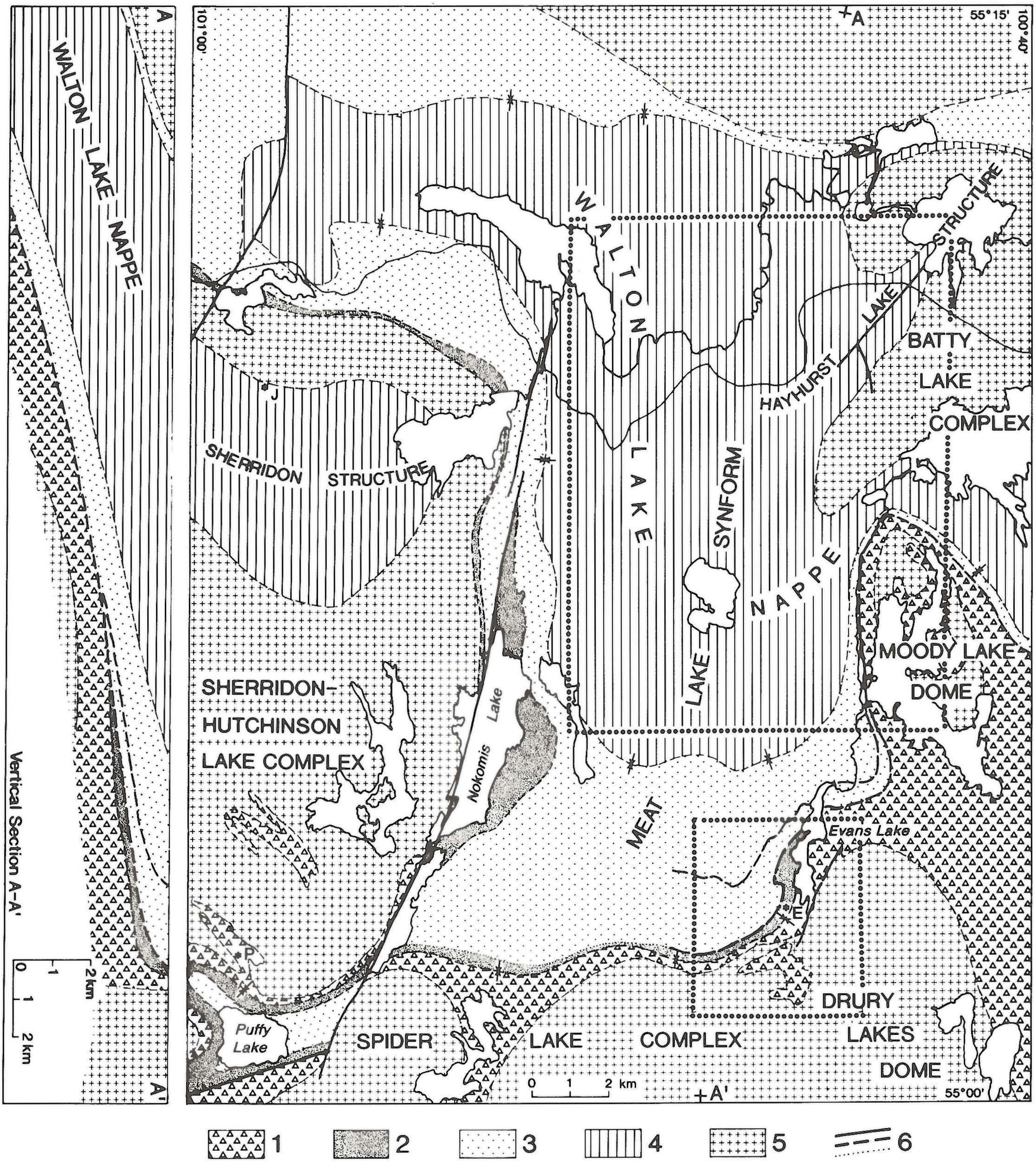

Figure GS-1-1: *Outlines of detailed map areas on sketch map with vertical section, showing structural units defined by sequences of lithologic assemblages: 1) Moody Lake-Drury Lakes Sequence; 2) Nokomis Lake-Evans Lake Sequence; 3) Gohl Lake Sequence; 4) Batty Lake-Meat Lake Sequence and Sherridon Group; 5) Granitic rocks; and 6) Faults (approximate, inferred, extended into drift cover). Dashed contacts with arrows are inferred traces of synclinal nappes. Stars are mineral deposits/occurrences: (J) Jungle Lake Cu-Zn, (P) Puffy Lake Au, (N) Nokomis Lake Au; and (E) Evans Lake Au.*

GS-2 GEOLOGY OF THE WEBB LAKE-FAY LAKE AREA (NTS 63K/14NE, 63K/15 NW)

by D.C.P. Schledewitz

Schledewitz, D.C.P., 1992: Geology of the Webb Lake-Fay Lake area (NTS 63K/14NE, 63K/15 NW); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 7-9.

INTRODUCTION

The Webb Lake-Fay Lake project was initiated in 1990 to take advantage of the high quality bedrock exposures that resulted from extensive deforestation by forest fires in 1989. Mapping in 1992 was conducted in the region from Fay Lake to Webb Lake, between Fay Lake and King Lake, and between Webb Lake and Spider Lake (Fig. GS-2-1).

PREVIOUS WORK

The area of Fay Lake and Webb Lake was mapped at 1:63 360 as part of the Elbow-Heming Lakes Area (McGlynn, 1959). Webb Lake was examined briefly by Syme (1978).

GENERAL GEOLOGY

Amisk Group mafic, and felsic volcanic and volcaniclastic rocks occur throughout the map area (Schledewitz, 1990, 1991). These rocks are intruded by medium grained gabbro sills, and quartz and quartz-plagioclase porphyry dykes and sills. The gabbro sills are 1 to 700 m thick and vary in strike length from several metres to 3 km. The Saddle Lake gabbro is the largest single body (0.7 by 3 km), whereas other intrusions range from a single narrow sill, to sill and dyke complexes that make up 50% of the bedrock exposures in certain areas. The gabbro sills are interpreted to be synvolcanic and are most common in the volcanic sequences exposed at, and east of, Fay Lake. The felsic porphyry dykes are most common in the Webb Lake area.

The Amisk Group rocks are unconformably overlain by Missi Group basal conglomerate and quartzofeldspathic paragneisses. The Missi Group rocks outcrop north of Fay Lake and have been traced 8.5 km between Fay Lake and Wajusk Lake. The easterly continuation of the Missi Group basal conglomerate and overlying paragneisses will be examined in 1993.

Two large composite intrusive bodies, the Echo Lake pluton (Whalen, 1991) and the Gauthier Lake pluton (Syme, 1991), underlie over 50% of the area. The Echo Lake pluton is a quartz diorite to hornblende-biotite granodiorite that extends from southeast of Fay Lake to the west shore of Webb Lake. The Gauthier Lake pluton is a quartz phyric, variably hornblende-bearing granodiorite to granite that outcrops east and north of Webb Lake. Intrusion of quartz-rich granite, with up to 40% quartz phenocrysts, accompanied or postdated intrusion of the Gauthier Lake pluton, as did intense silicification, and alkali

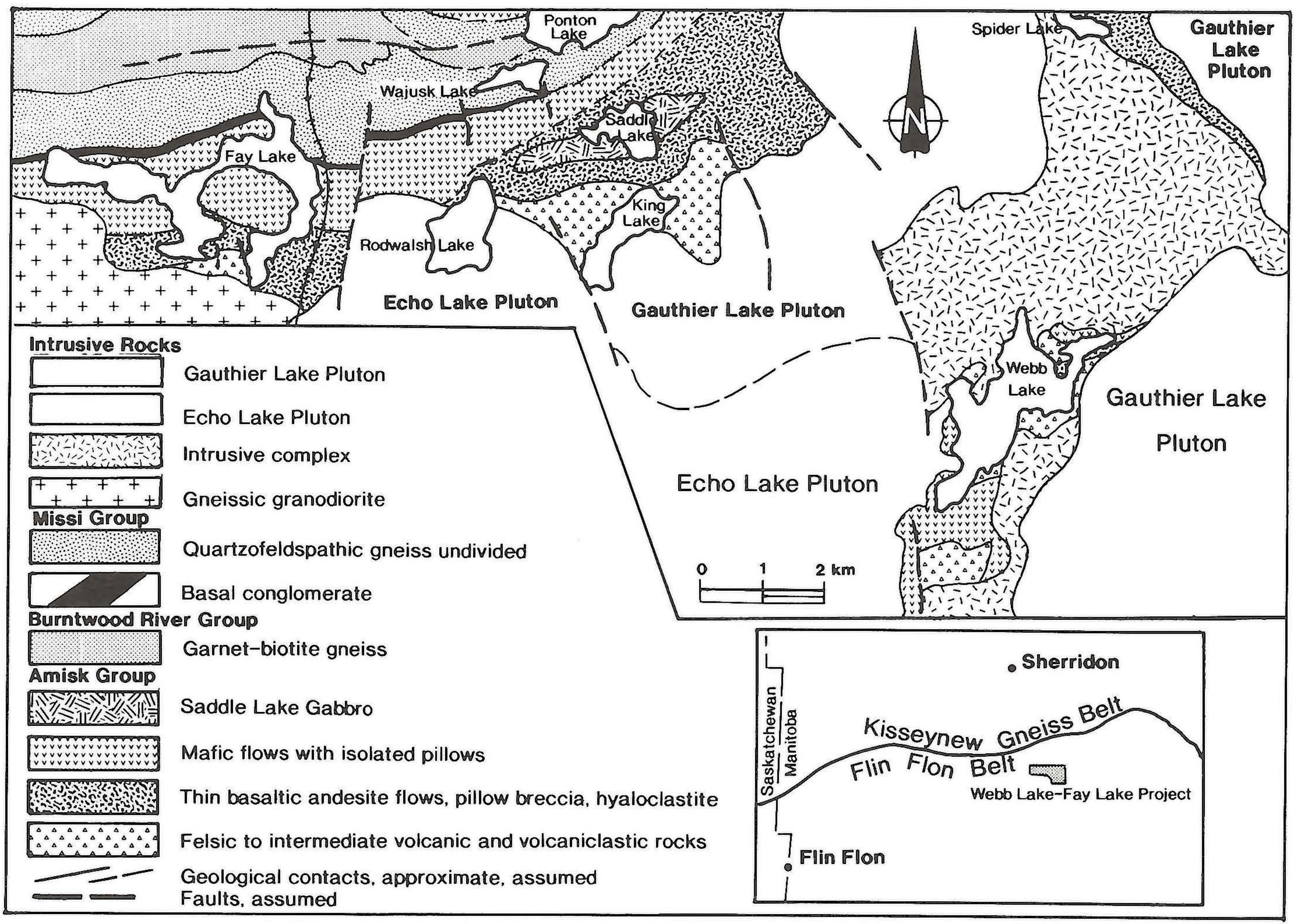

Figure GS-2-1: Simplified geology of the Webb Lake-Fay Lake Area.

and sulfide mobility along its margins and within the supracrustal rocks in the Webb Lake area.

The volcanic rocks at Webb Lake were cut by multiple intrusions prior to the emplacement of the Echo Lake and Gauthier Lake plutons. The area south of Webb Lake, north to Spider Lake, is a complex roof pendant of supracrustal rocks and postvolcanic intrusion breccia that appears to lie on the margins of both of the Echo Lake and Gauthier Lake plutons.

The supracrustal rocks were deformed into upright large scale folds that predate the emplacement of the large complex plutons. A period of deformation characterized by shearing and faulting along easterly- and northerly-trending zones of deformation postdates the emplacement of the Echo Lake and Gauthier Lake plutons.

WEBB LAKE-SPIDER LAKE REGION

Mapping in the Webb Lake-Spider Lake region concentrated on supracrustal rocks at Spider Lake, and the intrusive complexes between Webb Lake and Spider Lake, and to the west and south of Webb Lake.

SPIDER LAKE BASALT

The Spider Lake basalt occurs as a southeasterly-trending narrow linear zone with a strike length of 4 km and a width of 200 to 600 m. The basalt extends into the Batty Lake map area (Zwanzig, 1988). It is flanked to the north by the Gauthier Lake granodiorite and to the south by fine grained tonalite, quartz porphyry and quartz-rich granites. Primary layering on the south shore of Spider Lake trends southeast for 1 km, dips south and tops to the south. Flattened pillows and pillow breccia fragments are folded and have a moderately steep southeasterly plunge.

Supracrustal rocks at the north contact with the Gauthier Lake granodiorite represent the lowermost part of the stratigraphy. They comprise a suite of very fine grained, dark green mafic rocks with thin variably garnet + magnetite-bearing interlayers intruded by fine grained diorite sills. This suite is overlain by well foliated, uniform green, buff weathering variably plagioclase phyric basalt (with tectonically flattened epidosite domains) interpreted to be a deformed pillowed mafic flow. This unit is overlain by a 24 m thick unit that comprises thin layers of amygdaloidal pillowed basalt, pillow fragment breccia and hyaloclastite, and is in turn overlain by a massive mafic flow. This flow sequence indicates stratigraphic facing directions are upright to the southwest. The uppermost massive flow is truncated by intrusions that extend to the south of Spider Lake .

The rocks exhibit a well developed tectonic fabric, which varies from a schistosity to a metamorphic layering that parallels the margins of the Spider Lake basalt. The metamorphic layering is overprinted by two sets of steeply-dipping crenulation cleavage that trend 165° and 012°. A system of conjugate faults (with sinistral displacement along northerly trends and dextral displacement on trends of 130°) offsets the metamorphic layering and the intrusive contacts with the Gauthier Lake pluton.

INTRUSIVE COMPLEX

An intrusive complex that contains xenoliths of supracrustal and igneous rocks forms a north-trending belt *ca.* 1.5 to 2.0 km wide and 10 km long. Fine grained variably quartz phyric tonalite, in part with abundant mafic xenoliths, is the main intrusive rock type. The tonalite postdates emplacement of gabbro to ultramafic intrusions and fine grained diorite. Intrusion breccia composed of a tonalite matrix and variable amounts of mafic inclusions, that range from 1 cm to several metres, are common throughout this zone. This complex was intruded by the Echo Lake hornblende-biotite granodiorite, and then by quartz porphyry that contains 15 to 40%, 1 to 5mm quartz phenocrysts. Quartz-rich granodiorite to granite of the Gauthier Lake pluton was the last major phase of intrusion. These rocks are differentially deformed. Some weakly foliated zones, with only slightly flattened intrusion breccia xenoliths, grade into broad, tectonically laminated high strain zones.

FAY LAKE-SADDLE LAKE AREA

Mapping in the Fay Lake-Saddle Lake area concentrated on the metavolcanic rocks of the Amisk Group from the east end of Fay Lake to a point 2 km to the east of Saddle Lake. The Amisk Group rocks in the eastern part of Fay Lake were mapped previously (Parbery, 1986; Schledewitz, 1990). Overlying Missi Group rocks were examined from the west end of Fay Lake to the east end of Wajusk Lake.

AMISK GROUP ROCKS

Felsic volcanic and volcaniclastic rocks occur at the southeast end of Fay Lake, and from the northeastern shore of Rodwalsh Lake to King Lake. The felsic rocks are structurally overlain by a sequence of interlayered, pale green weathering plagioclase phyric and hornblende phyric basaltic andesite, dark green weathering mafic volcanic flows and flow breccia, amygdaloidal pillow basalt with pillow breccia and rare laminated mafic interflow sediment. At one location a well-preserved sequence of trough-laminated sedimentary rock overlies an uneven flow surface; this indicates an upright north-facing flow sequence. The flows are overlain by compositionally uniform, fine grained, well foliated metabasalt that contains diorite, gabbro and diabase sills. The basaltic rocks appear to have massive and pillowed components. The pillowed component is indicated by areas of thin epidosite lenses interpreted to be highly tectonized pillow cores and selvages. This unit of multiple basaltic flows is 1200 m thick at Fay Lake and appears to thin to 500 m north of Saddle Lake. The intensity of tectonic overprint decreases to the northeast along strike from Fay Lake, to the area north of Saddle Lake. In the region north of Saddle Lake flattened pillow basalt grades into massive, variably amygdaloidal basalt; however, the large volume of gabbro sills and dykes makes continuous mapping of individual flow units very difficult.

The Echo Lake pluton truncates the volcanic stratigraphy to the south and east of Fay Lake, and the Gauthier Lake pluton truncates the easterly trend of volcanic rocks northeast of Saddle Lake. The Amisk Group volcanic rocks are overlain to the north by Missi Group rocks.

MISSI GROUP

Missi Group basal conglomerate is 10 to 50 m thick and extends almost continuously for 8.5 km from the west end of Fay Lake to the east end of Wajusk Lake. The one exception is the area on the north-trending short limb of a large Z-fold at the east end of Fay Lake. At this locality the conglomerate is attenuated, and granite is intruded. The basal conglomerate is clast-supported and has a variably hornblende-bearing, biotite-feldspar matrix with abundant epidote and quartz. The clasts are mafic volcanic, minor quartz porphyry, diorite, tonalite, rare granite, vein quartz and magnetite-quartz iron formation. The clasts are flattened, elongated down dip in the plane of the steep foliation, and have aspect ratios of 4.5 : 1 : 18.

The conglomerate is overlain by 100 to 400 m of variably cross-bedded meta-arkose with isolated pebble beds and cobbles. The arkose as intruded by mafic dykes and sills that predate the peak of metamorphism and subsequent deformation. A 200 to 300 m thick suite of interlayered hornblende-epidote-bearing, quartzofeldspathic and grey biotite-feldspar-quartz paragneiss overlies the meta-arkose. The average thickness of the Missi Group appears to be 700 m. A 1600 m thick sequence of Missi Group in the large Z-fold at the east end of Fay Lake suggests considerable thickening has taken place in the north trending short limb of this structure during deformation.

BURNTWOOD RIVER GROUP

Burntwood River Group garnet-biotite-quartz-feldspar paragneiss overlies the Missi Group north of Fay Lake. The contact between them has been mapped intermittently over a distance of 4 km to the east immediately west of Wajusk Lake. The Missi Group and Burntwood River Group rocks are highly strained on either side of this contact, which has been folded into a series of tight S-folds. This tight folding contrasts with the style of deformation observed along the southern contact of the Missi Group with the Amisk Group. There, the contact, although highly strained as indicated by the fabric in the basal conglomerate, is not folded except for the large Z-fold at the east end of Fay Lake. The differential movement on opposite sides of the Missi Group argues for a strain gradient and possible tectonic detachment within the Missi Group.

ECHO LAKE PLUTON

The composite Echo Lake pluton has been mapped from the east side of Fay Lake to the west side of King Lake, and along the southwest side of Webb Lake. A segment of the pluton was also mapped 8 km to the southwest of Webb Lake at Echo Lake in the Elbow Lake map area (Whalen, 1991). The interpretation that the pluton extends from the east side of Fay Lake to the west side of Webb Lake will be tested in 1993. The western segment of the pluton ranges from a massive, medium grained, hornblende-biotite-quartz diorite that grades eastward to a hornblende-biotite granodiorite. At Webb Lake the pluton has a margin of hornblende-quartz diorite with abundant inclusions of melagabbro, gabbro, diorite and less common pyroxenite. To the west of this zone hornblende-biotite granodiorite is predominant.

GAUTHIER LAKE PLUTON

The Gauthier Lake pluton ranges from quartz-rich granite to biotite granodiorite with variable hornblende content. The quartz-rich granite phase appears to be intrusive into the granodiorite. The granodiorite occurs along the west side of the supracrustal-intrusive complex that extends from south of Webb Lake to Spider Lake. It also occurs on the northwest side of the supracrustal-intrusive complex where it appears to intrude foliated rocks of the Echo Lake pluton. The quartz-rich granite phase most commonly occurs in the area from King Lake to Spider Lake

REFERENCES

McGlynn, J. C.
1959: Elbow-Heming Lakes Area, Manitoba; Geological Survey of Canada, Memoir 305, 72p.

Parbery, D.
1986: Mineral occurrence studies - Flin Flon area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1986, p. 49-55.

Syme, E. C.
1978: Elbow Lake Reconnaissance; **in** Manitoba Mines, Resources and Environmental Management, Mineral Resources Division, Report of Field Activities, 1978, p. 20-23.
1991: Elbow Lake Project-Part A: Supracrustal Rocks and Structural Setting; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 14-27.

Schledewitz, D. C. P.
1990: Webb Lake-Fay Lake; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 58-61.
1991: Geology of the Webb Lake Area; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 5-7.

Whalen, J. B.
1991: Elbow Lake Project-Part B: Granitoid Rocks; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 28-30.

Zwanzig, H. V.
1988: Kisseynew Project: Batty Lake Region; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 49-52.

GS-3 BASE METAL INVESTIGATIONS IN THE JUNGLE LAKE AREA OF THE KISSEYNEW GNEISS BELT (NTS 63N/)2

by G. Ostry

Ostry, G., 1992: Base metal investigations in the Jungle Lake area of the Kisseynew Gneiss Belt (NTS 63N/2); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 10-14.

INTRODUCTION

A multiyear mineral investigations project designed to determine the geological setting of base metal deposits/mineralization within the Kisseynew gneiss belt was initiated in 1990 (Ostry and Bieri, 1990). During 1992 a 1:5 000 geological mapping project covered an area of recent (1989) burn northeast of Sherridon, Manitoba and south of Jungle Lake (Fig. GS-3-1) in the vicinity of the Jungle Lake massive sulphide deposit.

GEOLOGY

Rocks exposed at the surface in the map area compose a north-dipping homoclinal sequence of medium- to coarse-grained layered intermediate to mafic hornblende-feldspar $\pm$ garnet $\pm$ quartz gneiss that is structurally underlain by a sequence of medium- to coarse-grained, quartz-rich, quartzofeldspathic $\pm$ biotite and/or hornblende - garnet gneiss (Fig. GS-3-2).

The intermediate to mafic gneiss (Unit 4, Fig. GS-3-2) is predominantly grey weathered, fine- to medium-grained, and is layered on the order of centimetres to tens of centimetres. The contact with the tonalite (Unit 7, Fig. GS-3-2) is marked by breccia that comprises intermediate to mafic gneiss fragments in a tonalite/pegmatite matrix, or interleaved intermediate to mafic gneiss and less than 1 m wide tonalitic sills. Conformable lenses of medium- to coarse-grained mafic to ultramafic amphibolite or hornblendite (Unit 5, Fig. GS-3-2) form an important constituent of this unit (Fig. GS-3-2). Minor amounts of fine grained disseminated pyrite and graphite were documented in Unit 2 at its southern contact with the quartz-rich quartzofeldspathic gneiss unit.

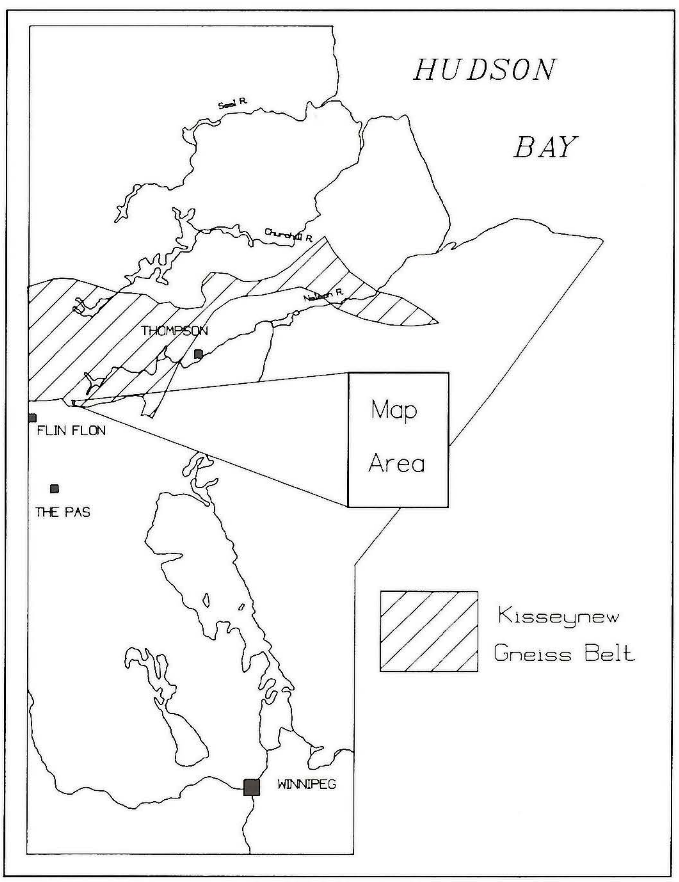

Figure GS-3-1: Location of 1992 project area.

The quartzofeldspathic gneiss (Unit 1, Fig. GS-3-2) is predominantly a layered, medium grained to very coarse grained, felsic, quartz - feldspar - garnet - biotite and/or hornblende gneiss. These rocks are easily identified by a distinctive ridgy texture on weathered surface. This texture delineates numerous closely spaced (mm scale) quartz-rich segregations that form discontinuous, parallel to sub-parallel, 1 to 3 mm wide quartz ribbons throughout the rock. Very coarse grained, up to 7 cm but more commonly 2 to 4 cm, sieve textured, subhedral to anhedral garnets, or aggregations of finer grained garnets, are also a typical component of these rocks. The quartz ribbons either deflect around or cut through the garnets. Compositional layering is on the order of centimetres to tens of centimetres thick within the felsic rocks and is usually distinguished by the biotite, hornblende and/or garnet content of the layers. Locally, layers contain up to 2% fine grained epidote and less than 5 by 3 cm calc-silicate pods. Calc-silicate layers that range from a few centimetres to 1 m or more in thickness, and mafic to intermediate garnet - hornblende $\pm$ biotite $\pm$ Fe-sulphide layers on the order of centimetres to tens of centimetres thick, are important local constituents of the stratigraphy. In the south portion of this unit three layered sequences of intermediate, massive, fine- to medium-grained hornblende - feldspar $\pm$ garnet $\pm$ quartz gneiss (Unit 2, Fig. GS-3-2) were documented. Layers are on the order of meters thick and locally exhibit polygonal joint outlines that are distinguished by concentrations of hornblende and garnet $\pm$ feldspar (Fig. GS-3-3). Where deformed, the polygonal joint outlines can resemble pillow shapes.

A unit/zone that contains white weathered pegmatite, tonalitic rock, and hybridized quartz-rich quartzofeldspathic gneiss (Unit 6, Fig. GS-3-2) locally crosscuts stratigraphy near the south margin of the map area. This unit probably represents an area of pegmatite and tonalite intrusion or partial anatexis of the quartz-rich quartzofeldspathic gneiss.

STRUCTURE

At least three and possibly four periods of deformation have affected the rocks in the map area. The earliest deformation recognized (D_1) produced a well developed foliation (S_1) defined by biotite and/or hornblende alignment parallel to compositional layering. Small-scale intrafolial folds within the intermediate to mafic gneiss unit (Fig. GS-3-4) display an axial plane foliation (S_1) and may have been produced during D_1 deformation. The second deformation (D_2) produced small-scale flat lying S-asymmetry flexural folds (F_2) that fold the S_1 foliation (Fig. GS-3-5). Locally, a well developed stretch lineation that plunges approximately 20° to 30° at 020° to 040° is defined by pressure shadows about garnet and hornblende porphyroblasts, and is parallel or close to parallel with F_2 fold axes generated during D_2. D_3 deformation produced local small-scale F_3 folds that deform F_2 minor folds (Fig. GS-3-6) about axes with shallow plunges to the north and steeply dipping axial planes that exhibit north-trending axial traces (*cf.* Ostry, 1988).

ALTERATION AND MINERALIZATION

Local occurrences of hydrothermally altered rocks associated with pyrite - pyrrhotite $\pm$ chalcopyrite mineralization were recognized south of the Jungle Lake massive sulphide deposit (Fig. GS-3-7). Alteration assemblages included: a) areas/veins composed of coarse grained to very coarse grained red garnet (up to 90%) and hornblende with or without biotite (Fig. GS-3-8); b) coarse grained to very coarse grained hornblende-rich (up to 90%) areas/veins with or without garnet or biotite; and c) up to 90% blocky aggregations (up to 15 cm by 15 cm) of pink garnet (Fig. GS-3-9). Alteration assemblages 'a' and, less

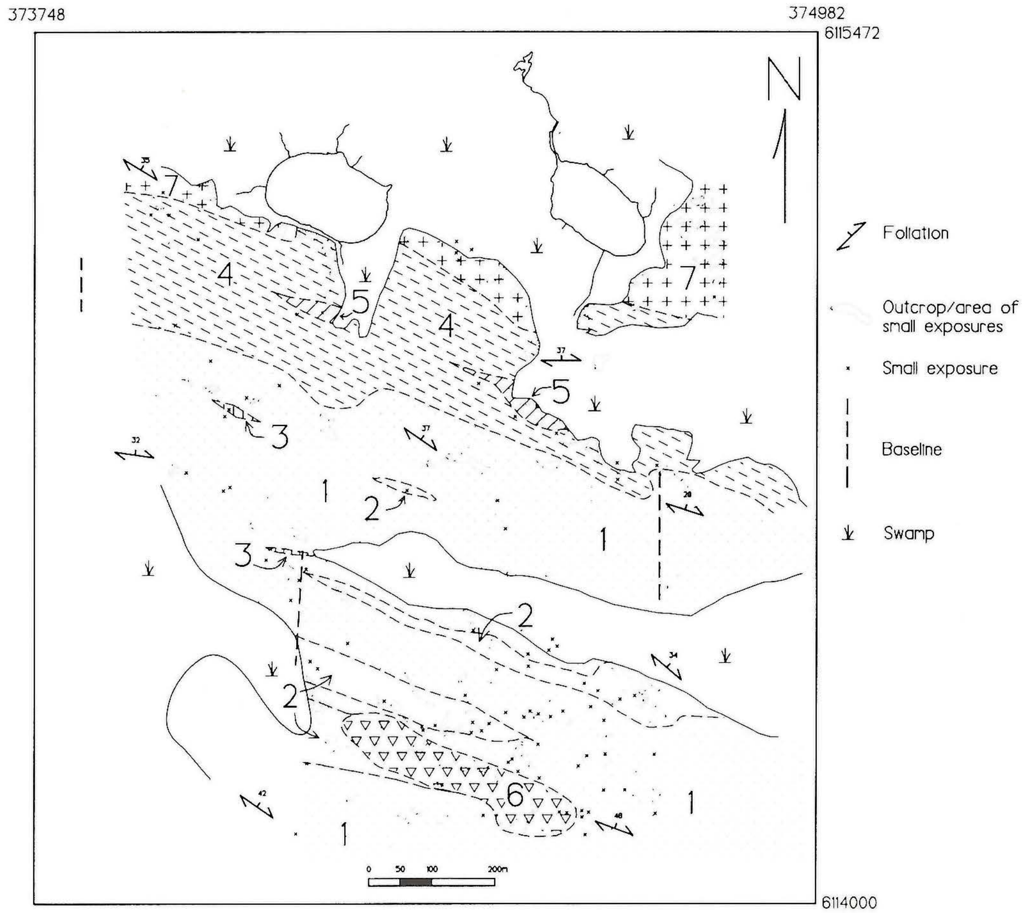

Figure GS-3-2: *Geology south of Jungle Lake, Manitoba. Legend: 1) medium to very coarse grained, felsic quartz-feldspar-garnet-biotite and/or hornblende gneiss; 2) intermediate, massive, fine- to medium-grained hornblende - feldspar ± garnet ± quartz gneiss; 3) calc-silicate rock; 4) medium grained intermediate to mafic hornblende-feldspar ± garnet ± quartz gneiss; 5) medium- to coarse-grained mafic to ultramafic amphibolite or hornblendite; 6) white weathered pegmatite, tonalitic rock, and hybridized quartz-rich quartzofeldspathic gneiss; and 7) medium- to coarse-grained tonalite.*

Figure GS-3-3: *Polygonal joint outlines in Unit 2 that are distinguished by hornblende and garnet ± feldspar.*

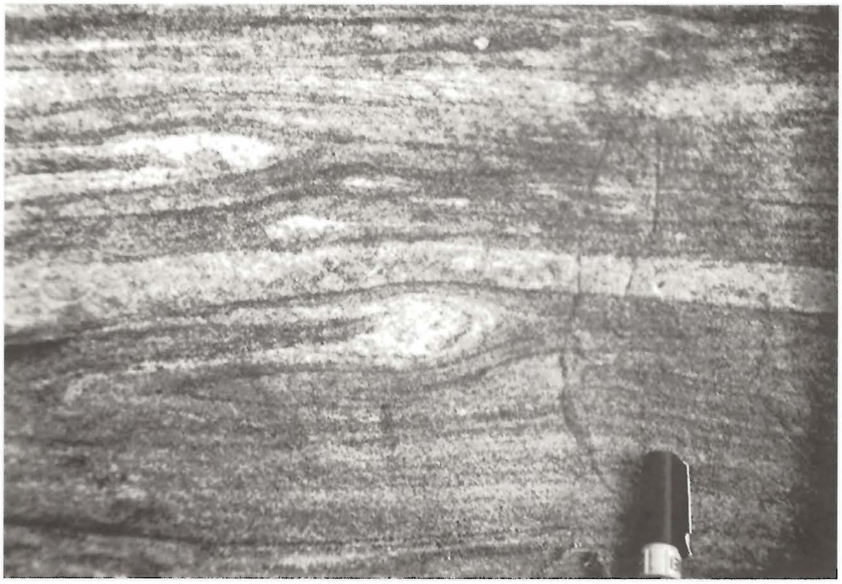

Figure GS-3-4: *Small-scale intrafolial folds in Unit 4 displaying an axial plane foliation (S_1).*

Figure GS-3-5: *Small-scale flat lying S-asymmetry flexural fold (F_2) in Unit 1 that folds the S_1 foliation.*

Figure GS-3-6: *The upper limb of an flat lying S asymmetry flexural F_2 fold in Unit 1 deformed by small-scale folds (F_3) that have axes with shallow plunges to the north and steeply dipping axial planes.*

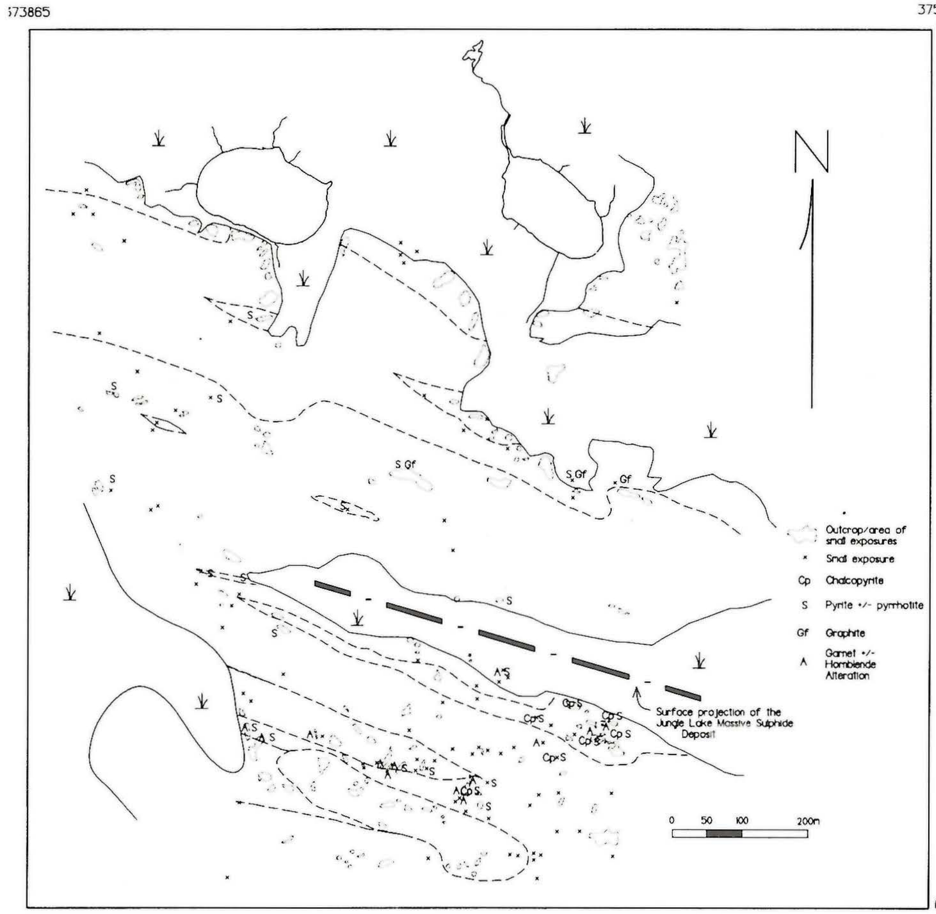

Figure GS-3-7: *Surface projection of the Jungle Lake massive sulphide deposit (HBED/HBM&S written communication, 1990) and the location of hydrothermally altered rocks and sulphide mineralization in the 1992 project area.*

Figure GS-3-8: *Areas/veins composed of coarse- to very coarse-grained red garnet and hornblende with or without biotite in Unit 1/Unit 2.*

Figure GS-3-9: *Very coarse blocky aggregations (up to 15 cm by 15 cm) of pink garnet in Unit 1.*

commonly, 'b' occur within the intermediate hornblende-feldspar layers. Alteration composition 'c' preferentially occurs within the quartz-rich quartzofeldspathic gneiss. These alteration compositions all reflect enrichment of iron in the host rocks and occur within areas of rusty weathered rock. High magnesium minerals were not recognized. Adjacent to these areas less intense alteration is manifested by rusty weathered garnet porphyroblasts in otherwise visually nonaltered rock. These rocks contain 1% or less fine grained pyrite ± pyrrhotite ± chalcopyrite grains (Fig. GS-3-7) that commonly form the cores of garnet porphyroblasts.

Minor amounts of disseminated pyrite and/or pyrrhotite were documented elsewhere in the area (Fig. GS-3-7).

Diopside-carbonate alteration has locally affected all rocks in the map area and is most conspicuous within the intermediate to mafic/ultramafic rock units. Sulphide mineralization is not commonly associated with this type of alteration.

SUMMARY

The garnet ± hornblende alteration associated with the Fe sulphide and chalcopyrite mineralization may represent part of an iron-rich hydrothermal alteration pipe related to formation of the Jungle Lake massive sulphide deposit. The Jungle Lake massive sulphide deposit is Fe sulphide rich and comprises near solid pyrrhotite and pyrite, and blebs and stringers of chalcopyrite and sphalerite (HBED/HBM&S written communication, 1990). The iron-rich nature of the deposit may be a reflection of an iron-enriched hydrothermal feeder system.

ACKNOWLEDGEMENTS

Ed Kowalyk and Tim Tuba are thanked for their able assistance during the course of the field work.

REFERENCES

Ostry, G.
1988: Mineral Investigations in the Kisseynew gneiss terrain; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 80-83.

Ostry, G. and Bieri, M.
1990: Investigation of base metal potential in the Sherridon area (NTS 63N/2); **in** Manitoba Energy And Mines, Minerals Division, Report of Field Activities, 1990, p. 95-97.

GS-4 GEOLOGICAL INVESTIGATIONS OF THE BAKER PATTON FELSIC COMPLEX (NTS 63K/12 AND 63K/13)

by G.H. Gale, M. Simpson and J. Underhill

Gale, G.H., Simpson, M. and Underhill, J., 1992: Geological investigations of the Baker Patton Felsic Complex (NTS 63K/12 and 63K/13); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 15-18.

INTRODUCTION

Geological mapping of the Baker Patton Felsic Complex (NTS 63K/12 and 63K/13) was continued on the peninsula south of the Pine Bay deposit (Sourdough Peninsula) and in an area northeast of Thompson Lake (Leo Lake area). The ten week program, undertaken mainly by the two junior authors, attempted to delineate the major lithologic units within the predominantly rhyolitic extrusive rocks of the Complex (Fig. GS-4-1). Portions of the Complex have been mapped previously at 1:5 000 and larger scales by Gale and Foote (1988), Norquay and Gale (1990) and Ferreira (1991). Complete coverage of the Complex will require an additional field season.

Outcrops were mapped using available cut grid lines and 1:5 000 scale airphotos. The main geological subdivisions are illustrated in Figures GS-4-2 and GS-4-3, and selected units are described below. The geological data has been digitized and the information is available in either digital or paper copy upon request.

SOURDOUGH PENINSULA

The peninsula south of the Pine Bay deposit consists predominantly of rhyolitic rocks that have been intruded by quartz and feldspar porphyry, diorite-gabbro and quartz and feldspar- bearing rhyolite dykes (Fig. GS-4-2).

Unit 1 consists predominantly of 1 to >5 m thick lobes/dykes of massive aphyric, white, grey-white and reddish (potassic alteration ?) weathered rhyolite that is grey to black on fresh surfaces. One to 5 mm vesicles are common. Feldspar phyric (1-5% white, 1-2 mm phenocrysts) rhyolite dykes are also scattered throughout the unit, but the percentage of dykes in this unit is not known. Up to 50 cm thick lenses/dykes of aphyric black rhyolite, with sparse to over 50% spherulites, are also scattered throughout this, and other units of rhyolite. Unit 1 is characteristically magnetic; locally, it contains 1 to 2 mm grains of pyrrhotite and several tens of centimetre oval shaped lenses of epidosite.

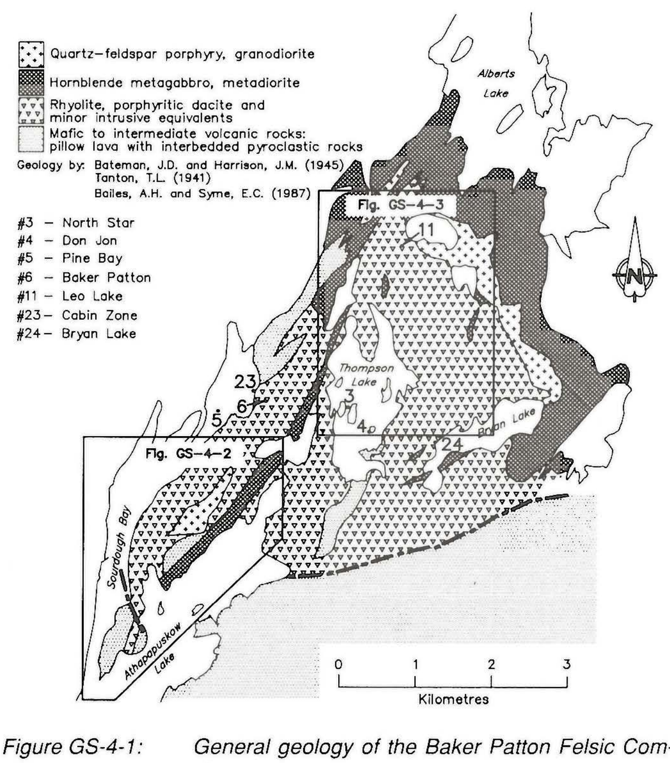

Figure GS-4-1: General geology of the Baker Patton Felsic Complex.

Unit 2 consists predominantly of aphyric to sparsely feldspar phyric, buff to brownish weathering rhyolite flows. The flows contain massive fine grained granular textured rhyolite, flow breccia and massive vesicular white weathered grey rhyolite lobes. Although contacts are normally difficult to distinguish on lichen covered outcrops, individual rhyolite flows have been determined to be 5 to 10 m thick at several localities, but flow thicknesses of several tens of metres occur in the southern part of the unit. The flow breccia generally consists of 10 to 20 cm fragments of granular textured amygdaloidal rhyolite with indistinct margins supported by a matrix of granular textured rhyolite identical to the massive granular rhyolite portions of the flow. Locally, angular fragments of vesicular and amygdular flow banded (mm scale) rhyolite have amygdules up to 10 mm in length by a few mm in thickness; the amygdule/cavity content of these rocks varies from over 30% in the angular fragments to 10% in the flow breccia fragments, 5 to 10% in the massive lobes and nil in the massive granular rhyolite. The angular fragments are interpreted as chilled blocks of the original highly gas charged flow that subsequently reacted completely with water to form the massive granular textured rhyolite (sand sized hyaloclastite); partial reaction of the flow with water formed flow breccia that consists of interfragment hyaloclastite and fragments, in which some of the vesicles collapsed during continued movement of the flow.

Visually the massive flinty lobes of rhyolite resemble the grey weathered lobes/dykes that form part of Unit 1.

Unit 3 is a fine grained, massive, white-weathering rhyolite with local flow banding and minor interlobe microbreccia/hyaloclastite. The microbreccia has developed a pronounced foliation in contrast to the massive rhyolite. This unit occurs along the western margin of the peninsula; its relationship to megascopically similar rhyolites (unit 3a) on the eastern margin of the peninsula is not certain.

Unit 3a consists predominantly of white weathered massive aphyric (?) rhyolite lobes and up to 30% fine grained foliated interlobe microbreccia. Locally, this unit contains flows/dykes with 2 to 3% quartz phenocrysts. Quartz phyric and aphyric rhyolite dykes are distinguishable in several places, but constitute less than 5% of the rocks by volume.

Rhyolitic pyroclastic rocks (unit 4) are exposed in several outcrops near the southern tip of the peninsula. One exposure consists of crudely layered ash to 30 cm sized angular rhyolite fragments; the larger fragments tend to be concentrated towards the central parts of the layers. Some of these rocks may be debris flows. These possible debris flows are intruded by lobes of rhyolite and are separated from Unit 5 basalt by a 10 to 30 m thick rhyolite flow.

Two units of basaltic rocks are exposed near the southern end of the peninsula. Unit 5 is a brownish green to dark green rock and is composed of 20 to 40 cm subrounded blocks of massive (epidotized ?) basalt in a schistose mafic matrix; the matrix composes 20 to 70% of the rock. Locally, there are 10 to 20 cm amoeboid shaped dark green fragments in a fine grained foliated dark green matrix. Unit 6, which structurally overlies a reworked volcaniclastic breccia that contains both rhyolitic and mafic fragments, contains an amygdaloidal basaltic flow at its eastern margin, but consists predominantly of basaltic flow breccia with 20 to 30 cm amygdaloidal fragments separated by a fine grained basaltic matrix, which probably represents fine grained hyaloclastite.

Fine- to medium-grained, quartz- and feldspar-bearing rhyolitic dykes (unit 8) occur throughout the area (Fig. GS-4-2). The 5 to 30 cm margins of these dykes consist mostly of brown weathering aphanitic rhyolite with <5 to 10% phenocrysts, whereas the main body of the dykes contain over 50% quartz and feldspar crystals. Locally, these

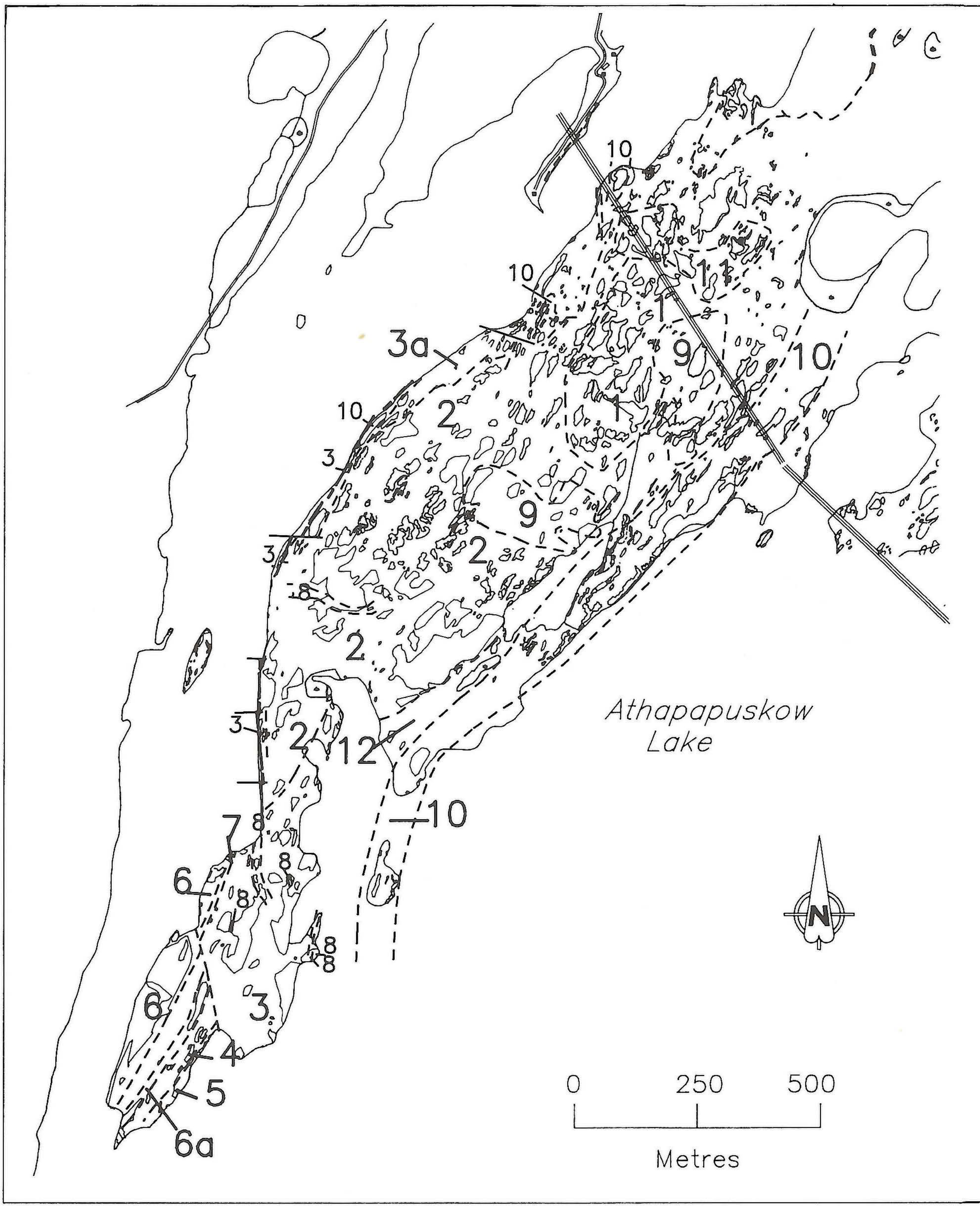

Figure GS-4-2: Geology of the Sourdough Peninsula. Legend: 1).Massive dykes and lobes of aphyric and feldspar phyric rhyolite (in part related to unit 2); 2) Rhyolite flows-dominantly brownish weathered hyaloclastite and flow breccia and minor grey vesicular massive lobes; 3) Rhyolite flow-white weathered aphyric rhyolite lobes and brown weathered microbreccia (generally <10% of rock), 3a. Rhyolite flow lobes and up to 30% interlobe microbreccia; 4) Rhyolite breccia and minor rhyolite flows; 5) Basaltic flow; 6) Amygdaloidal basaltic flow breccia, 6a. Basaltic sill or flow; 7) Layered polymictic breccia; 8) Quartz-feldspar rhyolite dykes; 9) Quartz-feldspar porphyry; 10) Diorite/gabbro - fine- to medium- grained; 11) Diatreme; 12) magnetite-bearing silicic rocks in a chloritic matrix.

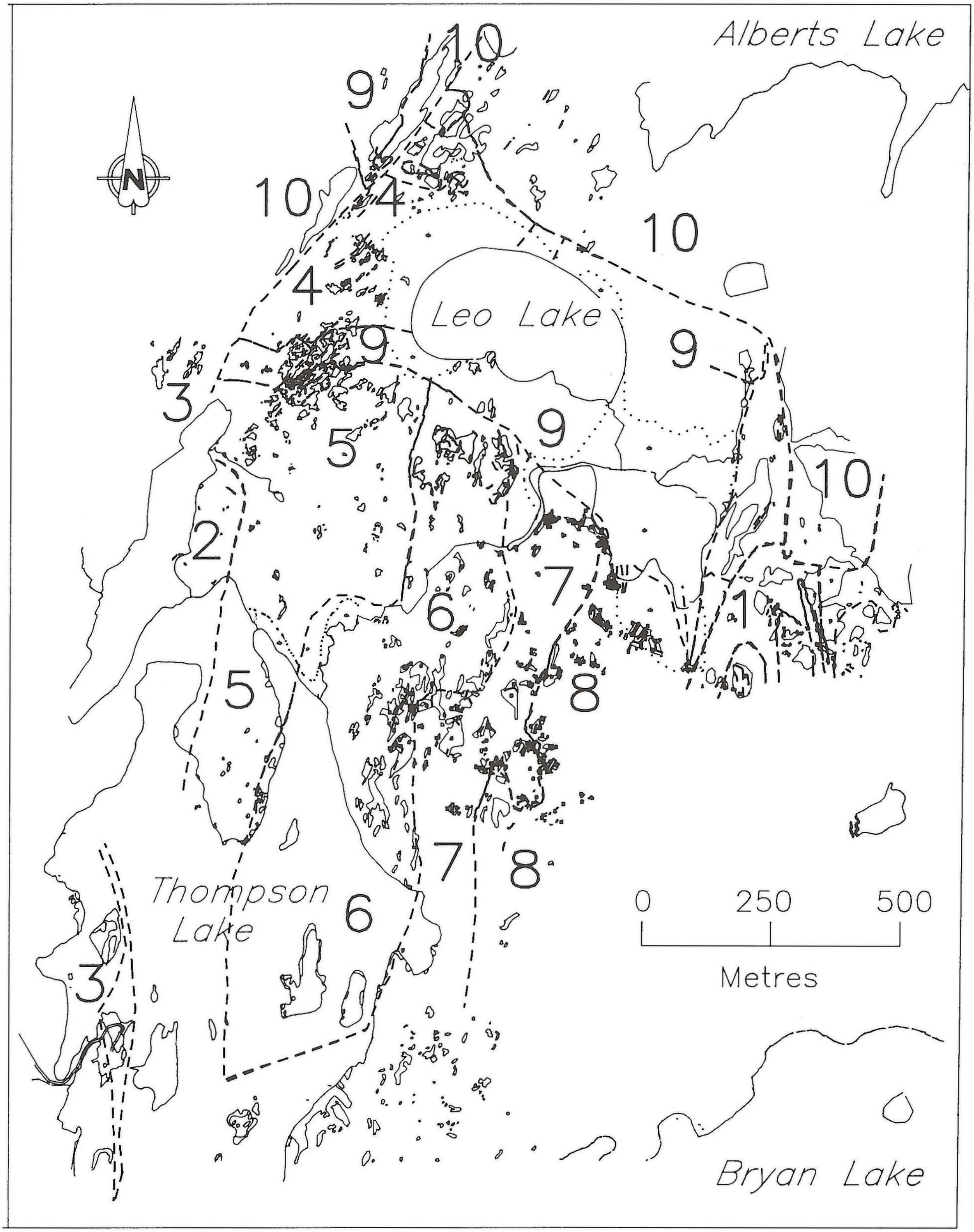

Figure GS-4-3: Geology of the Leo Lake area. Legend: 1) Basaltic flows; 2) Dacitic rocks; 3) Rhyolite flow lobes and microbreccia; 4) Rhyolite flow, massive; 5) Rhyolite - amygdular flows and abundant rhyolite dykes; 6) Rhyolite lapilli tuff, 5-25% quartz crystals; 7) Rhyolite flows, aphyric; 8) Rhyolite flows, quartz and feldspar phyric; 9) Rhyolite dyke, 1 to 1.5 cm quartz crystals; 10) Gabbro.

dykes contain 1 to 5% angular <20 cm fragments of mafic or felsic volcanic rocks.

Up to 1 m thick feldspar phyric dykes with up to 10% 1 to 2 mm phenocrysts have been noted at several places throughout the area. At one locality a 60 cm thick dyke has aphanitic margins with 3 to 10 cm spherulites; these dyke margins visually resemble the spherulitic lenses/dykes observed in Unit 1.

A reddish weathered pink quartz-feldspar porphyry (unit 9) occurs as two small bodies (Fig. GS-4-2) and as 1 to 2 m thick dykes in Unit 2 adjacent to the margins of Unit 9. This rock consists of 75 to 85%, 2 to 5 mm pink feldspar and 5 to 7%, 5 to 10 mm quartz crystals in a matrix of fine grained felsic material.

Fine- to medium-grained dioritic to gabbroic dykes occur along both margins of the peninsula. Locally, small exposures of one to 5 m thick fine grained mafic dykes occur throughout the rhyolitic rocks. One 5 by 10 m exposure, contains angular to subrounded fragments of gabbro and the quartz feldspar porphyry.

A small exposure of magnetite-bearing silicic clasts in a chloritic and epidotized matrix (Unit 12) occurs in the southeast corner of the map area (Fig. GS-4-2). It is not certain at this time if this rock represents alteration or a magnetite-bearing chert.

LEO LAKE AREA

Additional detailed mapping in the Leo Lake area by the senior author in 1991 permitted revision of several of the contacts of Ferreira (1991) and extended units mapped by Norquay and Gale (1990) northward into the Leo Lake area (Fig. GS-4-3). The more significant aspects of the 1992 fieldwork are noted below.

A distinctive lapilli tuff and reworked lapilli tuff (Unit 6) with bimodal sized quartz ± feldspar crystals can be traced from Thompson Lake to Leo Lake. This unit is characterized by up to 20% quartz crystals and crystal fragments that are 1 to 2 and 3 to 5 mm across. Feldspar crystals, 1 to 2 mm in length, are present in some layers/lenses. The western part of this unit contains only 5 to 20% ash and is not layered, whereas towards the eastern margin the lapilli tuff is interlayered with debris flows (?) and aphyric rhyolite flows. Angular fragments of white weathered quartz phyric rhyolite (5-7% quartz phenocrysts) in the pyroclastic deposits are considered to represent the pre-existing rock or magma for the lapilli tuff. Aphyric rhyolite dykes occur throughout this unit and other rhyolitic units in the area, but predate Unit 9 (Fig. 3). Large blocks of the lapilli tuff, which occur within Unit 6 and the aphyric dykes, are considered to be rafts in the younger rhyolitic magmas. This unit of lapilli tuff is considered to be the stratigraphic equivalent of the "'Two quartz' rhyolite breccia" of Gale and Foote (1988).

A medium- to coarse-grained quartz feldspar porphyry (Unit 9) has distinctive large quartz crystals that are up to 14 mm across. Locally, this rock appears to be a tuff, but in general it appears to be a massive dyke or lava dome that cuts across lithologic boundaries; at several localities minor amounts of a mafic volcanic rock occurs as 10 to 20 cm rafts .

Unit 1 mafic volcanic rocks include a distinctive amygdaloidal (scoriaceous) basaltic flow that contains flow breccia and pillow-like massive portions.

Only rudimentary structural investigations were undertaken during this past field season. A pervasive schistosity in the lapilli tuffs occurs as a spaced cleavage in massive flows and dykes. This fabric is axial planar to Z-symmetry minor folds that were probably formed during the first of three recognized fold events. Several ages of faults were noted or inferred from the distribution of rock units and the presence of quartz carbonate alteration.

ACKNOWLEDGEMENTS

The area of Figure GS-4-2 was mapped in cooperation with Placer Dome geologists and the authors greatly appreciate the discussions and assistance provided by David Mallieux and Louis Gauthier during the field work.

REFERENCES

Gale, G.H. and Foote, G.
1988: Geological setting of the Baker Patton alteration zone; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 77-79

Ferreira, K.J.
1991: Geology of the Leo Lake area, Flin Flon,Manitoba; Manitoba Energy and Mines, Geological Report GR91-1, 51p.

Norquay, L.I., and Gale, G.H.
1990: Geological setting of base metal mineralization in the Baker Patton Felsic Complex, Flin Flon area (NTS 63K/13); **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1990, p. 74-76.

GS-5 STRUCTURAL OBSERVATIONS IN THE NORTH STAR LAKE AREA (NTS AREA 63K/15)

by L.I. Norquay and N.M. Halden[1]

Norquay, L.I. and Halden, N.M., 1992: Structural observations in the North Star Lake area (NTS area 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 19-22.

INTRODUCTION

Detailed mapping of a part of the area burnt by forest fire in 1989 was initiated in 1990 (Trembath *et al.*, 1990a, b) and extended in 1991 (Norquay *et al.*, 1991a, b, c). During the 1992 field season mapping was continued in other parts of the burnt area that are underlain by supracrustal rocks (Norquay *et al.*, GS-6, this volume). It was recognized early in the project that the rocks in the North Star Lake area had an extensive polydeformational history. Consequently during the 1992 field season the first author concentrated on a systematic structural analysis of the area covered during the 1990 and 1991 field seasons. Structural analysis of the area will be undertaken as part of M.Sc. thesis work by the first author.

At least three phases of ductile deformation have been identified as have several episodes of late ductile to brittle faults. Peak regional metamorphism, which produced garnet, hornblende, and sillimanite or kyanite, appears to have been associated with the second phase of deformation.

STRUCTURAL OVERVIEW

The first phase of deformation (D_1) folded the primary layering (S_0) and produced tight to isoclinal folds (F_1) with a well developed axial planar schistosity (S_1). These folds, which occur throughout the map area, have small amplitudes and most commonly occur in the banded iron formation of unit 5 (Fig. GS-5-1) (Norquay *et al.*, 1991b, c) where they have amplitudes of 10 cm to 1 m.

S_1 is well developed in micaceous felsic rocks and in biotitic amphibolites. S_1 is generally only well preserved, or easily recognized, in the hinge areas of younger folds.

The second phase of deformation (D_2) produced open to tight folds (F_2) that generally have north-trending axial traces and axial planes that dip steeply to the east (Fig. GS-5-2). The most commonly recognized F_2 structures are minor folds with predominantly Z-asymmetry and with vertical to near vertical axial planar cleavages (S_2). F_1 minor structures have been observed refolded by F_2. On the limbs of the F_2 structures the S_1 foliation is coplanar to near coplanar with the S_2 foliation. A large fold that is probably an F_2 structure is defined by units 5 through 8 between Lake 1 and Lake 2 (Fig. GS-5-1).

In quartzofeldspathic rocks, particularly in the southern part of the map area, there is a spaced cleavage (S_2) axial planar to F_2. This spaced cleavage is expressed by thin (< 5 mm) biotite-rich domains that separate quartzofeldspathic microlithons (≥1 cm). Although this cleavage is axial planar on a mesoscopic scale, in detail the biotite-rich domains commonly undulate along both the horizontal and vertical axes.

A distinctive feature of D_2 is a well developed lineation (L_2). In amphibolite this lineation is expressed as an alignment of amphibole crystals, as well as an alignment of plagioclase-quartz aggregates. In quartzofeldspathic rocks L_2 is defined macroscopically by lenses of quartz aggregates. L_2 generally has a 10° to 20° northerly plunge in the southern portion of the mapped area, and a 25° to 45° northerly plunge in the northern portion (Fig. GS-5-2).

Pillows, lithic fragments, and mineral aggregates define a *l>>s* fabric. Primary features such as pillows and lithic fragments have undergone substantial flattening and stretching with short:intermediate axis ratios of approximately 1:5 and short:long axis ratios of 1:10 to 1:20.

Minerals and mineral aggregates in amphibolitic rocks indicate that the peak of metamorphism occurred during D_2. Amphibole crystals and aggregates of plagioclase and quartz appear to have developed as the L_2 fabric, but confirmation of this requires petrographic investigations.

Further evidence of the timing of the peak metamorphism is preserved in the hinge areas of small F_2 parasitic folds. In some of these hinges subhedral to euhedral garnet and amphibole porphyroblasts overgrow the folded S_1 fabric. These porphyroblasts are flattened in later (D_3) fold hinges.

In unit 4 south of Creek 2 and west of Lake 1 (Fig. GS-5-1) semipelitic rocks have developed a prominent gneissosity (G_2). This gneissosity incorporates the L_2 fabric. In addition, the distribution of the gneissosity appears to have been controlled by compositional variations in the original lithological package. Several oriented samples of semipelitic rocks that display the G_2 fabric were collected in order to confirm the relative age of the G_2 gneissosity.

In the area along, and immediately to the east of, Creek 1 thin lithologic units generally strike north-south (Fig. GS-5-1). In this area tight minor folds (similar to F_2 in style) fold an older schistosity, possibly S_1. The axial planes of these folds have an orientation similar to those of F_2; however, the plunges of these fold are quite variable. Outside of the hinge areas of these folds there is a well developed schistosity with an orientation similar to the fold axial planes. Younger quartz veins lie in, and crosscut, the schistosity.

Refolding of S_1 and S_2 during the third deformational event (D_3) produced a new fabric (S_3) that developed locally in micaceous or lineated rocks. This deformational event produced folds (F_3) that exhibit a variety of styles, but have similar orientations. This variation in fold style is the result of differing response to deformation of different lithologies.

In the southern portion of the map area F_3 structures are generally oriented between 125° and 155° and have near vertical axial planes and steep plunges. In the western portion of this area this plunge is to the northwest, whereas in the eastern portion the plunge is to the southeast. In the northern portion of the map area F_3 structures are oriented between 090° and 125°, have near vertical axial planes and plunge steeply to the east (Fig. GS-5-2).

On the limbs of F_2 structures, the F_3 structures are commonly preserved as open folds with wavelengths that range from 1 m to several metres, fold the S_1/S_2 foliation and rotate the L_2 lineation.

Well developed examples of S_3 are apparently restricted to amphibolite characterized by a strong earlier foliation. In such cases S_3 is preserved as a near vertical crenulation cleavage that overprints the S_1/S_2 foliation. In these amphibolites F_3 is preserved as crenulate folds approximately 1 cm in wavelength.

Chevron folds (F_3) with an orientation similar to the crenulate folds have developed in micaceous quartzofeldspathic rocks that are characterized by a well developed earlier schistosity. These chevron folds commonly have a weak axial planar S_3. Locally (F_3) chevron folds contain axial planar quartz veins, pegmatitic or felsite dykes.

A further characteristic of the D_3 deformation is the development of cuspate and lobate folds (F_3). These cuspate and lobate folds have developed at the contacts between amphibolite dykes and the quartzofeldspathic country rocks. This indicates a moderate competency difference between the quartzofeldspathic country rock and the relatively incompetent amphibolite dykes. These cuspate and lobate folds have an orientation similar to the F_3 chevron folds and crenulate folds.

Younger ductile faults crosscut D_3 and older fabrics and occur throughout the map area. These faults strike at 025° to 050° and they are steeply, and generally irregularly, dipping. The ductile fabrics indicate sinistral movement. Continued or later movement along these surfaces commonly resulted in brittle deformation that is preserved in the core of these faults.

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[1] University of Manitoba

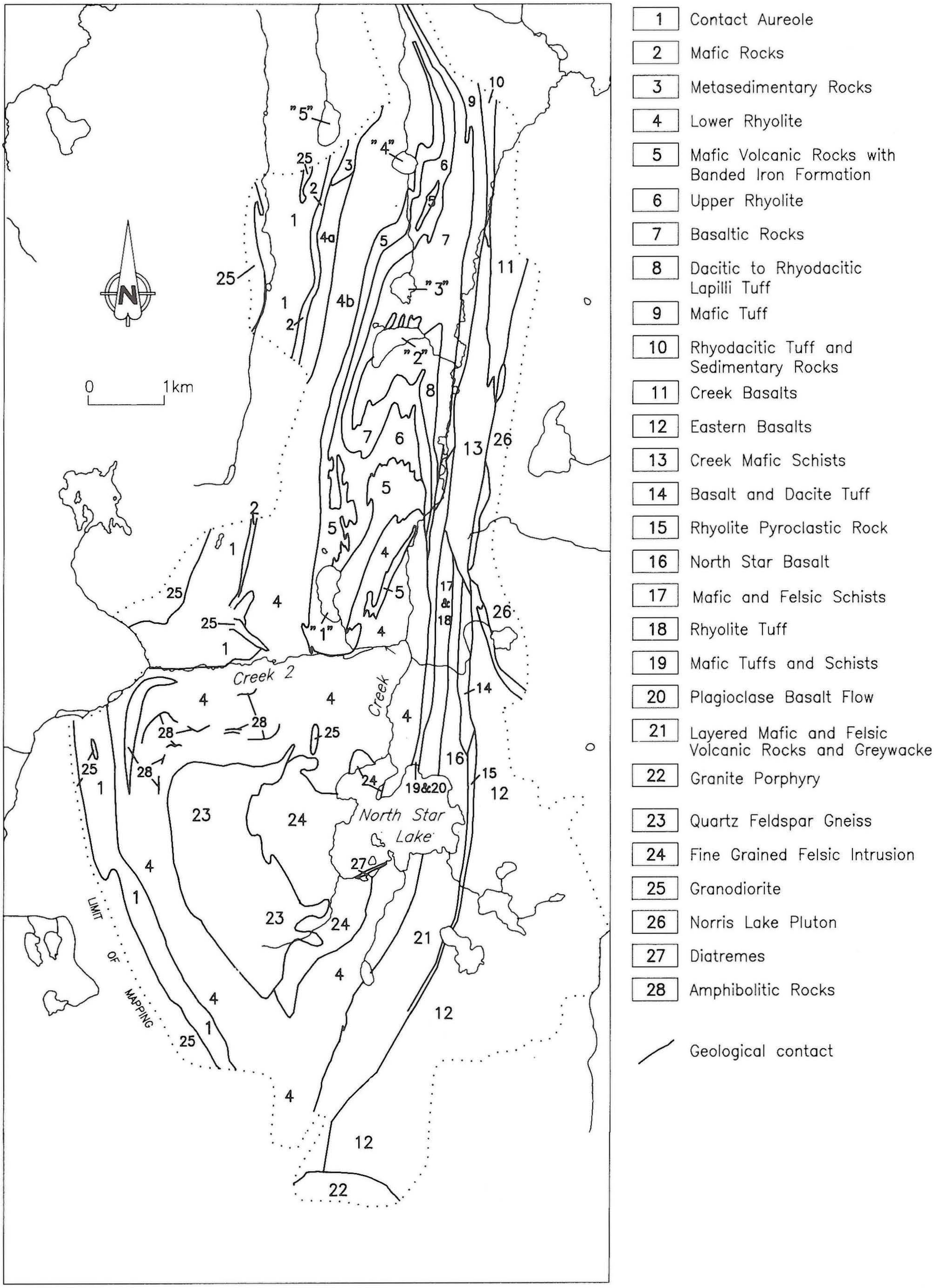


Figure GS-5-1: *General geology of the North Star Lake area.*

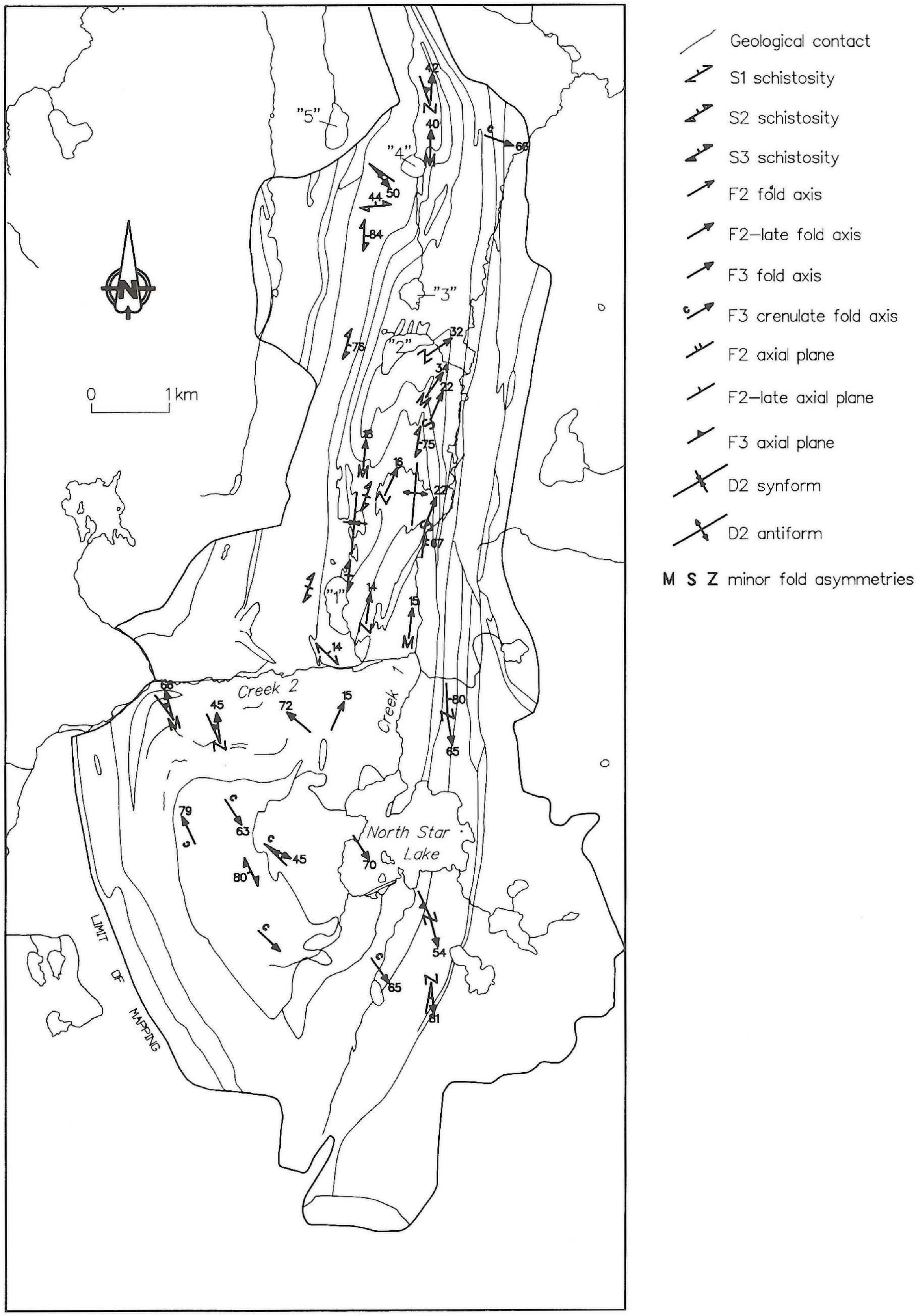


Figure GS-5-2: Structural geology schematic of the North Star Lake area.

The youngest faults are brittle, steep dipping and predominantly sinistral. These brittle faults can be divided into an older and a younger group. The older group is predominantly characterized by a north-south orientation, but can range from 340° to 035°, and commonly contain fault gouge, crush breccia and rare pseudotachylyte.

The younger group of brittle faults are predominantly oriented east-west, but can range from 055° to 135°. They commonly contain fault gouge, as well as quartz, carbonate and epidote.

ACKNOWLEDGEMENTS

Eric Bjornsson is thanked for his able assistance during the course of the field season.

REFERENCES

Norquay, L.I., Prouse, D.E., Beiri, M., and Gale, G.H.

1991a: Geology of the North Star lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 31-40.

1991b: North Star Lake area (part of NTS 63K/15 NE); Manitoba Energy and Mines, Minerals Division, Preliminary Map 1991F-1, 1:10 000.

1991c: North Star Lake area (part of NTS 63K/15 SE); Manitoba Energy and Mines, Minerals Division, Preliminary Map 1991F-2, 1:10 000.

Trembath G.D., Norquay, L.I., and Gale, G.H.

1990: Mineral investigations in the North Star Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 77-79.

McGlynn, J.C.

1959: Elbow-Hemming Lakes area, Manitoba; Geological Survey of Canada, Memoir 305, 72p.

GS-6 GEOLOGICAL INVESTIGATIONS IN THE NORTH STAR LAKE AREA (NTS AREA 63K/15)

by L.I. Norquay, D.E. Prouse, T.H. Heine and G.H. Gale

Norquay, L.I., Prouse, D.E., Heine, T.H. and Gale, G.H. 1992: Geological investigations in the North Star Lake area (NTS area 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 23-27.

Detailed mapping of supracrustal rocks in the North Star Lake area, exposed by forest fire in 1989, was extended beyond the limits of the 1991 mapping project (Norquay *et al.*, 1991a, b, c). The vicinity of the Lon base metal occurrence was mapped in greater detail than was possible in 1991. In addition, minor revisions to the 1991 preliminary maps (Norquay *et al.*, 1991b, c) resulted from the systematic documentation of structural features (see Norquay and Halden, GS-5, this volume). The outcrops and geological information for this project have been digitized and will be provided in digital or paper copy upon request; consequently there is no new preliminary map provided for this project. The areas mapped are shown in Figure GS-6-1 and new observations are summarized and presented here.

NORTH STAR LAKE AREA

Remapping of an area south and west of North Star Lake revealed more details of the volcanic textures and provided a basis for tentatively correlating Units 21 and 22 of Norquay *et al.* (1991b, c) with Unit 4, the lower rhyolite (Fig. GS-6-2); geochemical data are required to confirm this correlation. A re-examination of Unit 24, a fine grained felsic intrusion, (Norquay *et al.*, 1991b) resulted in the identification of a fine- to medium-grained, beige to light grey, massive to weakly foliated granitic (?) intrusion. The rock consists of approximately 45% quartz, 30% potassium feldspar, 10% plagioclase, 10 to 15% biotite and 1 to 2% garnet.

This unit contains abundant mafic (amphibolite) "rafts" and at least 3 sets of felsic to mafic crosscutting dykes. The contacts of this intrusion appear to be gradational with the extrusive rhyolitic volcanic rocks, but this observation requires further study because in the field this unit is easily mistaken for altered rhyodacitic rocks, which occur to the east, south and west (Fig. GS-6-2). If this unit represents a subvolcanic intrusion, then it is probably related to the felsic volcanic rocks south and west of North Star Lake.

The general geology of the area east and south of North Star Lake is illustrated in Figure GS-6-1. Details of the geology of a portion of the area mapped are illustrated in Figure GS-6-3.

The Unit 12, eastern basalts (Norquay *et al.*, 1991b, c), have been subdivided into: a) fine grained pale green, dark green and black pillowed flows; b) mafic volcanic rocks; and c) fine- to medium-grained dioritic to gabbroic rocks. Small intrusions of rhyolitic and granitic rocks occur throughout these mafic volcanic and intrusive rocks.

The pillowed basalts are characterized by well-defined pillow selvages, whereas the foliated mafic volcanic rocks are commonly layered or laminated, contain pyroclastic rocks and locally, may include flow breccias. In areas mapped as pillowed flows the pillows range from 0.25 m to approximately 1.0 m in length. Pillows commonly exhibit stretching ratios of 5:1 to 20:1 on the limbs of D_2 folds. In contrast, pillows and other flow textures, *e.g.*, hexagonal joints, amoeboid breccias and pyroclastic breccias, are relatively little deformed and well preserved in the hinge zones of these folds. In some foliated and schistose rocks it is possible to distinguish compositionally layered tuffs, whereas others are considered to be deformed tuff layers, breccia layers and massive and pillowed flows. Some fragmental rocks are the product of transposition of original layers and fragments by the intersection of foliations and beds in the hinges, and on the limbs of D_2 folds (*cf.* Norquay and Halden, GS-5, this volume).

Many of the mafic rocks exposed south and east of North Star Lake are massive to layered (commonly laminated) dark green to black basalt flows. Exposures of dominantly fine grained massive mafic flows commonly contain intercalated moderately foliated and laminated mafic rocks; in some instances these rocks may be deformed basalts. Locally, fine grained massive mafic flows (?) are gradational into synvolcanic (?) dioritic intrusive rocks. Local epidosite lenses are common within the layered and laminated mafic rocks, the pillowed basalts and dioritic intrusions.

Recognizable pillowed flow units are rare in Unit 12 south of North Star Lake (Fig. GS-6-3), and where pillows are evident they are usually flattened and stretched. Pillow cores, rims and selvages commonly contain minor to moderate epidote and/or carbonate alteration. Top directions in these pillowed flows are generally ambiguous.

A distinctive rhyolite pyroclastic rock (Unit 15, Norquay *et al.*, 1991b) also occurs along strike from the area mapped in 1991 (Fig. GS-6-1). This unit varies from brownish grey to greyish white. The exposures consist of up to 10 cm long rhyolite fragments, which are strongly flattened in the foliation plane, in a matrix of ash and lapilli. This unit has layers up to 5 cm thick, and more ash than lapilli and blocks along its eastern margin.

A thinly to thickly laminated quartz phyric rhyolite with variable (5-12%) biotite content is exposed in an area 3.5 km south of North Star Lake. This quartz phyric rhyolite contains subrounded to subangular, 1 to 3 mm, quartz crystals that are weakly to moderately flattened within the foliation. Several pink, approximately 3 cm thick, cherty layers that contain strongly-flattened quartz crystals occur near the granite porphyry contact. Invariably these rhyolitic rocks contain Tr to 2% pyrite.

Dark grey to black, fine- to medium-grained dioritic rocks underlie a large portion of the area east and southeast of North Star Lake (Fig. GS-6-3). These rocks vary in texture from massive to moderately foliated. Locally, these rocks are similar to massive basaltic flows and it is difficult to separate the two on some exposures. Mineralogically the unit consists of approximately 60% plagioclase, 30% hornblende and ± 5 to 10% quartz that is usually interstitial to plagioclase and hornblende. A number of gouge-filled fault zones that contain fine grained white carbonate veins and veinlets cut through this unit, but do not appear to have any preferred orientation.

A pink-orange granite porphyry (the 'quartz eye granite' of McGlynn, 1959) is massive to weakly foliated and predominantly coarse- to medium- grained; at its margins it becomes locally finer grained. This rock consists of approximately 40% quartz, which occurs in part as phenocrysts up to 10 mm in diameter, 30% pink-orange potassium feldspar, 5 to 10% plagioclase feldspar and 15% biotite. On the north side of this intrusion dykes of granite porphyry intrude the mafic volcanic rocks and dioritic intrusive rocks. These dykes appear to be relatively localized and disappear within 100 to 200 m of the contact. Xenoliths of supracrustal rocks are absent within the intrusion, but there is some contact metamorphic alteration of both mafic volcanic and intrusive rocks in the vicinity of the contact.

LOONHEAD AREA

The area around the Lon base metal occurrence was mapped in order to provide better stratigraphic control, and to attempt a subdivision of, the volcanic rock unit that occurs east of the Lon occurrence; in addition, mapping was extended north and west from the Lon occurrence (Fig. GS-6-4). The rhyolitic units observed south and east of 'lake 4' (Norquay *et al.*, 1991b) have also been recognized northward in the area of sparse outcrop immediately east of the Lon occurrence. Although the rocks in this area are intensely flattened and locally develop a weak gneissic fabric due to the aggregation of quartz and feldspar, it is still possible to recognize volcanic textures, such as flow lobes and flow breccia, in the rhyolitic rocks. Correlation of rhyolite between outcrops is based mainly on rock colour.

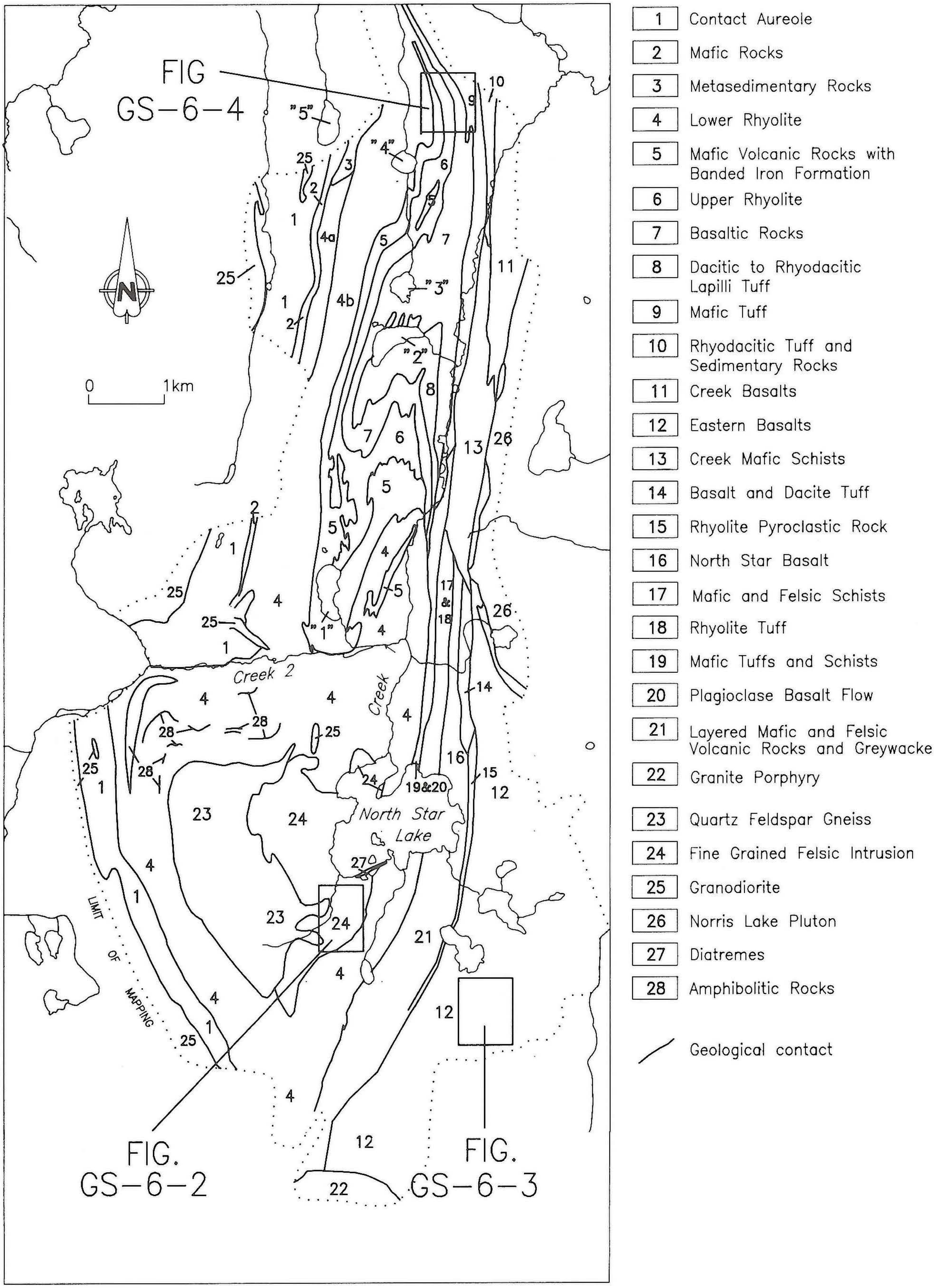


Figure GS-6-1: *General geology of the North Star Lake area.*

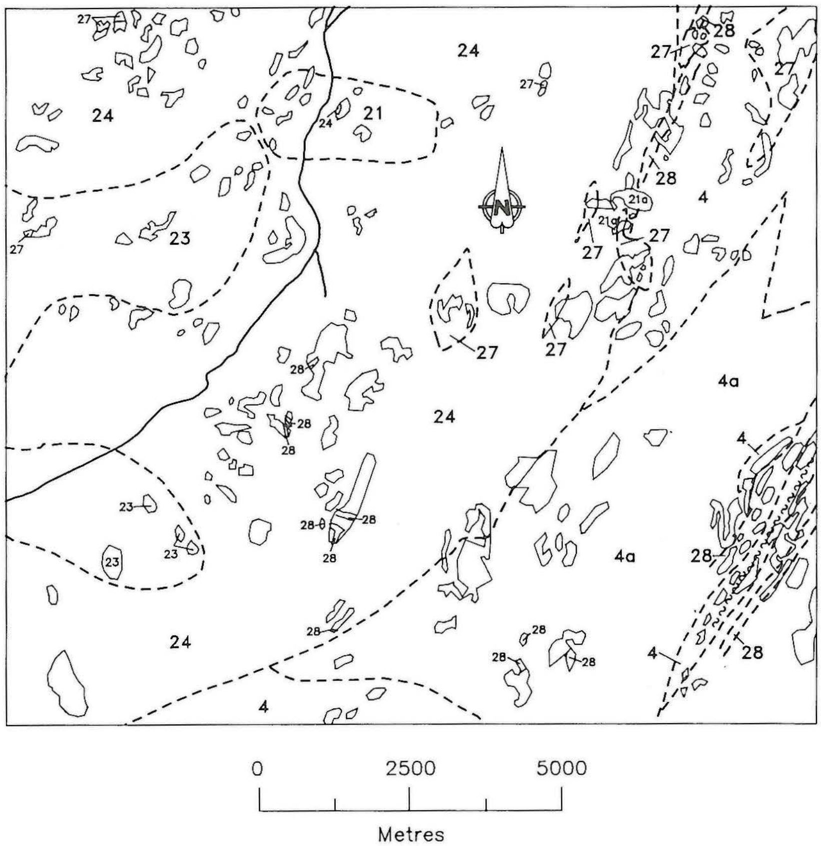


Figure GS-6-2: *Detailed geology of felsic rocks, southwest of North Star Lake. Legend: as in Figure GS-6-1; unit 4a includes fine grained amphibolite layers or dykes and feldspar porphyritic mafic dykes (?); 21a) pyroxenite and/or gabbro; 21b) diorite.*

Several exposures near the Lon occurrence include 2 to 10 m thick isoclinally folded, layered, brown-weathering psammopelitic rocks. These rocks consist predominantly of sand sized grains of quartz and feldspar in a matrix of brown-weathering biotite, which constitutes 5 to 25% of the rock. Locally, this rock is garnetiferous (<10% garnet), but also contains several metre-sized lenses and areas of garnetite (50-70% garnet).

Magnetite ± garnet- bearing silicate facies iron formation occurs at several places at the contact between rhyolitic and mafic volcanic rocks. At several localities the iron formation is a layered rock with magnetite-rich and quartz-rich (chert ?) layers; elsewhere the iron formation consists of variable amounts of garnet in a matrix of hornblende, quartz ± magnetite. These iron formations may represent more than one stratigraphic unit, but some are repeated due to early folds and late faults.

The mafic volcanic rocks associated with the iron formation to the south (unit 5 of Norquay *et al.*, 1991b) are sparsely exposed in this area. They are generally fine grained and massive with only vague, ill-defined fragment outlines. Locally, where these rocks have a well defined foliation, they are best described as amphibolites.

A detailed study of units 7 and 9 (Norquay *et al.*, 1991b) indicates that these mafic rocks can be subdivided into massive, fragmental and tuffaceous, and schistose mafic rocks. The massive rocks are fine- to medium-grained and dark green, grey and black. The grey rocks are medium grained and consist of 1 to 2 mm quartz-feldspar porphyroblasts in a matrix of fine grained hornblende. The greenish coloured rocks locally have porphyroblasts (?) of pyroxene and lesser quartz and feldspar than the grey rocks and appear to have a gradational contact with them. The grey rocks in turn are gradational into a fine grained garnetiferous (5-10%, 1-2 mm garnets) black rock. Rhyolitic rocks, which locally appear to be tuffs (?), occur as <1 to >10 m thick bands that are conformable to the regional schistosity and contacts within the massive basaltic rocks (Fig. GS-6-4); these may represent infolded felsic volcanic rocks or sills/dykes of rhyolite. The fine grained, commonly epidosite-bearing pyroclastic (?) rocks are associated with fine grained massive basaltic rocks (sills ?) and, in part, layered schistose rocks (tuff ?). Further work is required to establish whether the massive, medium grained mafic rocks are flows or intrusions.

Figure GS-6-3: *Detailed geology of a part of the eastern basalts, southeast of North Star Lake. Legend: 12) eastern basalts (cf. Fig.GS-6-1), a, pillowed basalt; b, foliated mafic volcanic rocks; c, fine- to medium-grained dioritic/gabbroic intrusion; d, rhyolitic intrusion; e, equigranular granitic intrusion; f, coarse grained massive gabbro; g, medium- to coarse-grained massive gabbroic rock with 30% feldspar.*

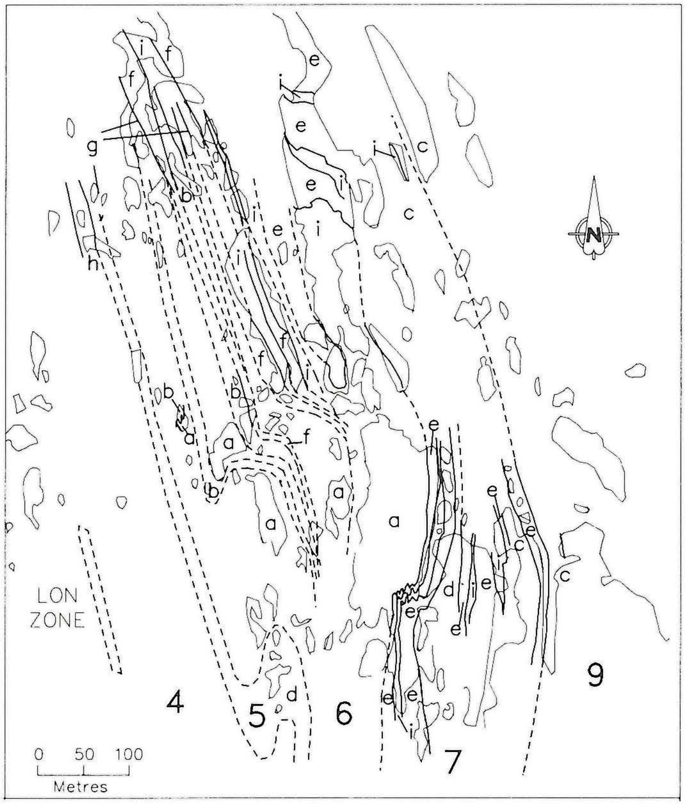


Figure GS-6-4: *Geology of the area in the vicinity of the Lon occurrence. Legend: as in Figure GS-6-1; a, flows; b, tuffs; c, volcanic breccia; d, fine grained extrusive (?) rocks; e, medium grained intrusive rocks (?); f, amphibolitic (foliated) rocks; g, banded oxide facies iron formation; h, garnetite; i, felsic rocks.*

REFERENCES

Norquay, L.I., Prouse, D.E., Bieri, M., and Gale, G.H.

1991a: Geology of a part of the North Star Lake area (NTS 63K/15); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 31-40.

1991b: North Star Lake area (Part of NTS 63K/15); Manitoba Energy and Mines, Minerals Division, Preliminary map 1991F-1, 1:10 000.

1991c: North Star Lake area (Part of NTS 63K/15); Manitoba Energy and Mines, Minerals Division, Preliminary map 1991F-2, 1:10 000.

McGlynn, J.C.

1959: Elbow-Heming Lakes area, Manitoba; Geological Survey of Canada, Memoir 305, 72p.

GS-7 DOCUMENTATION OF MINERAL OCCURRENCES IN THE NORTH STAR LAKE AND ELBOW LAKE AREAS (NTS 63K/15)

by T.H. Heine and D.E. Prouse

Heine, T.H. and Prouse, D.E., 1992: Documentation of mineral occurrences in the North Star Lake and Elbow Lake areas (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 28-31.

INTRODUCTION

Gold was discovered in 1921 in the Elbow Lake area and numerous prospects were subsequently staked, and work continued sporadically into the 40's and later. Stockwell (1935) described numerous gold prospects in the Elbow Lake and North Star Lake areas and provided a 1:126 720 geological map of the region. McGlynn (1959) re-examined the geology of the area and prepared a report with a 1:63 360 map; he also described five prospects that had been worked subsequent to Stockwell's visit.

Due to an improvement in the quality of surface exposures that resulted from a major fire in 1989, the burned areas around Webb Lake, Elbow Lake, Claw Lake and North Star Lake have been remapped in detail (1:20 000 and 1:5 000), and the results presented in preliminary form by Schledewitz (1990, 1991), Syme (1990a, 1991a, b, and GS-8, this volume), Trembath *et al.* (1990), Norquay *et al.* (1991, and GS-6, this volume), Whalen (1991) and Norquay and Halden (GS-5, this volume).

The documentation of mineral occurrences in the Elbow Lake area begun by Ostry (1985), Galley *et al.* (1987a, b) and Pippert and Gale (1990) was continued in the North Star Lake and Elbow Lake areas. These consist dominantly of gold and a number of sulphide occurrences. The gold occurrences were accurately located on 1:5 000 air photographs and examined in the field. Where the workings were not overgrown, caved or filled in, they were mapped at 1:200 or 1:500. Descriptions for individual prospects will be outlined in a forthcoming Mineral Deposit Series volume for the Elbow Lake area (NTS 63K/15). The locations of the occurrences are shown in Figures GS-7-1 and GS-7-2.

NORTH STAR LAKE AREA

Geology

The northerly-trending lithologic sequence in the North Star Lake area comprises an assemblage of felsic and mafic volcanic and volcaniclastic rocks, and intrusive equivalents of the Amisk Group. Minor chemical sedimentary rocks (banded iron formation) are also present. At North Star Lake the felsic rocks form a sequence approximately 4 500 m wide that narrows somewhat to the north. East of the lake the lithologic assemblage consists primarily of basalt with associated related intrusive and mafic sedimentary rocks. Fine- to medium-grained gabbroic rocks are the most important intrusives within the mafic sequence. They appear to represent massive flows in part, regularly grading into pillowed and fragmental flows and flow breccia. Deformed polygonal joints are present in a number of exposures. No felsic extrusive rocks were noted within this sequence.

The volcanic and volcaniclastic assemblage is bounded to the west by plutonic rocks (McGlynn, 1959). Several lesser batholiths have also intruded the main part of the sequence, including the Norris Lake pluton (Bailes, 1980), the Sewell Lake pluton and several smaller "quartz-eye granite" (quartz megacrystic tonalite) bodies (McGlynn, 1959). A number of diatreme breccias have been recognized in the southern part of the North Star Lake area (Norquay *et al.*, 1991). All of the supracrustal and some of the intrusive rocks have suffered moderate to extreme degrees of polyphase ductile and brittle deformation. In many areas, this deformation has attained such a high degree of flattening that original textures are preserved only in fold hinges.

Gold Occurrences

Stockwell (1935) documented 17 gold occurrences in the North Star Lake area. Work during the 1920's and 30's exposed a series of quartz veins; some of these are reported to have contained spectacular gold contents over short intervals. None of the prospects achieved commercial production, but several were subjected to considerable exploration efforts. Diamond drill investigations have been undertaken on some of the occurrences; presumably the results proved to be disappointing and no further work was warranted. Two of the prospects were located and described by Ostry (1985): descriptions of his locations NS-3 and NS-4 correspond to the North Star No. 4 and Snow claims, respectively, of Stockwell (1935). Eight occurrences were mapped and documented in part by Pippert and Gale (1990).

Most of the gold prospects occur within the mafic volcanic and volcaniclastic rocks east and southeast of North Star Lake (Fig. GS-7-1). At several occurrences the mineralization occurs in

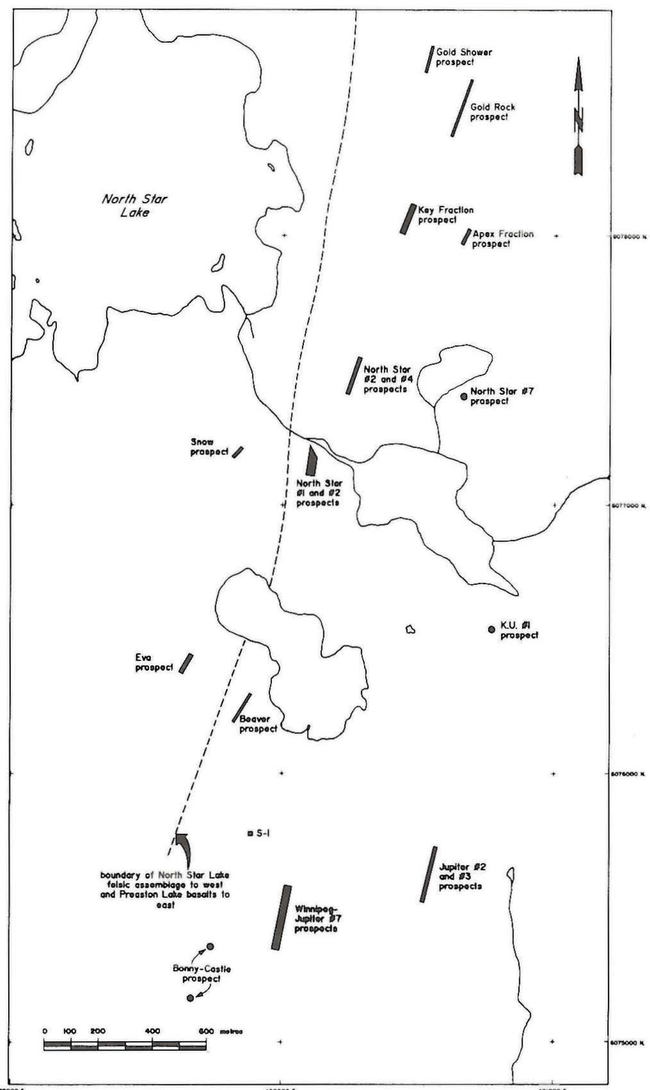
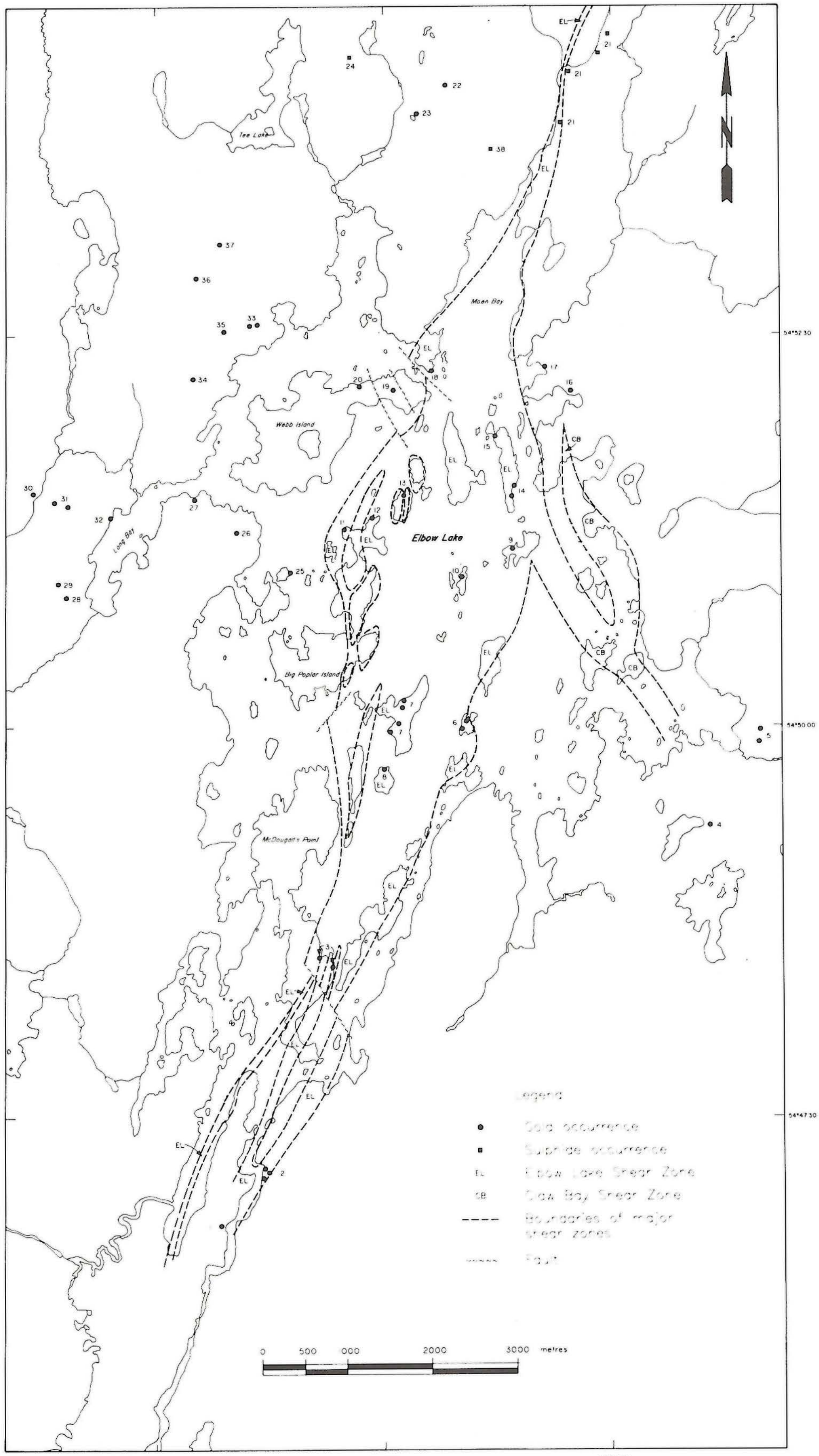


Figure GS-7-1: *Gold and sulphide occurrences in the North Star Lake area. Occurrences with extensive workings are indicated as solid black areas. Those with only a small number of trenches are indicated with solid circles. All of the occurrence names are after Stockwell (1935) except S-1, which is a fairly recent set of trenches.*



Occurrence Names:

1. Wire prospect
2. Murray prospect
3. Hanson prospect
4. Pato prospect
5. Big Dome prospect
6. Gold Pan (Ding How) prospects
7. Smith Island No.1 prospects
8. Smith Island No.2 prospects
9. Hanna prospect
10. Harbour prospect
11. Independent prospect
12. June Bug prospect
13. Florence prospect
14. Gold Dust prospect
15. Century prospect
16. Van prospect
17. Mack prospect
18. I.X.L. prospect
19. Webb-Garbutt prospect (Century mine)
20. Bow prospect
21. Silvertone prospects
22. Long prospect
23. Veda prospect
24. Tee Lake prospect
25. Fred prospect
26. G.H. prospect
27. Jessie prospect
28. Rod prospect
29. Beta prospect
30. Moneystone prospect
31. Gunwor prospect
32. Sherlock prospect
33. H.M.B. prospect
34. Dan prospect
35. Bell-Apex No.1
36. Apex No.2
37. Apex No.3
38. S-2 (post-Stockwell trenches)

Figure GS-7-2: *Gold and sulphide occurrences in the Elbow Lake area. The occurrence designations, with the exception of number 38, are after Stockwell (1935) and the geology is after Syme (1991).*

quartz veins, with an aggregate thickness of up to 4 m, although most are considerably narrower. Individual veins range from 5 mm to 1 m thick, and commonly contain fragments and screens of dark green chloritic country rock. The adjacent country rock does not appear to be appreciably altered. Sulphides, dominantly pyrite with much less chalcopyrite and sphalerite, are rare constituents of the veins and the host lithologies. The quartz veins occur along steeply-dipping relatively little-deformed linear zones that tend to pinch and swell along strike, and trend approximately 020°. They are discontinuous along strike and are separated by areas of barren country rock. Although the quartz-filled fractures reflect a late phase tectonic episode in the area, rotated chloritic lithic fragments noted in some of the prospects indicate continued post-emplacement movement along these breaks.

The main gold prospects occur in gabbro, which probably reflects the higher competency of these rocks relative to the surrounding volcanic and volcaniclastic units. These rocks failed along discrete well-defined planes rather than narrow diffuse stringer networks during brittle deformation. Good examples of this are the North Star No. 1 and 2 occurrences.

Base Metal Occurrences

The Eva and Snow claims (Stockwell, 1935) are associated with felsic rocks, and are probably unrelated to the event that formed the auriferous quartz veins.

At the Snow occurrence pyrrhotite with lesser pyrite and minor chalcopyrite occur associated with a felsic dyke intruded into a sequence of interlayered mafic and felsic rocks. None of the sulphides were observed *in situ*; pieces from rubble piles around the pit and trenches indicate that most of the sulphides occur as disseminations and irregular stringers with sporadic near solid lenses within the mafic rock. Almost all of the sulphides have been completely oxidized. The workings have been excavated into rusty-weathered rocks and much of the soil in this area is limonitic. Stockwell (1935) reports low gold values for this occurrence.

According to Stockwell (1935), the now overgrown Eva claim trenches expose a quartz vein 50 to 170 cm wide. The rubble piles are limonitic and contain minor Fe oxide stained quartz, but no sulphides were noted. Several more recent trenches have been excavated in limonitic areas a short distance to the north-northeast of the original workings. The rocks form a sequence of interbanded folded mafic and felsic units that contain minor white quartz veinlets parallel to the dominant foliation. Garnets are a common accessory. One trench exposes a quartz vein up to 80 cm thick with a limited strike length. Only pyrrhotite, composing up to 5% of the rock, was noted as disseminations in the siliceous bands. Fine grained light grey-weathering felsic rocks along strike from this occurrence commonly contain minor sulphides indicated by limonitic patches on the weathered surfaces. The soil in this area also tends to be ferruginous. No gold values have been reported.

Relatively recent trenches approximately 500 m south of the Beaver occurrence (location S-1, Fig. GS-7-1) have exposed a series of quartz veins in a quartz and feldspar porphyritic felsic dyke emplaced into pillowed basalt and gabbro. The quartz veins contain vugs that are lined with euhedral pyrite crystals. The veins have only a limited strike extent.

Ostry (1985) documented two sulphide occurrences approximately 11 km north of North Star Lake. One of these (occurrence NS-1) appears to be related to the Lon zone, a Zn-Cu massive sulphide occurrence southwest of Loonhead Lake. Although garnetite and oxide facies iron formation are present in outcrop, there are no exposures of sulphide mineralization. The general geology of the area is presented in Norquay *et al.* (GS-6, this volume).

ELBOW LAKE AREA

Geology

Recent work in the Elbow Lake area, notably that by Syme (1990a, b; 1991a, b), has done much to elucidate its geological framework. The supracrustal rocks are primarily a mafic volcanic and volcaniclastic assemblage with lesser chemical sedimentary rocks (cherts) and felsic volcanic and volcaniclastic rocks. These rocks have been cut by two major shears: the north-northeasterly-trending Elbow Lake Shear Zone and the northwesterly-trending Claw Bay Shear Zone (Fig. GS-7-2).

Gold Occurrences

A total of 38 gold prospects were documented by Stockwell (1935) in the Elbow Lake area. Most represent only minor occurrences or appear to be barren. Only the Century mine has recorded any production (Manitoba Energy and Mines, Mineral Inventory File 769).

Gold occurs in quartz veins and is commonly associated with minor pyrite, pyrrhotite, chalcopyrite and/or sphalerite. A distinctive green chlorite is commonly associated with the occurrences close to the Elbow Lake Shear Zone. Previous investigators (Galley *et al.*, 1987a) have classified the occurrences of this area according to a number of associations: those spatially related to felsic dykes; those spatially related to iron formation; and those within sheared volcanic or plutonic rocks. Syme (1991a) indicates that most of the occurrences are closely associated with the major shear zones and subsidiary splays. It has been noted that the quartz vein systems are commonly emplaced into rocks of higher competency than the surrounding lithotypes.

Base Metal Occurrences

Several sulphide occurrences have been noted north of Elbow Lake. These occur in mafic and felsic volcanic and volcaniclastic rocks.

A number of trenches were located north and north-northeast of Moen Bay (Fig. GS-7-2). These may be part of the Silvertone claim as described by Stockwell (1935); it could not be located with certainty in the field. All of the workings appear to be relatively recent. Most of the excavations expose sulphide-bearing shears that probably represent splays from the Elbow Lake Shear Zone. Although the rocks are limonitic (most of the sulphides have been completely oxidized) the dominant sulphide appears to be pyrrhotite with lesser quantities of pyrite. Only trace amounts of chalcopyrite and sphalerite occur in these trenches.

The Tee Lake occurrence, as reported by Stockwell (1935), could not be located and may have been obscured by later activity. Extensive trenching and stripping have been undertaken along the side of a hill north of Stockwell's location for this occurrence. At this location a 25 m wide rusty zone crosscuts the Tee Lake rhyolite of Syme (1991a, b). The host rocks of this prospect have been extensively altered to dark green to black (Mg-rich ?) chlorite and some of the rhyolite within this zone has a brecciated appearance; sericite is also present in the rocks that surround the main altered area. The main alteration zone contains areas with quartz-lined vugs and minor barren quartz veins. Magnetite is a common constituent in some parts of the rusty zone, and the association magnetite-quartz-chlorite is common. Most of the sulphide in the alteration zone has been altered to limonite: pyrrhotite was noted as small (<5 mm) disseminated masses, and disseminated pyrite was observed in a few pieces collected from the rubble piles.

Syme (1991a) indicates that rusty-weathering areas are widely distributed throughout the Tee Lake rhyolite. In addition, irregular black chloritic spots and masses occur for at least 1 km south of the stripped alteration zone. These features suggest that this rock unit has undergone extensive hydrothermal alteration, possibly related to the deposition of volcanogenic massive sulphides.

CONCLUSIONS

Very high grades of gold mineralization have been reported from occurrences in both the North Star Lake and Elbow Lake areas. The quartz vein systems that host these occurrences tend to be discontinuous and generally have a limited strike length. The potential for finding a small high grade deposit is still fairly high because the improvement in the quality of exposure (outcrop and float material) serves to make this area particularly amenable to surface prospecting and evaluation.

The Lon occurrence and the Dickstone deposit are the most significant massive sulphide deposits discovered to date in this area.

The Dickstone Cu-Zn deposit, east of North Star Lake and just beyond the map area, is hosted by felsic volcanic rocks of the Dickstone Formation (Bailes, 1980).

Work by Syme (1991) has indicated that economic massive sulphide deposits have been found only in the arc tholeiite portion of the Amisk Group in Manitoba. To date no economic massive sulphide deposits have been found in the Elbow and Cranberry lakes area. Preliminary work indicates that, in the Elbow Lake area, the Webb Island basalts represent arc tholeiites, and that the other mafic volcanics represent either transitional or back-arc basalts (Syme, 1991).

The Tee Lake rhyolite contains an alteration suite that appears to be a result of hydrothermal activity related to the deposition of volcanogenic massive sulphides. It appears that this unit has considerable potential to contain additional VMS type mineralization.

Detailed mapping and structural investigations within the felsic sequence of the North Star Lake area indicates that the sequence has undergone multiphase ductile deformation accompanied by a high degree of flattening (Norquay and Halden, GS-5, this volume). The consequences of these observations for volcanogenic massive sulphide deposits in this area remain to be assessed.

ACKNOWLEDGMENTS

Assistance in the field was capably rendered by Christine Poschadel and Kyla Arden.

REFERENCES

Bailes, A.H.
1980: Geology of the File Lake Area; Manitoba Energy and Mines, Mineral Resources Division, Geological Report 78-1, 134p.

Galley, A.G. and Ames, D.E.
1987a: Geological setting of gold mineralization, Elbow Lake, Manitoba (part of NTS 63K/15); Geological Survey of Canada, Preliminary Map Number 1987GSC, 1:20 000.

Galley, A.G., Ames, D.E. and Franklin, J.M.
1987b: Geological setting of gold mineralization in the Elbow Lake region, Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1987, p. 175-177.
1989: Results of studies on the gold metallogeny of the Flin Flon belt; in Investigations by the Geological Survey of Canada in Manitoba and Saskatchewan during the 1984-1989 Mineral Development Agreements, Geological Survey of Canada, Open File 2133, p. 25-32.

McGlynn, J.C.
1959: Elbow-Hemming Lakes Area, Manitoba; Geological Survey of Canada, Memoir 305, 72p.

Norquay, L.I., Prouse, D.E., Bieri, M. and Gale, G.H.
1991: Geology of a part of the North Star Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 31-40.

Ostry, G.
1985: Mineral occurrence studies in the North Star Lake area of Manitoba: **in** Manitoba Energy and Mines, Geological Services, Mines Branch, Report of Field Activities, 1985, p. 80-81.

Pippert, R. and Gale, G.H.
1990: Documentation of gold occurrences in the North Star Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1990, p. 80-82.

Schledewitz, D.C.P.
1990: Webb Lake - Fay Lake (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 58-61.
1991: Geology of the Webb Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 5-7.

Stockwell, C.H.
1935: Gold Deposits of the Elbow-Morton Area, Northern Manitoba; Geological Survey of Canada, Memoir 186, 74p.

Syme, E.C.
1990a: Elbow Lake project (part of NTS 63K/15W); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 49-57.
1990b: Stratigraphy and geochemistry of the Lynn Lake and Flin Flon metavolcanic belts, Manitoba; **in** J.F. Lewry and M.R. Stauffer, eds.: The Early Proterozoic Trans-Hudson Orogen of North America; Geological Association of Canada, Special Paper 37, p. 143-161.
1991a: Elbow Lake project - Part A: supracrustal rocks and structural setting; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 14-27.
1991b: Elbow Lake; Manitoba Energy and Mines, Minerals Division, Preliminary Map 1991F-3, 1:20 000.

Trembath, G.D., Norquay, L.I. and Gale, G.H.
1990a: Mineral investigations in the North Star Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 77-79.
1990b: Preliminary geological map of a part of the North Star Lake area; Manitoba Energy and Mines, Minerals Division, Preliminary Map 1990F-2, 1:5 000.

Whalen, J.B.
1991: Elbow Lake project - Part B: granitoid rocks; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 28-30.

GS-8 ELBOW LAKE PROJECT - PART A: SUPRACRUSTAL ROCKS

by E.C. Syme

Syme, E.C., 1992: Elbow Lake project - Part A: Supracrustal rocks; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 32-46.

INTRODUCTION

The Elbow Lake map area comprises 250 km^2 within the Early Proterozoic Flin Flon metavolcanic belt, 65 km east of Flin Flon and 55 km west of Snow Lake (Fig. GS-8-1). It is part of NTS 63K/15W, between latitudes 54° 45' and 54° 54.6' and longitudes 100° 45' and 100° 58.2'.

The project entails detailed (1:15 840) geological mapping of well-exposed supracrustal and plutonic rocks in a portion of the Flin Flon belt that was burned during the summer of 1989. Responsibility for mapping in the Elbow Lake area is divided between Manitoba Energy and Mines (Syme: supracrustal rocks; this report) and the Geological Survey of Canada (Whalen, GS-9, this volume).

Mapping of supracrustal rocks in 1992 centred on Claw Lake, the Grass River, Long Lake, and the northeast and northwest corners of the map area (Fig. GS-8-2). This work completes the Elbow Lake project, which began with a reconnaissance in 1990 (Syme, 1990) and continued in detail on Elbow Lake in 1991 (Syme, 1991). Previous work by Stockwell (1935), McGlynn (1959) and Galley *et al.* (1987) was reviewed by Syme (1990).

Significant findings this year include:

1. the definition of a large, layered mafic-ultramafic complex at Claw Lake;
2. extension of the Elbow Lake shear zone and related structures southwest through the Grass River; and
3. geochemical subdivision of the mafic volcanic rocks at Elbow Lake into back-arc/ocean floor and transitional types, with implications for VMS exploration.

GENERAL GEOLOGY

Supracrustal rocks in the Elbow Lake area comprise Amisk Group metavolcanic rocks and related intrusions, large stratiform gabbro intrusions, and a wide variety of high level intrusive rocks.

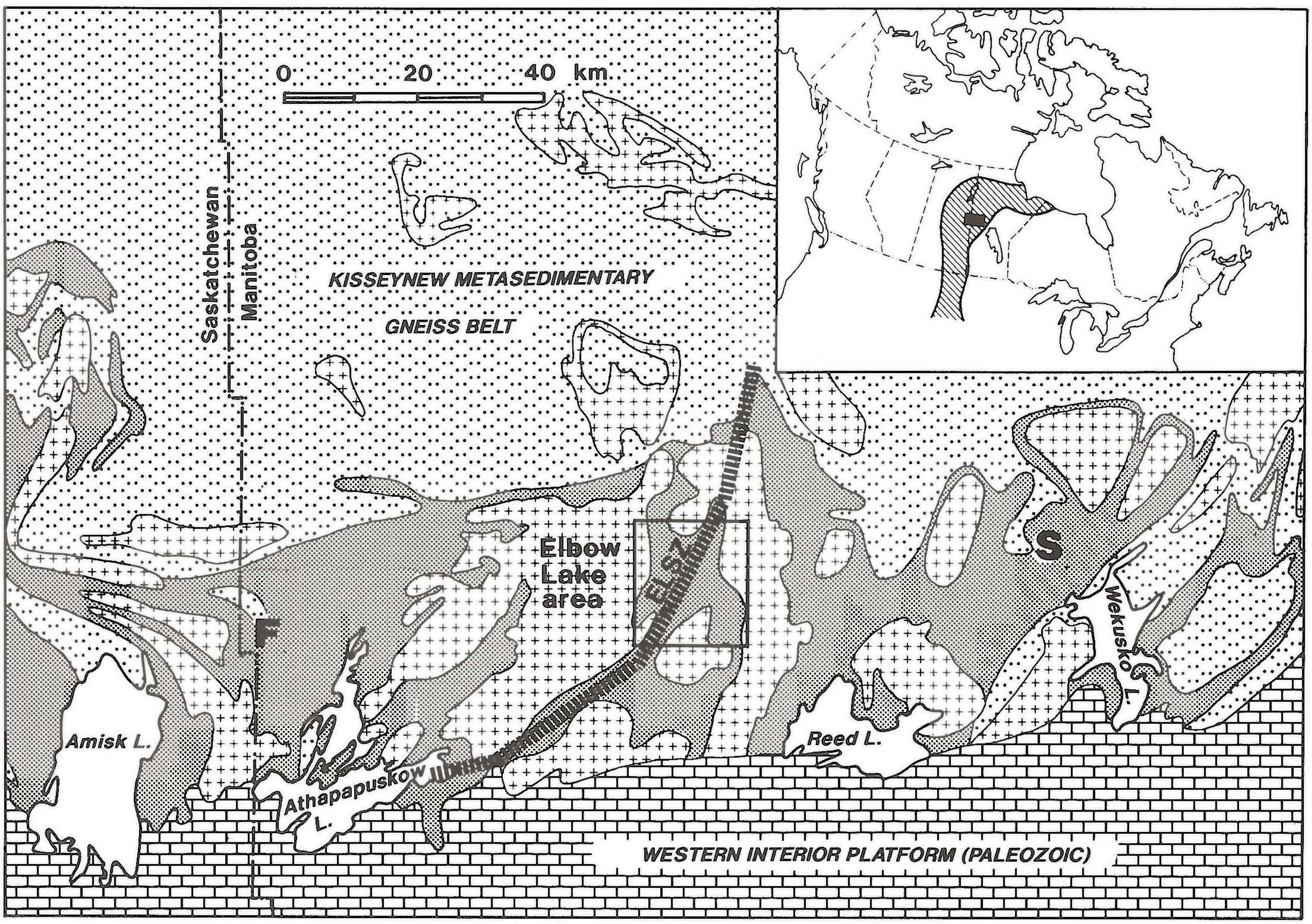


Figure GS-8-1: Simplified geological map of the Flin Flon belt with location of the Elbow Lake project area. F - Flin Flon; S - Snow Lake; ELSZ - Elbow Lake shear zone. Inset diagram shows location of Flin Flon belt within the Trans-Hudson Orogen (diagonal lines).

The supracrustal rocks are centered on Elbow and Claw lakes (Fig. GS-8-2).

Elbow Lake is transected by the Elbow Lake shear zone (ELSZ; Galley *et al.*, 1987; Syme, 1991), a north-northeast-trending structure up to 3 km wide (Fig. GS-8-1). Movement on the zone is sinistral oblique dip slip, with the east side up and to the north. Supracrustal rocks east of the ELSZ ("Centre Lake Domain") comprise a strongly deformed sequence of pillowed mafic flows and diabase, intruded by plug- and sill-like bodies of tonalite, and later by gabbros. All of the rocks have been metamorphosed in the upper greenschist to lower amphibolite facies (hornblende in mafic rocks and local garnet in felsic rocks), and are characterized by complete recrystallization, strongly developed planar fabrics, intense flattening, and the obliteration of primary volcanic textures.

West of the ELSZ ("Long Bay Domain") primary volcanic structures are generally well preserved. The rocks are at lower to middle greenschist facies, but are hornfelsed in 1 km wide aureoles around granitoid plutons. Metavolcanic units include pillowed basalt, rhyolite flows and breccia, intermediate fragmental and intrusive rocks, and heterolithologic mafic conglomerate. Tight north-northeast-trending folds are present in the volcanic rocks. In the northwest part of the domain (northwest of Long Bay and Webb Island) the supracrustal assemblage is dominated by high level dyke swarms within which metavolcanic rafts are a minor component.

Five phases of deformation are recognized:

P1 Rare, refolded east-trending isoclinal F_1 folds, lacking an axial planar foliation, developed in Long Bay conglomerate (unit 11; Syme, 1991);

P2 Northwest-trending foliation (S_2) developed east of Elbow Lake (in the Centre Lake Domain) and northwest of Elbow Lake (in the Long Bay Domain);

P3 North-northeast trending S_3 fabric through the centre of Elbow Lake, transecting the S_2 regional foliation. P_3 structures include a series of isoclinal upright F_3 folds, a well developed S_3 axial planar foliation, and the shear foliation associated with the ELSZ;

P4 Northeast-trending, generally rather open F_4 minor folds that refold S_2 foliation and tectonic lamination in the southern Centre Lake Domain. S_4 axial planar foliation, fracture cleavage, or mineral-filled fractures; and

P5 Conjugate set of late, brittle, northeast-, northwest-, and north-trending faults.

In the following sections, rocks in the areas mapped in 1992 are described. Lithologies and structure on Elbow Lake have been described by Syme (1991) and will not be repeated in this report. Unit numbers refer to those on Preliminary Map 1992F-1 (Syme and Whalen, 1992).

CLAW LAKE

Mafic tectonite (unit 2)

North and northeast of Claw Lake the supracrustal assemblage is dominated by mafic tectonites derived from pillowed, amygdaloidal, aphyric and plagioclase phyric basalt. These rocks have been termed Centre Lake mafic tectonite (unit 2; Syme, 1991), and are demonstrably derived from Claw Bay basalt (unit 1) through imposition of a strong fabric and intense flattening. A significant proportion of the unit is derived from narrow diabase dykes that intrude the basalts. Primary pillow structures such as selvages and interpillow hyaloclastite have been obliterated in the mafic tectonite, but amygdales are commonly preserved. Epidosite domains that formed in the cores of pillows are flattened into oval or lens shapes, and the rocks commonly display a crude banding or lamination due to the attenuation of heterogeneities (such as selvages) that were present in the original pillows.

Northeast of Claw Lake, structures in the mafic tectonites record a marked strain gradient towards the Gants Lake batholith. At the shore of Claw Lake pillowed basalts are well preserved and weakly strained, and contain equant epidosite domains. These pillowed flows grade northeast into mafic tectonites with epidosite augen (30 cm), in which selvages are no longer recognizable. Adjacent to the Gants Lake batholith the flows have been further deformed into thinly laminated, fine grained mafic gneiss (unit 2b) that contain ribbon-like epidosites and flattened amygdales.

A heterogeneous unit comprising parallel dykes of diabase, plagioclase-pyroxene porphyry, gabbro, and rhyolite is in shear contact with little-deformed pillow basalts northeast of Claw Lake. The dyke complex (unit 25a) is strongly deformed and locally gneissic; dykes are parallel to foliation. The 300 m thick unit consistently occurs on the east side of the Claw Lake shear zone (see below).

Claw Lake gabbro complex (unit 26)

A heterogeneous gabbro complex (unit 26) is emplaced in Centre Lake mafic tectonite and underlies most of the Claw Lake-Little Claw Lake area. The gabbro complex is in turn intruded by a dyke-like body of quartz diorite intrusion breccia (unit 22d), and is truncated by the Elbow Lake tonalite pluton (unit 29a) at the south end of Claw Lake.

The complex is composed of two distinct gabbroic units. The older unit (layered series; units 26h and 26i) is composed of modally layered mafic cumulates including gabbro, pyroxenite, peridotite, and anorthosite. This older layered sequence is intruded by a younger, more massive and homogeneous gabbro (unit 26k).

LAYERED SERIES (UNITS 26H, 26I)

The layered series is exposed on the west side of Claw Lake; it forms a lozenge-shaped body 3 km long and 1 km wide. The body contains 1500 m of mafic cumulates, but neither the top nor the bottom of the series is exposed. The body is intruded on the west by unit 26k gabbro and is truncated on the east by the Claw Lake shear zone.

Gabbroic rocks in the layered series (unit 26h; gabbro, leucogabbro, anorthosite, and subordinate pyroxenite) are modally layered at a scale of 30 cm to 5 m (Fig. GS-8-3). The layering trends northwest and dips steeply to moderately southwest. Layers are sharply bounded, parallel sided and laterally continuous; compositionally-graded layers are rare. Anorthosite layers are generally thinnest (5-20 cm), but anorthosite layers up to 1.5 m thick occur locally. In some places, gabbro pegmatite veins have intruded along the primary cumulate layering. Similarly, some thin anorthosites are concordant intrusive layers that contain tabular inclusions of gabbro.

Layered ultramafic rocks (unit 26i; pyroxenite, peridotite) occur in at least three distinct units 30 to 200 m thick within the sequence of modally layered gabbros. The ultramafic rocks are layered on a scale of about 10 cm to 5 m. Peridotite layers in the unit weather dun brown and have serpentinized, formerly olivine-rich bases grading to pyroxene-rich tops; from these graded layers it is clear that the sequence is overturned, and tops to the northeast. Pyroxenites in the sequence are layered by grain size and composition; they weather reddish brown to grey to green, and range in grain size from 2 to 7 mm.

The layered gabbros commonly exhibit complex, layer- and fracture-controlled metasomatic amphibolitization. Buff to brown gabbro is altered along igneous layering, and along anastomosing fractures, to a dark green, 2 mm grain size, melanocratic rock composed predominantly of equant black amphibole with little interstitial plagioclase. This dark green amphibolite, with the superficial appearance of a melagabbro or metapyroxenite, commonly contains ghost-like remnants of the buff gabbro (Fig. GS-8-4). Locally, some layers are partially or totally amphibolitized, whereas others display minimal alteration. As a result, primary layering in the gabbros is emphasized, with alternating dark green amphibolitized layers and buff brown "fresh" layers. White anorthositic layers are rarely altered. Parts of the layered series have been almost totally amphibolitized; in these, almost all traces of the original layering have been obliterated. Both the layered series and the younger massive gabbro exhibit metasomatic amphibolitization, suggesting that the process must have operated during the emplacement of both units. The alteration possibly records a late magmatic hydrous process related to the emplacement of ubiquitous gabbro pegmatites in the complex.

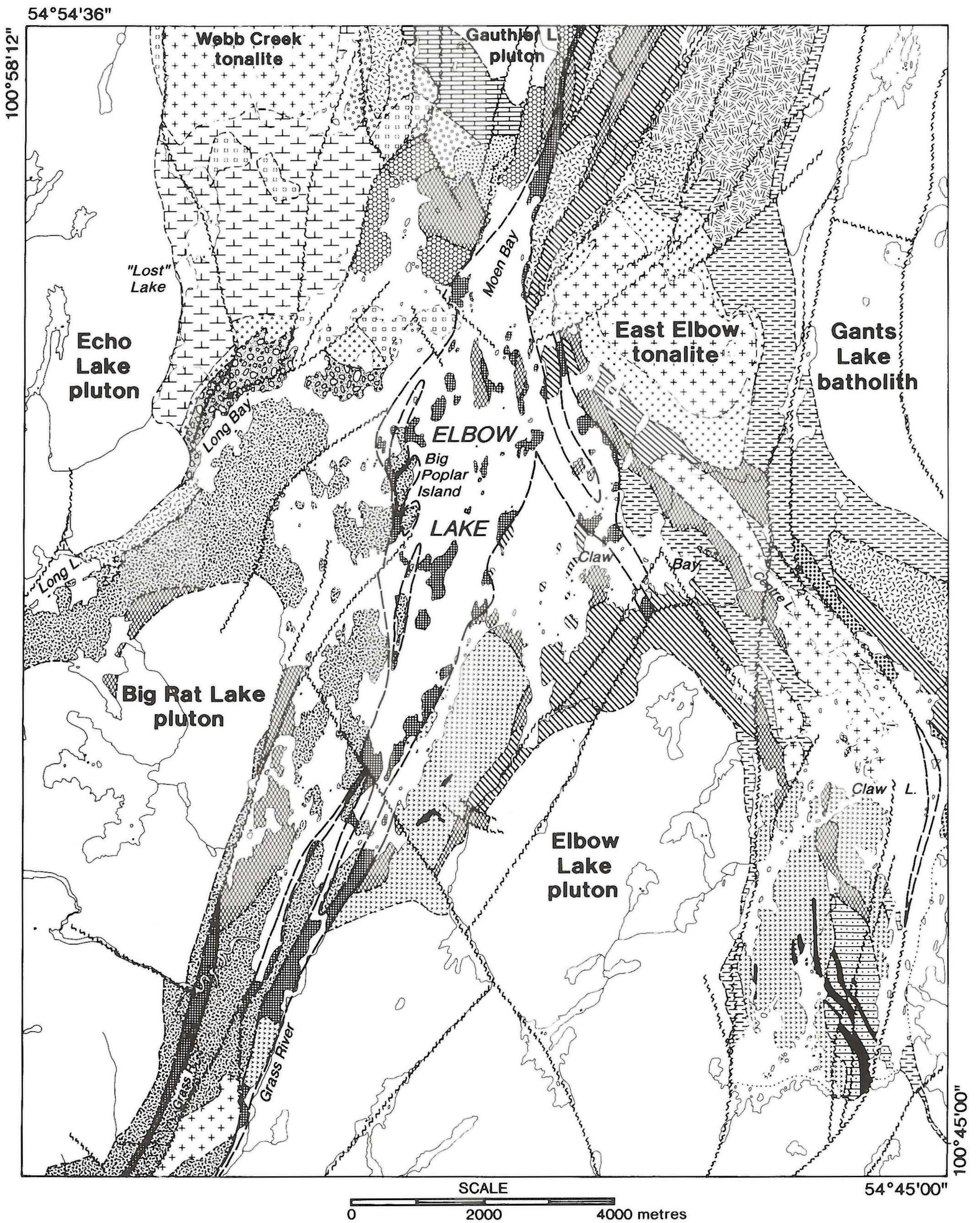
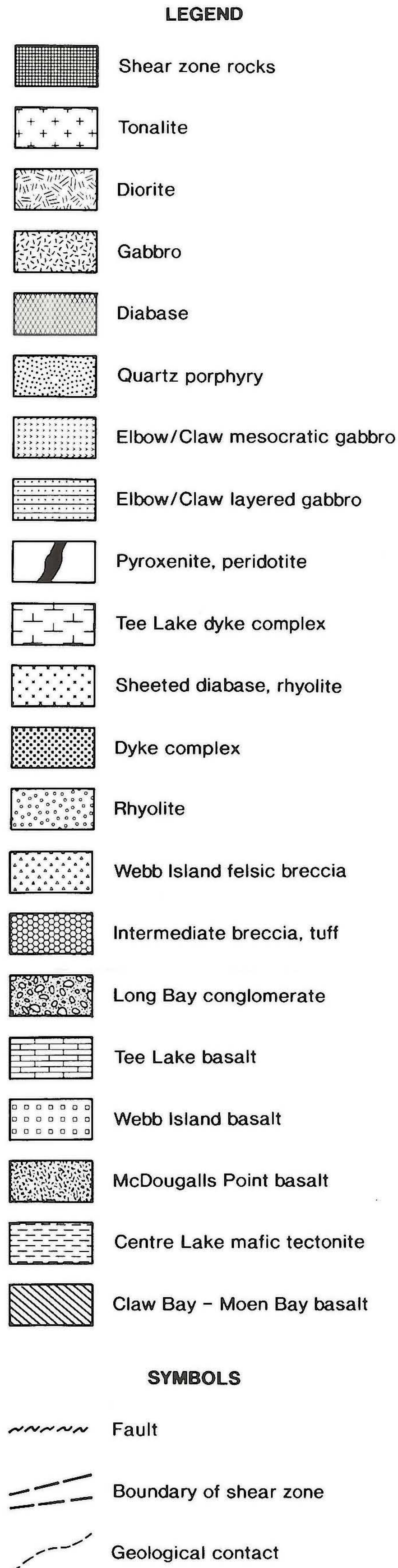


Figure GS-8-2: *Simplified geological map of the Elbow Lake area; minor intrusions in supracrustal rocks and internal contacts in plutons are omitted. For details see Preliminary Map 1992F-1.*



Foliation in the layered series crosses the layering at a high angle, implying that the sequence is folded, with a synformal axial trace that trends approximately north, through the centre of the large peninsula defined by the two arms of Claw Lake. The layered series is transected by north-northeast-trending dextral faults, across which continuity of layering and stratigraphy is lost.

YOUNGER GABBRO (UNIT 26K)

The gabbros and pyroxenites in the layered series are in abrupt, intrusive contact with more massive, light grey-green weathering gabbros (unit 26k) that form a major unit in the western Claw Lake-Little Claw Lake area.

The northern part of this unit is dominantly a fine- to medium-grained gabbro characterized by light green weathering colour, abundant white albite-epidote veinlets, common gabbro pegmatite veins and pods, pegmatitic gabbro intrusions, local wispy modal layering, and the occurrence of peridotite bodies. The gabbro is mesoscopically heterogeneous.

The younger gabbro is best exposed at Little Claw Lake. There, most of the gabbro complex consists of light grey-green, massive to wispy layered gabbros with locally abundant coarser pegmatitic gabbro intrusions, and gabbro pegmatite veins and pods. Parts of the unit are composed almost entirely of pegmatitic gabbro and gabbro pegmatite. Pegmatite bodies in this unit are locally extremely coarse, with some prismatic amphibole crystals 10 cm in diameter. The gabbro rarely displays the metasomatic amphibolitization so common in the layered series, and never displays the distinct medium-scale modal layering of the layered series. The only "layering" present is a wispy, centimetre-scale concentration of mafic minerals, or a small-scale interlayering of 1 to 2 mm grained mesogabbro and coarser, pegmatitic gabbro and leucogabbro. Large parts of the south central portion of the unit are massive and almost featureless.

Ultramafic rocks in the younger gabbro include dun-weathering peridotite, poikilitic peridotite (unit 26b), and rusty brown to green coarse grained pyroxenite. The peridotite masses are elongate, dyke- or lens-like bodies generally oriented parallel to regional foliation. They are interpreted to be inclusions stoped from the older layered series; they range in size from a few centimetres to, more commonly, several metres or tens of metres long. Some inclusions are modally layered. The presence of large peridotite rafts and smaller pyroxenite inclusions in the gabbro results in an elevated magnetic susceptibility and magnetically anomalous zones.

The younger gabbro complex includes a unit of amphibolitized gabbro veined and brecciated by pegmatitic gabbro (unit 26j). This unit is commonly strongly deformed, and occurs at the contact with layered series gabbros on Claw Lake.

Tonalite (unit 30)

Tonalite sills and a tonalite stock (East Elbow Lake stock, unit 30a; Syme, 1991) are emplaced in Centre Lake mafic tectonite (unit 2). The stock has an age of 1864 Ma (Hunt and Whalen, unpublished data), similar to the age of the Elbow Lake tonalite pluton (unit 29a; 1869 Ma, Hunt and Whalen, unpublished data). Tonalites of this suite occur only on the east side of the ELSZ.

The tonalitic sill forming the peninsula at the north end of Claw Lake (unit 30c) is fine- to medium-grained, equigranular to locally quartz phyric. An older grey-green phase is intruded by a younger, white, leucocratic phase. The tonalite is strongly deformed; southeast of Centre Lake it has gneissic layering and contains tonalitic and younger mafic (diabase) components. The eastern contact with unit 2a mafic tectonite is abrupt.

Tonalite contains a number of alteration features, such as disseminated garnet, magnetite and amphibole blasts, chlorite-amphibole-garnet-magnetite veins, Fe oxide along fractures, garnet and chlorite along fractures, that suggest the sill may be altered in much the same manner as synvolcanic tonalite sills at Snow Lake.

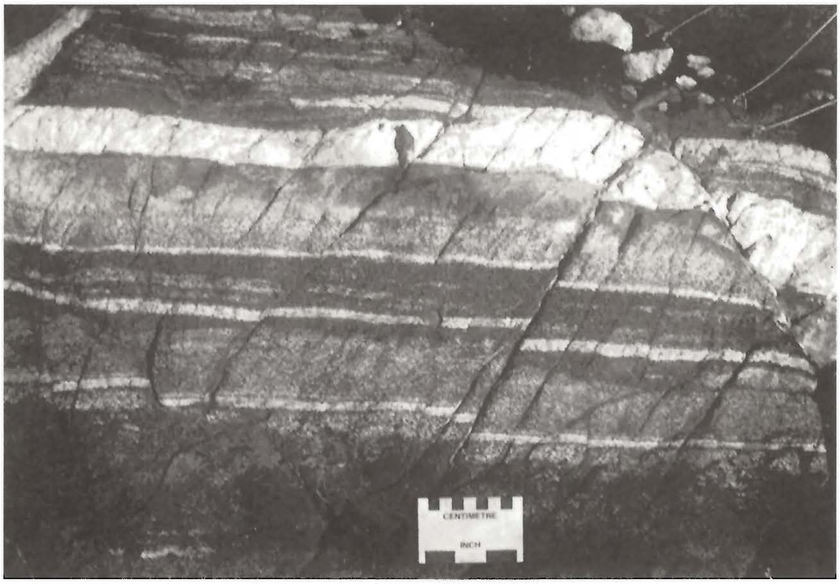


Figure GS-8-3: *Modal layering in Claw Lake gabbro.*

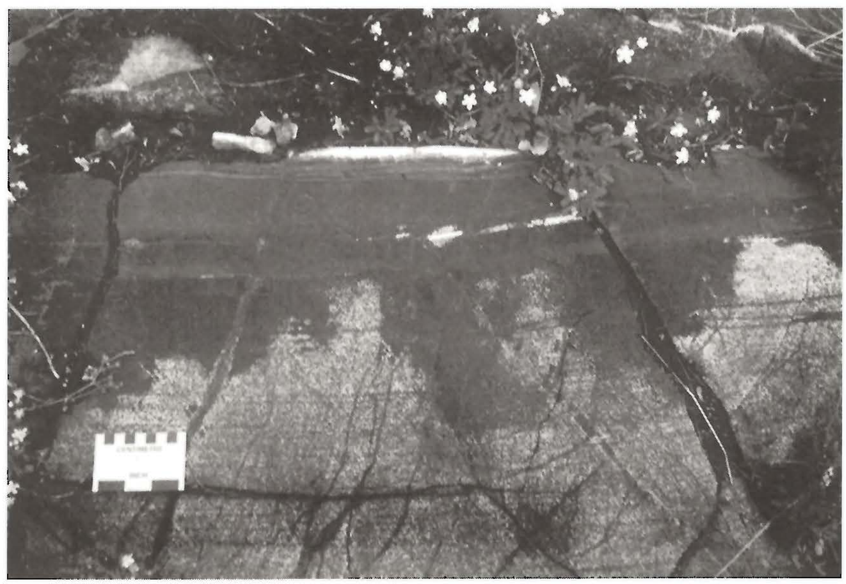


Figure GS-8-4: *Amphibolitization of gabbro in Claw Lake gabbro complex.*

East Claw Lake gabbro (unit 27)

The East Claw Lake gabbro complex is an elongate, oval mass 1 km wide and 4 km long, emplaced in unit 2 mafic tectonite east of Claw Lake. Only the north half of the body occurs within the Elbow Lake map area. This gabbro consists of several intrusive phases that may occur on a single outcrop. Although it is locally layered, it is not related to the Elbow Lake/Claw Lake gabbro; it is much coarser grained and more heterogeneous on a mesoscopic scale. The gabbro is typically only weakly foliated, and may be considerably younger than the tectonically laminated mafic flows in which it is emplaced.

The northern tip of the body was described in the 1991 Preliminary report (Syme, 1991). The central part of the body comprises two main units: a modally layered section (unit 27b); and a dominantly pegmatitic section (unit 27d).

The layered gabbro includes light grey to buff-weathering, mesocratic, medium- to coarse-grained gabbro with moderately defined 5 cm to 1 m modal layering, younger coarse grained white gabbro, dark green pyroxenite and melagabbro inclusions, and gabbro pegmatite. Pegmatites in this phase are large (up to several metres), amoeba-shaped bodies emplaced in older gabbros.

The pegmatitic section is composed of light grey to white-weathering, coarse grained (4-10 mm) pegmatitic gabbro that contains very coarse grained pegmatite pods and segregations. These are cut and locally brecciated by a finer grained leucodiorite and quartz diorite; white leucotonalite veins are latest. Outcrop-sized domains of coarse grained (5 cm) oikocrystic melagabbro are cut by gabbro, pegmatitic gabbro, quartz diorite and tonalite, and appear to represent, with pyroxenite and equigranular melagabbro, the oldest phases of the intrusion.

Quartz diorite intrusion breccia (unit 22d)

Quartz diorite intrusion breccia occurs around the margins of unit 30b tonalite northwest of Claw Lake, and as large dyke-like bodies that intrude unit 26 gabbro on northern Claw Lake. Their spatial association with unit 30 tonalite, and the local occurrence of quartz-megacrystic tonalite matrix material, suggests that these bodies are coeval with the tonalite.

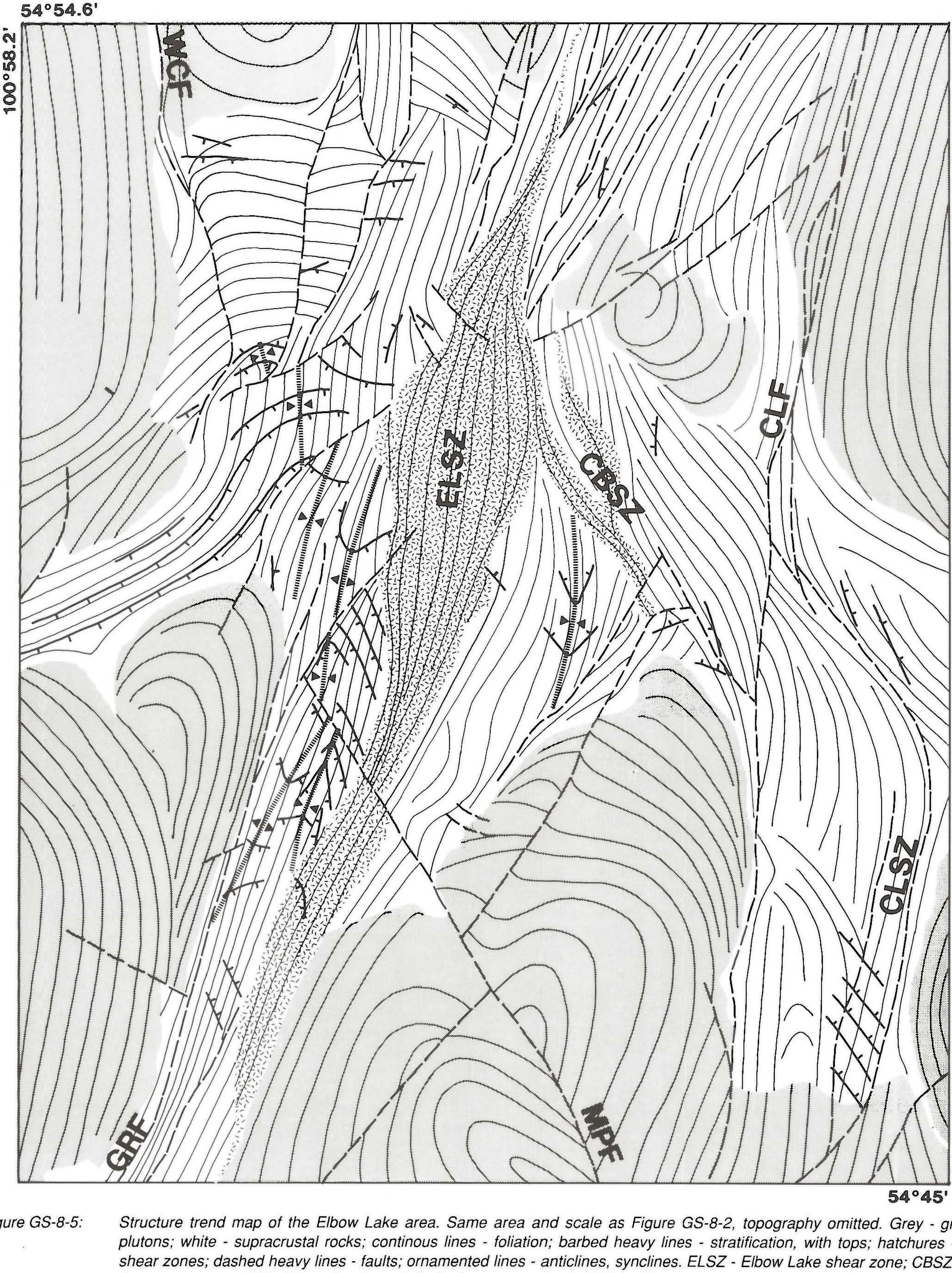


Figure GS-8-5: *Structure trend map of the Elbow Lake area. Same area and scale as Figure GS-8-2, topography omitted. Grey - granitoid plutons; white - supracrustal rocks; continous lines - foliation; barbed heavy lines - stratification, with tops; hatchures - major shear zones; dashed heavy lines - faults; ornamented lines - anticlines, synclines. ELSZ - Elbow Lake shear zone; CBSZ - Claw Bay shear zone; WCF - Webb Creek fault; CLF - Centre Lake fault; CLSZ - Claw Lake shear zone; GRF - Grass River fault; MPF - McDougalls Point fault.*

The intrusion breccia contains a heterogeneous suite of diabasic inclusions in a fine- to medium-grained quartz diorite to tonalite matrix. Variably assimilated inclusions are rounded to angular in shape and up to several metres in length; these are commonly elongate parallel to foliation. Large inclusions of gabbro with pegmatite veins occur in the intrusion breccia dykes emplaced in gabbro.

NORTHEAST CORNER

Elbow Lake deformation zone

Northeast of Moen Bay the Elbow Lake shear zone narrows from a width of more than 2 km to only a few tens of metres. The deformation is taken up, however, in a closely-spaced series of discrete 020°-trending faults (Fig. GS-8-5). Together with a similar zone on the east side of Moen Bay, the total width of the deformation zone in the Moen Bay area is 2.5 km.

The faults occur within a sequence of aphyric mafic flows (unit 3) and a variety of mafic intrusions. Many of the mafic flows display good preservation of primary pillow features; most are black-weathering, weakly foliated and hornfelsed. Late, pyroxene phyric gabbros (unit 16d), with 2 to 8 mm pseudomorphs after pyroxene in a recrystallized groundmass of plagioclase are associated with and intrude deformed mafic volcanic rocks. Rhyolite (unit 19) occurs in a highly strained fault panel where one 020° fault splays; it apparently intrudes, with granodiorite, foliated and sheared mafic volcanic rocks that contrast sharply with hornfelsed rocks in an adjacent fault panel.

Gants Lake batholith

The contact between Gants Lake granodiorite (unit 31a) and mafic tectonite (unit 2a) is exposed at several localities in the northeast corner of the map area. Much of this contact is occupied by a 100 m wide, pink, strongly foliated to mylonitic, leucocratic, granite pegmatite/aplite (unit 31e). This granitoid sheet locally cuts into the mafic tectonite, where it is enclosed by the mafic rocks. A splay from the Centre Lake fault repeats the mafic tectonite/granodiorite contact north of the long lake east of Elbow Lake.

East of Elbow Lake strain in the supracrustal assemblage increases towards the contact with the Gants Lake batholith. Adjacent to the contact, unit 2a mafic rocks are tectonically laminated. West of the contact, primary pillow features such as selvages, amygdales, interpillow epidote, and amoeboid pillow breccia are locally preserved.

East Moen diorite complex (units 16j, k, l)

The northeast part of the map area east of the Elbow Lake deformation zone is dominated by a diorite plutonic complex at least 1.8 by 3.4 km in size. The complex is bordered on the east by a narrow septum of unit 2a mafic tectonite, which separates the complex from granodiorite of the Gants Lake batholith. To the west, the diorite complex is truncated by the Elbow Lake deformation zone and is in fault contact with unit 3 pillow basalts and diabase.

The diorite complex is composed of fine- to medium-grained hornblende diorite, hornblende-biotite diorite and quartz diorite. These vary widely in composition and texture, and intrusive contacts between different phases are common. Massive diorite (unit 16j) occurs in the core of the complex, at the northern boundary of the map area. Most of the southern part of the complex is agmatite (unit 16k), in which quartz diorite and diorite sheets are emplaced in diabase and mafic tectonite. The agmatite contains small flattened assimilated inclusions and huge tabular rafts of unassimilated, metasomatically altered mafic material. Some of the mafic rafts are up to several metres wide by tens of metres long, elongate parallel to regional foliation; they were deformed prior to incorporation in the intrusive complex. Coarse hornblende blastesis is locally developed in the mafic inclusions; parts of the diorite complex are subpegmatitic and may have been the source of metasomatic fluids. Larger, dyke-like bodies of massive diorite occur within the inclusion-choked agmatite. The southern portions of the diorite complex are predominantly quartz diorite and tonalite intrusion breccia.

NORTHWEST CORNER

Tee Lake dyke complex (unit 24)

North of "Lost" Lake and southwest of Tee Lake the supracrustal assemblage is dominated by the Tee Lake dyke complex (unit 24; Syme, 1991). This complex consists of diabase, rhyolite, mafic plagioclase-pyroxene porphyry, and leucotonalite dykes, with common screens of black, fine grained, hornfelsed pillow basalt (unit 5). Some areas are dominantly basalt, and map out as enclaves within the dyke complex; good top criteria are present in both the smaller basaltic rafts and in the larger enclaves.

Webb Creek tonalite (unit 22e, f)

Webb Creek tonalite occurs along the north boundary of the map area, and is equivalent to a tonalite unit in the Webb Lake area to the north (Schledewitz, GS-2 this volume). The pluton contains two phases: an inequigranular to quartz megacrystic massive tonalite with no inclusions (unit 22e), and a fine grained equigranular to medium grained quartz megacrystic tonalite with abundant inclusions (unit 22f).

Massive tonalite occurs on the eastern and southern portions of the pluton. It is commonly plagioclase phyric and seriate textured, with plagioclase phenocrysts to 8 mm. Quartz megacrysts are up to 10 mm; groundmass plagioclase is 0.5 to 2 mm. The mafic mineral in massive tonalite is prismatic hornblende (to 3 mm), usually recrystallized to chlorite.

Inclusion-bearing parts of the pluton are commonly agmatitic and contain 40 to 60% inclusions. The inclusions are uniformly a brown to rusty brown, fine grained "mafic" rock that contains 5 to 10%, 1 mm quartz. They may represent either an early quartz dioritic plutonic phase, or metasomatized diabasic country rocks. The inclusions are irregular to tabular in shape, 30 cm to 2 m long, and are aligned when tabular. Large rafts (up to 24 m long by 6 m wide) in the agmatite are predominantly recrystallized mafic volcanic material. The agmatite matrix varies from fine grained leucotonalite (in the north and at the margins of the pluton) to quartz megacrystic tonalite (in the interior of the pluton). The agmatite tends to have a much better foliation than the massive tonalite, and has ubiquitous Fe oxide alteration and recrystallized plagioclase.

LONG LAKE

Porphyritic pillowed mafic flows exposed south of Long Lake are laterally equivalent to McDougalls Point basalt (unit 6; Syme, 1991) exposed on Elbow Lake. The flows face south to southeast, part of the west limb of a large F_3 synclinal structure whose axial trace lies southwest of Webb Island.

Pillows are commonly flattened parallel to stratification. The flows are dark grey-green to black within the contact metamorphic aureole of the Big Rat Lake and Echo Lake plutons (pillowed flows outside the aureoles weather light buff). The pillowed flows vary from plagioclase phyric to plagioclase-pyroxene phyric, with 5 to 20% plagioclase phenocrysts (unit 6c). Flows with contrasting phenocryst contents have been observed in sharp contact.

Strain increases southward towards the Big Rat Lake granodiorite contact, where aspect ratios of pillows are up to 15:1. Mafic flows also become more foliated northwards, towards the shore of Long Lake, suggesting that there may be a northeast-trending shear zone through Long Lake.

GRASS RIVER

The supracrustal belt in the Grass River inlet/outlet area is only about 1.5 km wide, between the Elbow Lake pluton to the east and the Big Rat Lake pluton to the west. Both the Elbow Lake shear zone (ELSZ) and Grass River fault (GRF) occur within the narrow confines of the supracrustal belt, and form a complex system of anastomosing faults, shear zones and intervening low-strain panels.

Lower-strain rocks in the Grass River area include well preserved aphyric McDougalls Point basalt (unit 6a), plagioclase phyric and plagioclase-pyroxene phyric pillowed basalt (unit 6b), plagioclase phyric mafic intrusions (unit 17g), and inequigranular to weakly quartz-megacrystic tonalite (unit 29b).

McDougalls Point basalt (unit 6a) weathers buff, and includes both pillowed flows (with abundant interpillow chert) and massive flows. The flows top northeast and are flattened parallel to a 020°-trending foliation. Flow contacts and interflow sedimentary layering in the sequence are locally transposed into minor 020° sinistral shear zones that are presumably related to the larger ELSZ.

West of the GRF, mafic flows are hornfelsed and flattened adjacent to the Big Rat Lake pluton.

AGE RELATIONSHIPS

1. The Claw Lake gabbro complex (unit 26h to m) is interpreted to be the same age as the Elbow Lake gabbro (unit 26a to g; Syme, 1991), on the basis of close lithologic similarity of gabbroic and ultramafic phases. The Elbow Lake and Claw Lake gabbros occur on the west and east sides, respectively, of the Elbow Lake tonalite pluton. Large ultramafic intrusions also occur on the south side of the Elbow Lake pluton (Hunt, 1970), raising the possibility that all of these early mafic and ultramafic intrusive rocks may be related, perhaps originally in a single large stratiform intrusion. The age of this major mafic intrusion is not yet precisely established; however, the tonalite pluton that intrudes the gabbro has been dated at 1869 Ma (Hunt and Whalen, unpublished data). The Amisk Group has been dated at 1886-1925 Ma (Gordon *et al.*, 1990; Machado and David, 1992; Syme *et al.*, 1991), so the possibility exists that these voluminous mafic intrusive rocks are approximately synvolcanic. Mesocratic gabbro from the Elbow Lake body is strongly depleted in REE and HFS elements (*e.g.* Zr, Ti, Y) relative to N-MORB, similar to arc tholeiite basalts in the Amisk Group (see Geochemistry, below).
2. Southeast of Claw Lake the contact between Elbow Lake tonalite pluton (unit 29a) and Gants Lake batholith (agmatitic phase; unit 31b) is occupied by a narrow septum of mafic tectonite. The agmatite contains inclusions and large rafts of mafic rocks, principally laminated mafic tectonite, mafic flows with epidosite augen, diabase, gabbro and green pyroxenite. Elbow Lake pluton unit 29a-type tonalite dykes clearly cut the quartz diorite agmatite, and locally contain large inclusions of the agmatite. This relationship indicates that the Gants Lake batholith is older than the Elbow Lake tonalite; that is, older than 1869 Ma. The mafic tectonite inclusions in the agmatite must have been deformed prior to 1867 Ma.
3. The eastern margin of the Elbow Lake tonalite contains inclusions of tectonically laminated mafic rocks identical to the mafic tectonite country rocks. This relationship indicates that the mafic rocks were deformed prior to intrusion of the pluton; the deformation may have been related to emplacement of the pluton itself.

FAULTS AND SHEAR ZONES

Elbow Lake shear zone

The Elbow Lake shear zone (ELSZ) on Elbow Lake has been described by Syme (1991) and Galley *et al.* (1987). This year, the southwest extension of the zone was mapped, through the Grass River area.

On the southern part of McDougalls Point the ELSZ is 820 m wide, and comprises three separate shear zones separated by lower-strained rocks (Fig. GS-8-5). To the south, the two easterly zones join to form a single zone 370 m wide. The westerly zone bifurcates to form two discrete faults, one down the Grass river inlet and one down the Grass River outlet. The structures on the Grass River outlet side probably connect with structures mapped by Hunt (1970) in the Iskwasum Lake area, while those on the Grass River inlet connect with major faults and shear zones through the Cranberry lakes.

The eastern, 370 m wide part of the ELSZ contains abundant syn-kinematic felsic dykes (unit 41) emplaced in mafic phyllonite (unit 35) derived from pillowed basalt. The felsic dykes include quartz-feldspar porphyry, aphyric rhyolite, quartz phyric rhyolite, quartz megacrystic rhyolite, and quartz megacrystic tonalite. Small dykes in the zone are commonly folded, with a consistent S-asymmetry, indicating sinistral shear within the zone. The eastern margin of this zone is marked by the truncated margin of the Elbow Lake tonalite. Outcrops of tonalite within metres of the projected trace of the ELSZ are foliated but not sheared or brecciated. One outcrop of mafic schist on the east margin of the zone has dextral shear sense indicators (Z-asymmetric folds, extensional fractures, dextral conjugate faults), opposite to the sinistral indicators in the felsic dyke suite. Unit 29a tonalite dykes in this schist are boudinaged and clearly deformed by the shearing. This eastern part of the ELSZ narrows significantly to the south, so that at the south end of the map area the zone is no more than 50 m wide.

A sinistral sense of offset is demonstrated by the displacement of a segment of the Elbow Lake gabbro complex (unit 26) along the ELSZ in the Grass River outlet area. A gabbro body lithologically identical to mesocratic gabbros in the Elbow Lake gabbro complex occurs within the ELSZ, indicating at least 2 km of left-lateral displacement in the zone. The gabbro (unit 26a) is strongly sheared along the Grass River (the east margin of the ELSZ), but is less sheared in low strain zones and in the interior of the body. The gabbro is intruded by an agmatite (unit 22d) with abundant small inclusions of various diabase, gabbro and diorite in a fine grained quartz diorite matrix.

Flattened, plagioclase phyric pillowed flows (unit 6b) and a plagioclase phyric mafic intrusion (unit 17g) occurs between the eastern and western parts of the ELSZ. The pillowed flows are unlike McDougalls Point basalt exposed between the western part of the ELSZ and the Grass River fault.

LINEATIONS

Lineations in the ELSZ are defined by alignment of chlorite in mafic rocks, sericite in felsic rocks, rodded epidosite domains, pencil-like cleavage fragments, elongate primary mineral pseudomorphs, and rodded primary fragments or clasts. All lineations in the ELSZ lie within the foliation plane and are steep to vertical, with variable plunge azimuth depending on the foliation attitude. There are a few shallow north plunges in the Grass River outlet area, where both sinistral and dextral kinematic indicators have been recorded. In the south and central parts of the ELSZ the dominant plunge is easterly (*i.e.* subvertical directly down dip) to northeast (steep rake to the north). In the northern part of the zone, there is some indication that the lineation plunges to the southeast to southwest. Lineations in the Claw Bay shear zone are similar to those in the ELSZ.

Lineations outside the ELSZ are parallel to those within the zone. For example, on Webb Island lineations generally plunge steeply to the southeast. The main difference between the Webb Island fabric and the ELSZ fabric is the extreme flattening exhibited within the shear zone. West of the shear zone there is little flattening, and outcrop surfaces perpendicular to the elongation lineation display well preserved primary features such as amoeboid pillow breccia, clasts, pillows, and amygdales. Primary features are generally highly attenuated within the shear zone.

Pillow basalts outside the shear zones on Elbow Lake have poorly developed lineations. Objects such as spherulites and amygdales in the pillows are undeformed, and the rocks are too fine grained to observe a mineral lineation, even in moderately foliated rocks. The pillows commonly appear to be somewhat flattened, but not extended. In the shear zones there is both extreme flattening and extreme extension, forming a prominent mineral and elongation lineation.

Subvertical lineations within the ELSZ suggest that movement within the zone was dominantly dip-slip, although sinistral kinematic indicators, sinistral offset of Long Bay conglomerate (unit 11; Syme, 1991), and sinistral offset of Elbow Lake gabbro (unit 26) indicate that there was also a strike-slip component of movement.

Grass River fault

The Grass River fault (GRF; Syme, 1991) is a major, north-northeast-trending structure oriented parallel to the ELSZ in the Grass River inlet area. This structure probably links up with mapped structures in the Cranberry Lakes area (Podolsky, 1951).

Along the Grass River south of Separation Creek a zone of shearing and brittle deformation is laterally equivalent to mylonites that mark the GRF west of McDougalls Point. Rocks in this 230 m wide zone of brittle deformation are characterized by lens-shaped tectonic fragments and open-space-filling buff carbonate; basalt and diabase appear to have been sheared prior to brecciation. A similar style of deformation is associated with the GRF farther north; there the brittle deformation lies to the west of the mylonite zone. Lineations in the GRF zone are steep to the north, similar to those in the ELSZ.

Centre Lake fault

The Centre Lake fault is a straight, linear feature that has been mapped for 18 km, from the bottom to the top of the map area (Fig. GS-8-5). This structure postdates both the Elbow Lake tonalite pluton and Gants Lake batholith. East of Elbow Lake the fault is a narrow, presumably brittle structure that typically occupies a narrow topographic linear, whereas in the Claw Lake-Little Claw Lake area it is a shear zone up to 20 m wide. Good exposures of this zone on southwestern Claw Lake contain kinematic indicators that suggest the sense of shear within the zone is sinistral, with a shallow, south-plunging lineation (*i.e.* east side up and to the north; pluton side down and to the south). The zone consists of mafic phyllonite that contains boudinaged quartz and aplite veins, and local, mylonitized, isoclinally folded felsic members.

East of Elbow Lake the Centre Lake fault bifurcates and rejoins, forming a lens-shaped fault block. The contact between the Gants Lake batholith and mafic tectonites in the supracrustal belt is repeated within the fault block.

Claw Lake shear zone

The Claw Lake shear zone is one of a number of north-northeast-trending faults and shear zones that occur in the Claw Lake area. The zone cuts the Elbow Lake tonalite pluton in the south, trends north-northeast through the east arm of Claw Lake, then curves to trend northwest through the area north of Claw Lake. The zone is narrow to the north and south, but widens to at least 200 m on central Claw Lake. In the south it is probably a narrow brittle structure, and is accompanied by intense ductile deformation in the hanging wall (east side).

This structure truncates igneous layering in the layered series gabbro on southern Claw Lake, and juxtaposes plutonic material (agmatites and tonalite) against the greenstones in south Claw Lake. Within the shear zone are mafic chloritic phyllonites with abundant intrafolial quartz and carbonate, similar to the ELSZ.

Webb Creek fault

The Webb Creek fault is a north-trending, curvilinear structure that occurs along Webb Creek north of "Lost" Lake, and extends south into the Long Bay area (Fig. GS-8-1). The fault truncates the western margin of the Webb Creek tonalite, cuts the Tee Lake dyke complex, and offsets the Webb Island felsic breccia/Long Bay conglomerate contact. An exposure of sheared rocks within this zone at the north end of "Lost" Lake contains sinistral kinematic indicators (asymmetric folds, boudins) consistent with mapped sinistral offset of lithologic contacts.

GEOCHEMISTRY

As part of the mapping project at Elbow Lake, samples of metavolcanic and intrusive rock units were collected for geochemical analysis. The purpose of the geochemical investigation is to compare the composition of metavolcanic rocks at Elbow Lake with those in the Flin Flon area, where there is a large geochemical data base that contains analyses of metavolcanic rocks that are known to host VMS deposits. This is important, because massive sulphide deposits of economic size and grade have not been found in Amisk Group rocks in the Elbow and Cranberry lakes area. Considering the number of massive sulphide orebodies that occur elsewhere in the Flin Flon belt, the absence of deposits in this area appears to be anomalous. Significant differences in composition between Elbow Lake and Flin Flon metavolcanic rocks may explain, in part, the absence of VMS deposits at Elbow Lake.

Basalt geochemistry

Recent work at Flin Flon has demonstrated that the metavolcanic belt represents an Early Proterozoic island arc complex that contains arc tholeiite, back arc/ocean floor and shoshonitic assemblages (Syme, 1990, 1988; Bailes and Syme, 1989). Most of the Amisk Group is dominated by subaqueous mafic volcanic rocks with island arc tholeiite geochemical characteristics: relative to N-MORB, basalts in this group have high contents of large ion lithophile (LIL) elements (*e.g.* K, Rb, Ba, Th, Sr), low contents of high field strength (HFS) elements (*e.g.* Hf, Ti, Zr, Y), and very low Ni and Cr contents. Back-arc/ocean floor basalts in the Athapapuskow Lake area are more magnesian than the arc tholeiites, and have higher HFS element, Ni and Cr contents. Nearly all of the VMS deposits at Flin Flon are associated with the arc tholeiite assemblage, and occur in complex stratigraphic sequences which represent volcanic constructs and associated intravolcanic basins within the former magmatic arc. Similar results are reported from Snow Lake (Bailes, 1988). Back-arc or ocean floor basalts in the Flin Flon area host only a few, small, Cu-rich massive sulphide deposits, and consequently have a lower exploration potential than the arc tholeiite assemblage (Syme and Bailes, in prep.).

Considering the difference in base metal potential between arc tholeiite and back-arc/ocean floor assemblages at Flin Flon, a primary objective of the present study is to classify the tectonic affinity of metavolcanic rocks at Elbow Lake. Preliminary results, discussed below, suggest that the ELSZ has juxtaposed basaltic units that were emplaced in different tectonic environments:

1. East of the ELSZ, Claw Bay - Moen Bay basalts (units 1-3) have back-arc/ocean floor geochemical characteristics;
2. West of the ELSZ, most of the basalts (McDougalls Point basalt, unit 6) appear to be magnesian arc tholeiites that contain characteristics of both the arc tholeiite and back-arc/ocean floor assemblages at Flin Flon;
3. Possible Flin Flon-type arc tholeiites occur only in a small part of the area, west of the ELSZ (Webb Lake and Tee Lake basalts, units 4 and 5); and
4. Basalt clasts in Long Bay conglomerate (unit 11) have geochemical characteristics which suggest that the source flows were erupted in a within-plate setting.

Basalts in the four groups above can be readily distinguished by a variety of geochemical criteria. For example, Claw Bay-Moen Bay basalts (units 1-3) east of the ELSZ have convex rare earth element (REE) patterns that are slightly depleted at the light rare earth (LREE) end and flat at the heavy rare earth (HREE) end (Fig. GS-8-6). In contrast, McDougalls Point basalts (unit 6) from west of the ELSZ have dead flat REE patterns, with REE concentrations about 10 times chondritic values. A representative of the arc tholeiite assemblage from the Webb Island area (unit 5) has very low REE concentrations (only 3-4 times chondrite) and a flat pattern. Basalt clasts in Long Bay conglomerate (unit 11) have very distinctive REE patterns showing a steady increase in REE abundance from the heavy (Lu) to the light (Ce) end; the LREE enrichment in these particular basalts is notable because they are the most magnesian of all basalt suites at Elbow Lake (7.2-13.4 wt.% MgO, average 9.4%).

These data clearly demonstrate that basalts in the Elbow Lake area are petrogenetically heterogeneous. The compositional heterogeneity can be interpreted to reflect different tectonic environments in which the basalts were erupted, as follows.

1. Claw Bay-Moen Bay basalts east of the ELSZ have flat MORB-normalized patterns, similar to back-arc/ocean floor basalts in the Flin Flon area (Fig. GS-8-7). These basalts are enriched (relative to MORB) in the mobile LIL elements Rb, Ba and K, but the less-mobile LIL element Th has a concentration similar to MORB and is more likely to reflect primary LIL element concentrations. On tectonic discriminant diagrams (Fig. GS-8-8) Claw-Moen basalts plot in the ocean floor basalt field. The LREE depletion exhibited by these rocks is consistent with the interpretation of units 1-3 as back-arc basalts.
2. McDougalls Point basalts (unit 6) west of the ELSZ have a sloping MORB-normalized pattern that demonstrates enrichment in LIL elements (notably including Th), similar to arc tholeiite basalts at Flin Flon (Fig. GS-8-7). However, HFS element concentrations are not as low as in Flin Flon arc tholeiite assemblage, and Ni and Cr con-

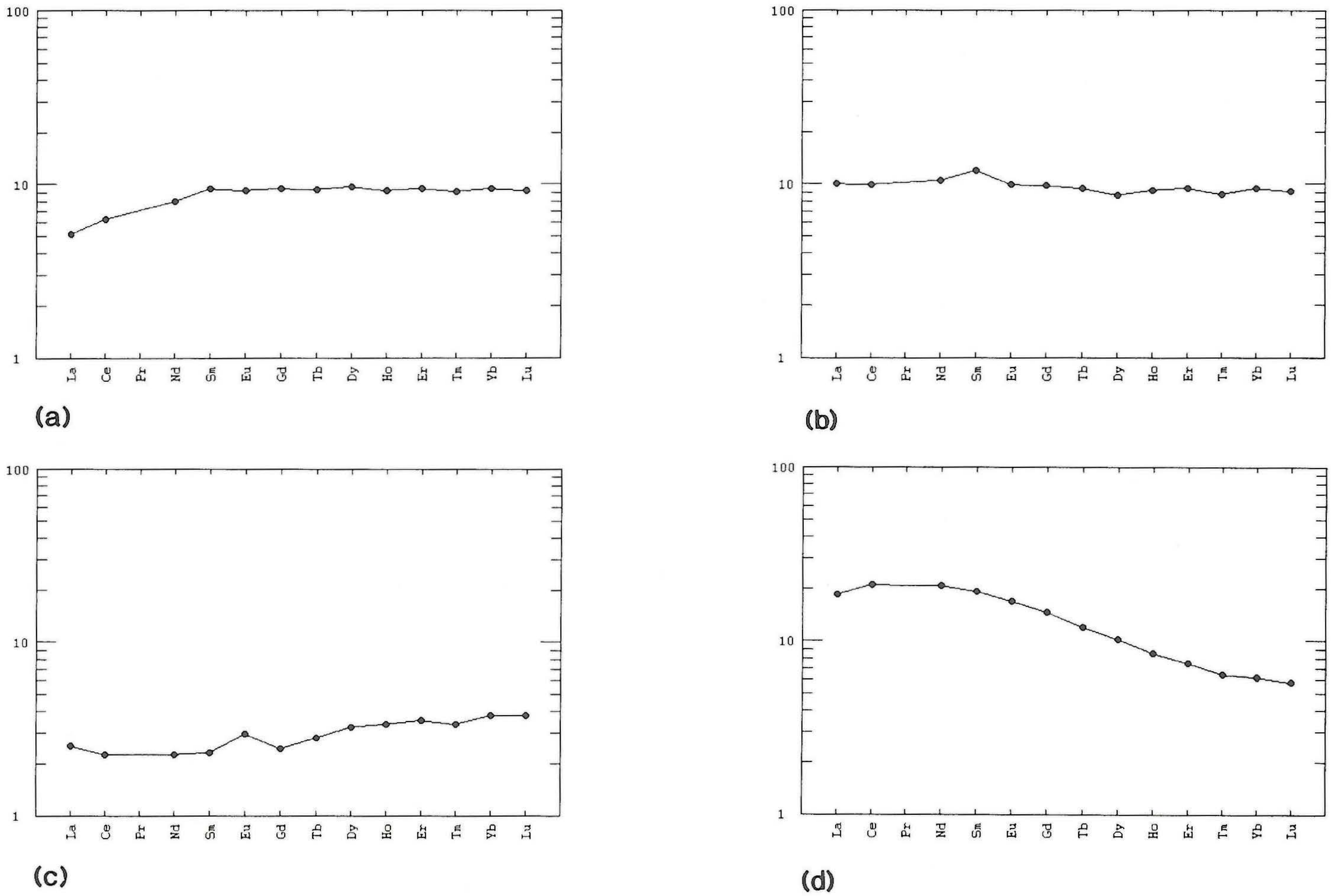


Figure GS-8-6: Chondrite-normalized rare earth element patterns of basaltic units in the Elbow Lake area; each represents an average (n = number of samples). a) Claw-Moen basalts (n = 4); b) McDougalls Point basalt (n = 9); c) Webb Island basalt (n = 1); and d) basalt clasts, Long Bay conglomerate (n = 5).

tents in McDougalls Point basalts are much higher than in Flin Flon arc tholeiites. On tectonic discriminant diagrams, these rocks plot in both the island arc basalt and ocean floor basalt fields. They are more magnesian than Flin Flon arc tholeiites (average 7.3 wt.% MgO, vs. 5.2% MgO for arc tholeiites), and appear to represent a group of rocks transitional between back-arc basalts and HFS-depleted arc tholeiites. On Elbow Lake these basalts form a homogeneous mafic pile at least 1.3 km thick, containing no intercalated felsic or volcaniclastic units.

3. Webb Island basalts (unit 5) in the northwest part of the map area are strongly depleted in HFS elements, Ni and Cr, and thus are broadly similar to Flin Flon arc tholeiites (Fig. GS-8-7). They are clearly different from McDougalls Point basalts, but there are too few data for this group to confidently assign tectonic affinity. Webb Island basalts occur in a sequence that contains felsic volcaniclastic rocks, rhyolite flows, and intermediate tuffs and breccias, broadly similar to arc sequences at Flin Flon.
4. Basalt clasts in the Long Bay conglomerate (unit 11) are enriched in LIL, HFS and REE elements relative to MORB, with the notable exception of Y and Yb (Fig. GS-8-7). These magnesian basalts also have high Ni and Cr contents. As a group, they are characterized by high TiO_2 contents (1.3-2.3 wt.%, average 1.9%), much higher than Flin Flon back-arc or arc tholeiite basalts (which average 1.1% and 0.6% TiO_2, respectively). On a tectonic discriminant diagram Long Bay basalt clasts plot in a tight group in the within-plate basalt field (Fig. GS-8-8). The elevated REE contents of these highly distinctive rocks are consistent with the interpretation that they represent flows that were erupted in a within-plate setting, very different from other, arc-related, basalts in the Elbow Lake area. The basaltic, clastic components of Long Bay conglomerate were transported from their place of origin by subaqueous debris flows (Syme, 1991); nevertheless, the large clast sizes and thickness of beds suggests that these epiclastic rocks are proximal.

In the Flin Flon-Athapapuskow Lake area, arc tholeiite and back-arc suites can be readily distinguished by their Mg/Ni ratios (Fig. GS-8-9). This provides an excellent discriminant function that does not rely on expensive trace element analysis. When applied to basalts in the Elbow Lake area, the discriminant suggests that Claw Bay-Moen Bay basalts, and McDougalls Point basalts, are similar to Flin Flon back-arc/ocean floor units (Fig. GS-8-9).

Rhyolite geochemistry

Rhyolites at Elbow Lake are less useful than basalts to interpret tectonic affinity, in part because there are so few rhyolite flows in the stratigraphic succession. In fact, the only probable rhyolite flows are two bodies west of the ELSZ, one on Webb Island (Century rhyolite, unit 9) and one east of Tee Lake (Tee Lake rhyolite, unit 9). Rhyolite intrusions are common, but vary in age from probably synvolcanic (units 19, 21, 24) to syn-plutonic (unit 23) to syn-kinematic (unit 41).

Different rhyolite units in the Elbow Lake area can, like the basalts, be distinguished geochemically. Century rhyolite has an elevated, flat REE pattern, characterized by a large negative Eu anomaly

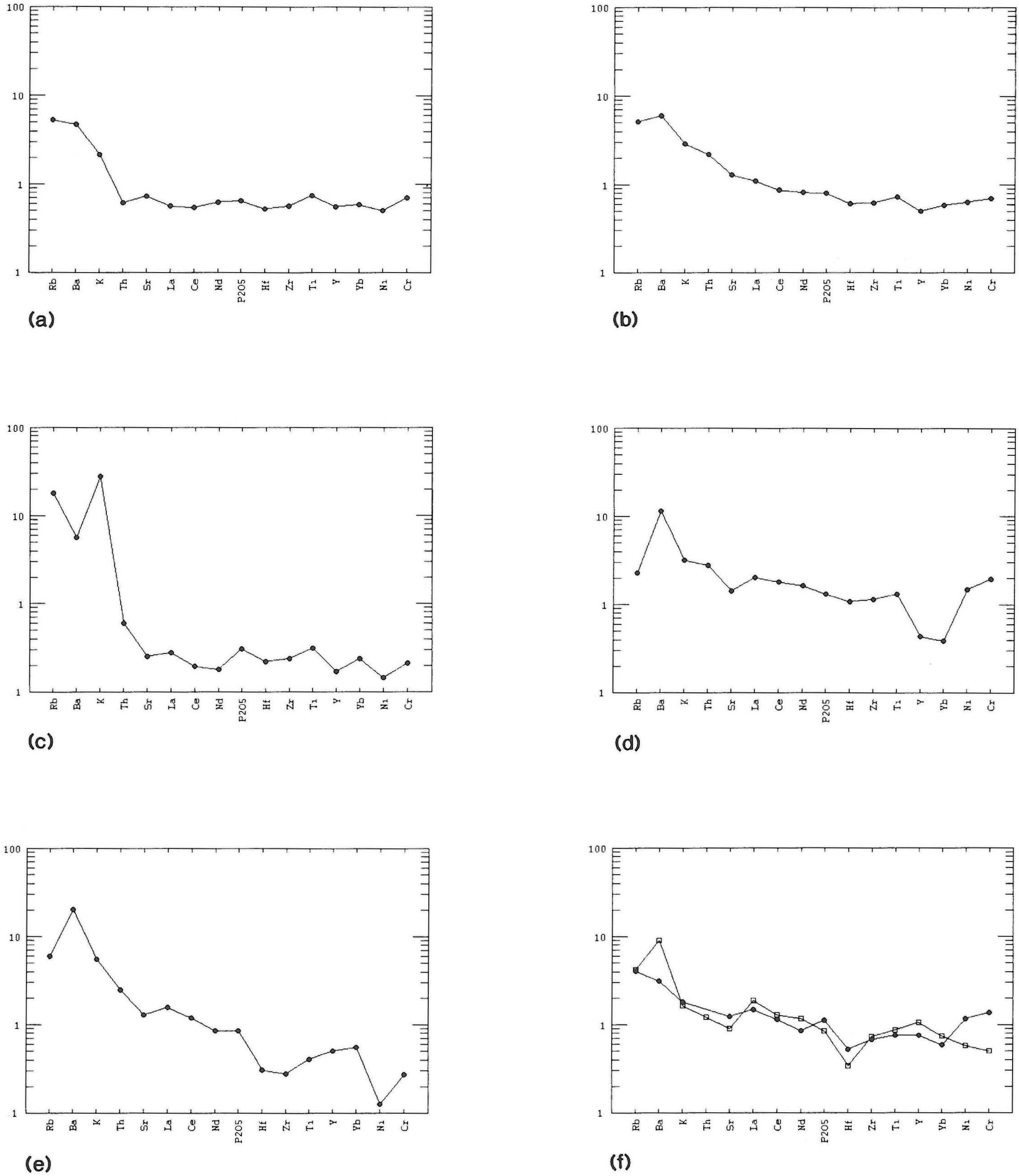


Figure GS-8-7: *N-MORB-normalized trace element patterns for average basalt units at Elbow Lake; data for average arc tholeiite and back-arc/ocean floor basalts at Flin Flon for comparison. a) Claw-Moen basalts; b) McDougalls Point basalt; c) Webb Island basalt; d) basalt clasts, Long Bay conglomerate; e) Flin Flon arc tholeiite (n = 63); and f) Flin Flon back-arc/ocean floor basalts (Athapapuskow - filled circles; Millwater - open squares).*

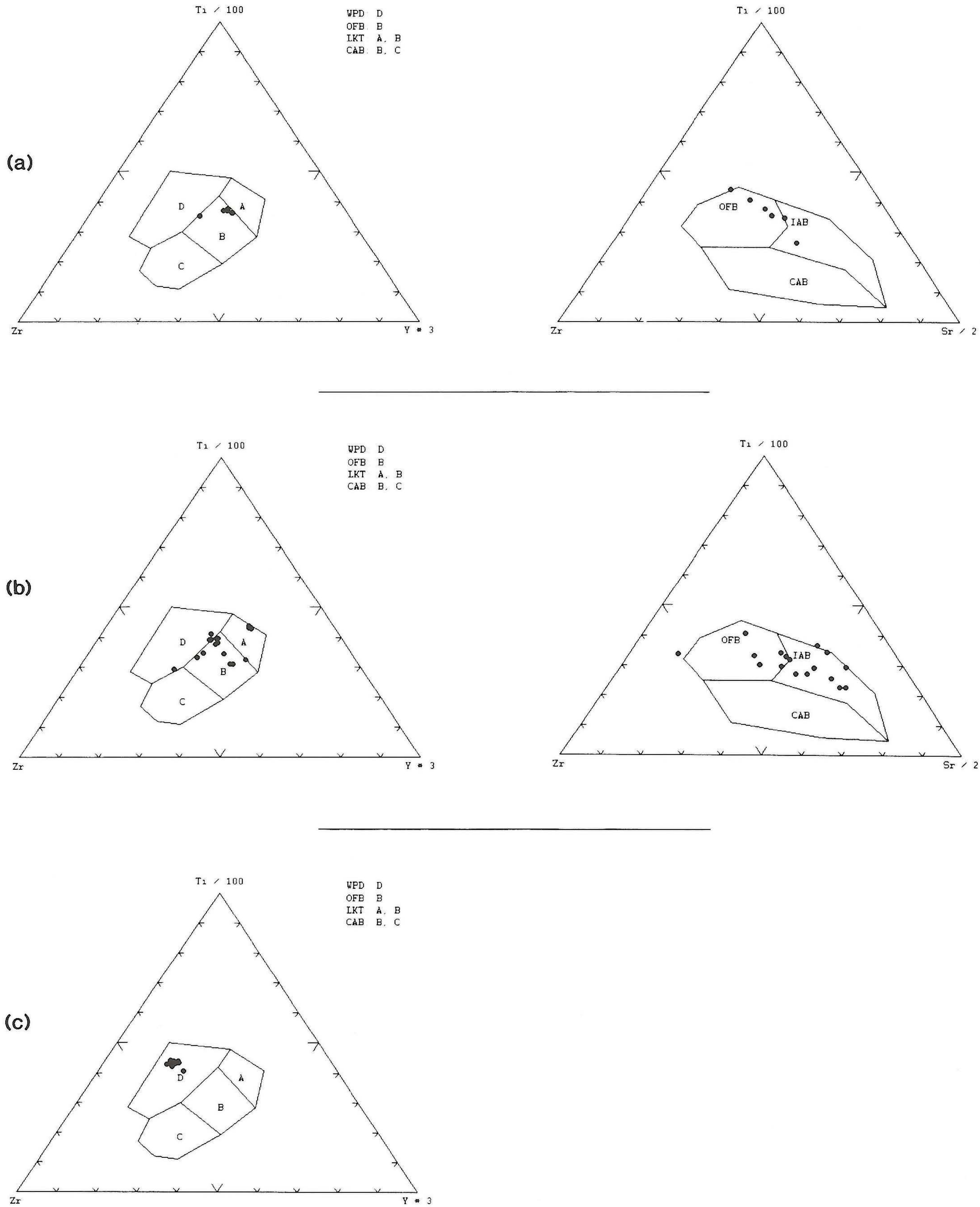


Figure GS-8-8: *Tectonic discriminant diagrams (Pearce and Cann, 1973). OFB - ocean floor basalt; IAB - island arc basalt; LKT - low K tholeiite; CAB - calc-alkaline basalt. a) Claw-Moen basalts; b) McDougalls Point basalt; and c) basalt clasts, Long Bay conglomerate.*

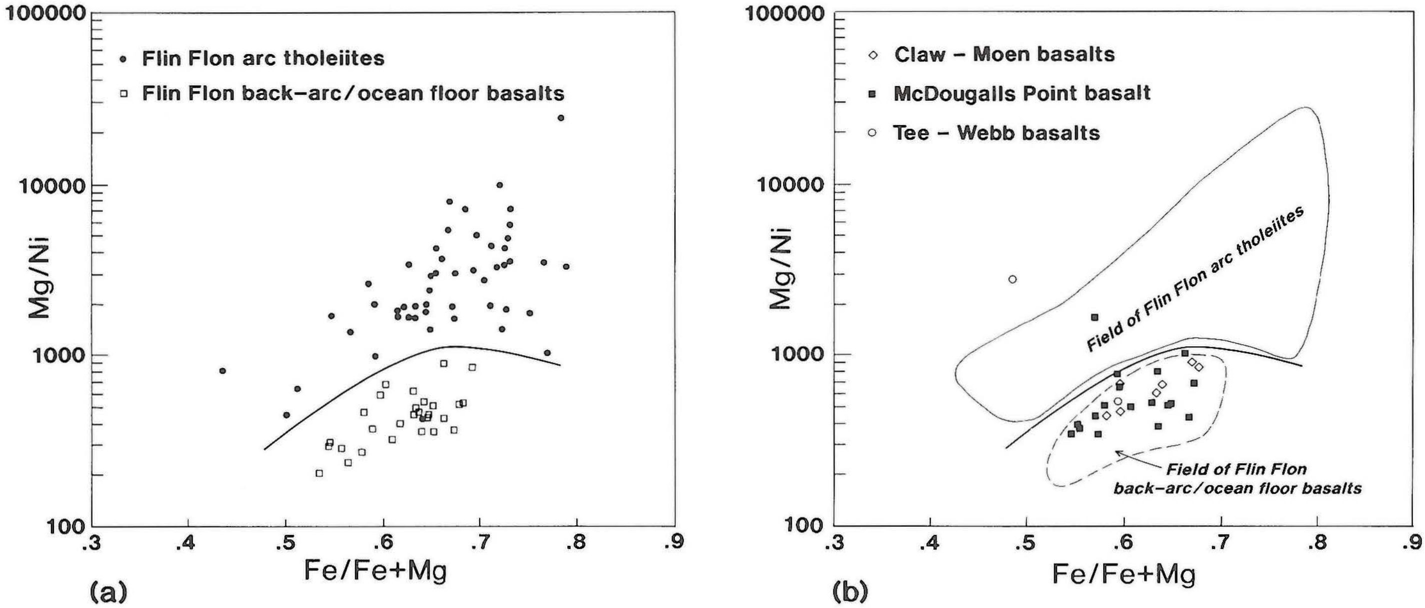


Figure GS-8-9: *Mg/Ni vs. Fe/Fe+Mg plots for basaltic rocks in the Flin Flon belt. Back-arc/ocean floor basalts have much lower Mg/Ni ratios than arc tholeiites. Basalts at Elbow Lake have Mg/Ni ratios identical to back-arc/ocean floor rocks at Flin Flon. a) arc tholeiites and back-arc/ocean floor basalts at Flin Flon; and b) major basalt units at Elbow Lake.*

(Fig. GS-8-10), and elevated contents of Zr, Y, Hf and Nb. Tee Lake rhyolite has a a LREE-enriched REE pattern with a negligible Eu anomaly. Intrusive rhyolites (in the Tee Lake dyke complex (unit 24) and Moen Bay quartz porphyry (unit 21a)) have LREE-enriched patterns similar to Tee Lake rhyolite (Fig. GS-8-10). Century rhyolite is clearly a felsic flow, whereas Tee Lake rhyolite could be either wholly intrusive or a mixture of intrusive and extrusive rhyolites (Syme, 1991). The REE data indicates that the sampled Tee Lake rhyolite phase is geochemically similar to other, clearly intrusive, felsic units in the Amisk Group.

Syn-kinematic felsic dykes emplaced in the ELSZ are HREE-depleted and LREE-enriched (Fig. GS-8-10). These data indicate that felsic dykes in the ELSZ are petrogenetically unrelated to volcanic or synvolcanic rhyolites.

Implications for VMS exploration

Preliminary results of this geochemical investigation indicate that there are significant differences between the VMS-hosting arc tholeiite assemblage at Flin Flon and the majority of the basalts at Elbow Lake. None of the volcanic units sampled at Elbow Lake correspond exactly in composition or stratigraphic setting to the Flin Flon arc assemblage. Most of the basaltic units at Elbow Lake have either back-arc/ocean floor affinity (those east of the ELSZ), or are transitional rocks with both back-arc and island arc characteristics (those west of the ELSZ). The only rocks with compositional and stratigraphic similarities to Flin Flon are a small group of diverse volcanic rocks northwest of Elbow Lake (including the Tee Lake-Webb Lake basalts).

This interpretation has implications for base metal exploration in the Elbow Lake area. In view of the fact that Amisk Group rocks at Elbow Lake are compositionally different from those at Flin Flon, exploration criteria developed for VMS deposits in the arc tholeiite assemblage at Flin Flon likely will not apply at Elbow Lake. For example, base metal deposits hosted by the arc tholeiite assemblage at Flin Flon occur in association with felsic volcanic units, at major stratigraphic and compositional breaks in the volcanic sequence; they are associated with coarse, mafic, intermediate or felsic volcaniclastic rocks in the stratigraphic footwall, and the best-documented examples are clearly localized in basinal structures (Bailes and Syme, 1989). VMS deposits hosted by back-arc/ocean floor rocks in Saskatchewan differ in that they are small, Cu-rich, are not associated with rhyolite flows, and are not underlain by volcaniclastic rocks (Syme and Bailes, in prep.). VMS deposits in the Claw Bay-Moen Bay basalts and McDougalls Point basalts, if present, would probably be similar to the latter, basalt-hosted deposits.

That part of the Amisk Group on and northwest of Webb Island has arc tholeiite affinity, suggesting that Century rhyolite (unit 9) and Tee Lake rhyolite (unit 8) are the primary exploration targets in the Elbow Lake area. The REE pattern of Century rhyolite is similar to that of Archean rhyolites associated with VMS deposits (*e.g.* Lesher *et al.*, 1986), and is also similar to that of Mine rhyolite and South Main domes at Flin Flon main mine (Bailes and Syme, 1989; Syme and Bailes, in prep.).

ACKNOWLEDGEMENTS

Assistance in the field and subsequently in the office was ably and cheerfully rendered by Reg Yaworski and Renee Cunningham. Len Chackowski and Paul Lenton were responsible for digital preparation of Preliminary map 1992F-1, with computer cartography and production supervised by Boyan Brodaric and David Viljoen (GSC) in Ottawa.

REFERENCES

Bailes, A.H.
1988: Chisel-Morgan Lakes project; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 53-61.

Bailes, A.H. and Syme, E.C.
1989: Geology of the Flin Flon-White Lake area. Manitoba Energy and Mines, Geological Report GR87-1, 313p.

Gordon, T.M., Hunt, P.A., Bailes, A.H., and Syme, E.C.
1990: U-Pb zircon ages from the Flin Flon and Kisseynew belts, Manitoba: Chronology of crust formation at an Early Proterozoic accretionary margin, **in** Lewry, J.F. and Stauffer, M.R., eds., The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 177-199.

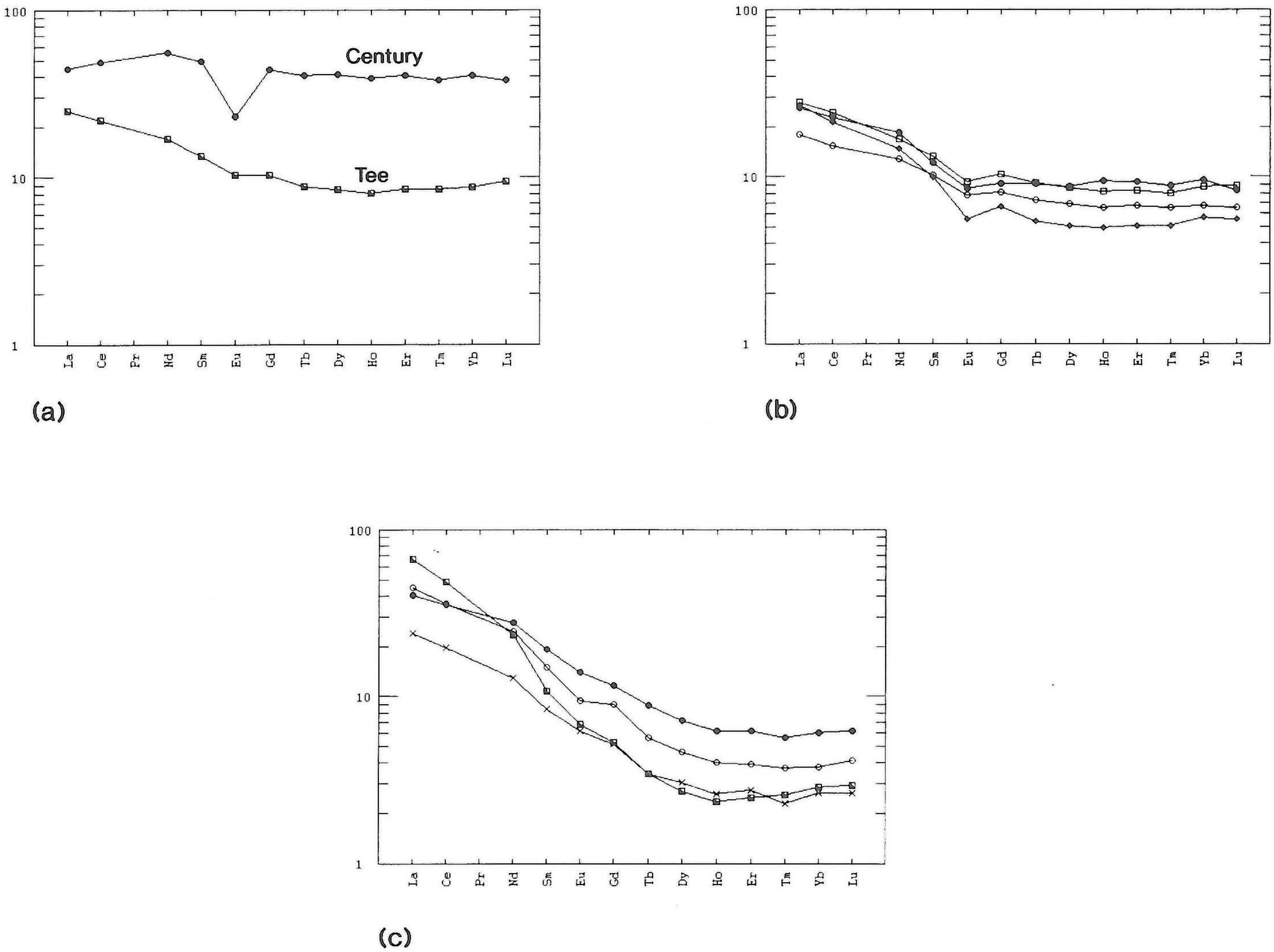


Figure GS-8-10: *Chondrite-normalized rare earth element plots of felsic rocks in the Elbow Lake area. a) Century rhyolite and Tee Lake rhyolite; b) felsic hypabyssal intrusions in the Tee Lake dyke complex; and c) synkinematic dykes in the Elbow Lake shear zone.*

Galley, A.G., Ames, D.E. and Franklin, J.M.
1987: Geological setting of gold mineralization in the Elbow Lake region, Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1987, p. 175-177.

Hunt, G.H.
1970: Geology of the Iskwasum Lake area (west half), Manitoba; Manitoba Mines Branch, Publication 65-3, 40 p.

Lesher, C.M., Goodwin, A.M., Campbell, I.H. and Gorton, M.P.
1986: Trace-element geochemistry of ore-associated and barren, felsic metavolcanic rocks in the Superior Province, Canada; Canadian Journal of Earth Sciences, v. 23, p. 222-241.

Machado, N. and David, J.
1992: U-Pb geochronology of the Reindeer-Superior transition zone and of the Snow Lake area: preliminary results; **in** Lithoprobe Trans-Hudson Orogen Transact workshop No. 2, Lithoprobe Report No. 26.

McGlynn, J.C.
1959: Elbow-Hemming Lakes area, Manitoba; Geological Survey of Canada, Memoir 305, 72 p.

Pearce, J.A. and Cann, J.R.
1973: Tectonic setting of basic volcanic rocks determined using trace element analysis; Earth and Planetary Science Letters, v. 19, p. 290-300.

Podolsky, T.
1951: Cranberry Portage (east half); Geological Survey of Canada, Paper 51-17, preliminary map with marginal notes.

Schledewitz, D.C.P.
1992: The geology of Webb Lake; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992 (this volume).

Stockwell, C.H.
1935: Gold deposits of the Elbow-Morton area, Northern Manitoba; Geological Survey of Canada, Memoir 186, 74 p.

Syme, E.C.
1988: Athapapuskow Lake Project; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 20-34.

1990: Elbow Lake project (parts of NTS 63K/15W), **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 49-57.

1990: Stratigraphy and geochemistry of the Lynn Lake and Flin Flon metavolcanic belts, Manitoba; **in** Lewry, J.F. and Stauffer, M.R., eds.: The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 143-161.

1991: Elbow Lake project - Part A: supracrustal rocks and structural setting, **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 14-27.

Syme, E.C. and Bailes, A.H.
in prep. Stratigraphic and tectonic setting of volcanogenic massive sulfide deposits, Flin Flon, Manitoba.

Syme, E.C. and Whalen, J.B.
1992: Elbow Lake; Manitoba Energy and Mines, Preliminary Map 1992F-1; 1:20 000.

Syme, E.C., Hunt, P.A and Gordon, T.M.
1991: Two U-Pb zircon ages from the western Flin Flon belt, Trans-Hudson orogen, Manitoba; **in** Radiogenic Age and Isotopic studies: Report 4, Geological Survey of Canada, Paper 90-2, p. 25-34.

Whalen, J.B.
1991: Elbow Lake Project - Part B: Granitoid rocks; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 28-30.

GS-9 ELBOW LAKE PROJECT - PART B: GRANITOID ROCKS

by J.B. Whalen[1]

Whalen, J.B., 1992: Elbow Lake project - Part B: Granitoid rocks; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 47-51.

INTRODUCTION

As part of the post-fire mapping project carried out by Syme in the Elbow Lake area (for location see Fig. GS-8-1 in GS-8, this volume), this summer the author continued his geological and petrological study of the granitoid rocks. 1:20 000 scale geological mapping of the granitoids, which form about 50% of the map area, is complete. Significant progress was also made in petrographic, geochemical, isotopic (Nd, O and Pb) and U-Pb geochronological work on these rocks. In addition, 1:50 000 scale geological mapping of granitoids within the Elbow Lake NTS 63K/15W, but outside the map area, was about 60% completed. Some comments regarding the results of this 1:50 000 mapping are included in this report. In 1993, 1:50 000 mapping of 63K/15W and burnt portions of adjacent NTS sheets will be continued. These granitoid studies will help constrain the timing of tectonic events and the tectonomagmatic evolution of the area. The economic potential of the various plutons was also evaluated.

The geological context of this area is outlined by Syme (1990, 1991, GS-8, this volume). Metavolcanic rocks and related intrusions that belong to the Amisk Group are intruded by five major granitoid plutons (Fig. GS-8-1). Descriptions of each of these plutons are given below (see Preliminary Map 1992F-1), followed by a preliminary discussion of their geochemical characteristics.

DESCRIPTION OF PLUTONS

1. Echo Lake Pluton

The composite Echo Lake pluton (map unit 33) covers an area of about 16 km^2 on the northwest side of the map area (Fig. GS-8-1). Although no radiometric age data are available, based on its massive character and ovoid outcrop pattern, a phase of this pluton (unit 33e) is thought to be the youngest in the map area. It may be equivalent in age (1847 Ma; Gordon *et al.*, 1990) to plutons such as the Lynx Lake pluton south of Flin Flon, which postdate regional D_2 deformation. Phases of the Echo Lake pluton will be described from youngest to oldest.

The northwestern portion of this pluton is massive and apparently undeformed. Sharp contacts have been observed between massive, feldspar-amphibole porphyritic granodiorite (unit 33e) and well foliated, coarse grained, hornblende-biotite granodiorite (unit 33d). Matrix grain size in unit 33e varies from very fine grained near margins to medium grained in its interior. Textures exhibited by this unit, together with the presence of crosscutting amygdaloidal mafic dykes, suggest that it was intruded at a relatively high level. Equigranular, coarse grained, hornblende-biotite granite (unit 33f) occurs at a number of localities near the edge of unit 33e where it cuts both units 33d and 33e. Its coarse grained texture and more felsic composition are unusual for what appears to be a marginal or contact phase of unit 33e. It probably represents a younger phase which has been emplaced along the contact of unit 33e, like a ring-dyke.

The older, tectonically foliated portion of this pluton has been subdivided into a number of compositional variants that become more felsic and more lithologically homogeneous to the northwest. The most eastern unit (33b) exhibits textural variation from fine- to coarse-grained and compositional variation from melagabbro to diorite and quartz diorite. Included in this unit are areas of diorite that contain a high portion (10 to 40%) of pyroxenitic inclusions. Coarse grained pyroxenite occurs as bands or schlieren, and as massive zones (unit 33a). It is thought that some of the abrupt compositional and textural variations in this unit could be due to left lateral faulting and shearing with displacements varying from a few metres to several kilometres.

There is a close textural resemblance between the two more western phases. The split into two units is based on quartz content and the fact that the diorite to quartz diorite unit 33c commonly contains mafic (basaltic or gabbroic) inclusions. In contrast, such inclusions are less common in the quartz diorite to granodiorite (unit 33d), and biotite is more abundant than hornblende. The two units are probably gradational; however, in many locations the map contact corresponds to an airphoto linear that may represent a fault.

Various compositional and textural types of dykes are most common in the eastern portion of this pluton and include grey to beige feldspar-quartz rhyolite porphyry, dark pink granitic aplite and basaltic to diabasic dykes. These dykes generally can not be followed for any distance along strike due to later deformation. In contrast, only one generation of amygdaloidal basaltic dykes cuts the western massive granodiorite unit 33e. These dykes can often be followed for up to 500 m.

1:50 000 mapping was completed for the portion of the Echo Lake pluton located between the western edge of the map area and the western edge of NTS 63K/15W. No new phases were identified. Unit 33e forms an oval plug centred just east of the southern end of Echo Lake. The rest of the area is underlain by unit 33d, except for a small area occupied by unit 33c adjacent to the north shore of Long Lake.

2. Big Rat Lake Pluton

The composite Big Rat Lake pluton (map unit 32) covers an area of about 20 km^2 on the southwest side of the map area (Fig. GS-8-1). Preliminary U-Pb zircon results on a sample of coarse grained, equigranular, hornblende-biotite granodiorite (unit 32e) from the northeast margin of the pluton indicate that all phases are 1845 ± 3 Ma in age (P. Hunt, pers. com. 1991). K-Ar hornblende and biotite mineral ages from this same sample of 1757 ± 21 Ma and 1768 ± 22 Ma, respectively, probably record younger metamorphic overprinting. Though all intrusive phases have a pervasive foliation, primary contact relations can be established. Granitic units (32f to 32h) cut more mafic phases (units 32a to 32e) and appear not to be cut by dykes that intrude the more mafic phases. This suggests that there could be an age gap between granitic and dioritic to granodioritic phases. The older, more mafic phases appear to be consanguineous components of a pluton that is zoned from a granodioritic rim to a dioritic core. Various phases in the Big Rat Lake pluton will be described from youngest to oldest.

The more felsic units, 32f to 33h, are exposed on the southwestern side of the pluton. 1:50 000 mapping west of the map area, airphoto interpretation and exposures on the railway line west of the Grassy River indicate that this granite crops out over an extensive area southwest of the map area. This medium to dark pink, foliated biotite granite is remarkably uniform in composition, lacks mafic enclaves and is only cut by some probably comagmatic granitic aplite dykes. Based on consistent variations in grain size, it has been subdivided into fine- to medium- (32g) and medium- to coarse-grained (32h) portions. Along the eastern margin of this granite, there is a thin (100-500 m), more biotite-rich and quartz-poor, hornblende-bearing marginal phase (32f). Unit 32f, which is also characterized by the presence of ovoid to stretched (4 to 50 cm) fine grained, hornblende-biotite granodioritic inclusions, may reflect marginal contamination or assimilation of older quartz diorite to granodiorite. Sharp intrusive contacts were observed between unit 32f and older unit 32c.

Two gradational textural subtypes of a relatively compositionally homogeneous granodiorite form the outer zones of the northeastern portion of this pluton. The outer, coarser grained, more equigranular phase (unit 32e) is variably foliated and sheared such that it is difficult to distinguish primary feldspar porphyritic texture from feldspar augen texture. There is a gradation from coarse grained, equigranular unit

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32e through subporphyritic to porphyritic unit 33d from the margin inward. As no intrusive contacts were observed between these granodiorite units and other phases of this pluton, contacts are thought to be gradational. Adjacent to Elbow Lake, north of Separation Creek, these phases are apparently cut off by a fault. As the displaced, or missing, portions of the pluton have not been identified, this fault may have dip-slip movement, either normal or reverse.

Other subunits in the northeast portion of this pluton are uniformly medium grained equigranular but compositionally variable. There is variation from more felsic (quartz diorite to granodiorite)(unit 32c) to more mafic (quartz diorite to diorite)(unit 32b) towards the core. Mapped boundaries, based on field estimates of quartz and mafic mineral content, are apparently gradational over short distances rather than intrusive.

Areas of agmatite (unit 32a) consist of mainly rounded mafic igneous inclusions (5 cm to >3 m) in a matrix of diorite to quartz diorite. Inclusions form about 40 to 60% of this subunit. Some inclusions are obviously supracrustal rocks, which were deformed prior to their incorporation. These consist mainly of mafic volcanic rocks, but include at least one large block (30 by 40 m) of folded biotite-muscovite-bearing, banded rock. Many other inclusions appear to be comagmatic mafic intrusive rocks. These plutonic inclusions have cuspate, sometimes chilled margins and have not undergone any deformation that has not affected the host intrusive rock.

Various dykes, including basalt to diabase, grey granodioritic feldspar-hornblende porphyry and composite basalt-dacite dykes, are common and cut units 32a to 32e north of Separation Creek.

The presence of a right lateral fault in Separation Creek, is indicated by offsets in approximately north-trending intrusive boundaries. Compositional contrasts between phases across this creek could be due to some normal displacement on this fault.

1:50 000 mapping was completed of that portion of the Big Rat Lake pluton that is located between the western edge of the map area and the western edge of NTS 63K/15W. No new phases were identified. Units 32g to 32h occupy most of this area except for an area of 32c adjacent to the south side of Little Long Lake.

3. Gants Lake Batholith

The Gants Lake batholith (map unit 31) is an elongate, north-trending body that extends for over 54 km, from beneath the Shield margin to the Kisseynew belt. Of the 550 km^2 it occupies, only about 4% is located in the map area (Fig. GS-8-1). The middle portion of this body located within NTS 63K/15K was described by McGlynn (1959) as consisting simply of gneissic biotite granodiorite. However, mapping within and outside the map area indicate this to be a composite batholith. It includes a large gabbro body, zones of gabbroic to tonalitic agmatite, 'old' tonalitic gneisses, and various ages of gneissic to slightly foliated biotite and biotite-hornblende granodiorite and granite. Only the phases that occur within the map area will be described here from youngest to oldest.

On the northwest side of the Gants Lake batholith, adjacent to its contact with the Unit 2a, there is a narrow sheet of strongly foliated to mylonitic, dark pink, aplitic to pegmatitic, biotite granite (unit 31e). This phase was probably intruded at the contact between unit 2a and unit 31a.

Units 31d and 31c, related phases with gradational contacts, consist of foliated, equigranular, fine- to medium-grained (31d) and medium- to coarse-grained (31c), pink to grey, biotite-hornblende granodiorite to granite. Within unit 31d, there are areas of compositionally similar gneisses. Subtle mafic and felsic compositional banding in these gneisses was folded prior or during intrusion of units 31d and 31c. Areas of similar coarser grained gneisses occur within unit 31c to the east of the map area. Due to their compositional similarity, it is only in areas of good exposure that the two ages of granodiorite can be separated.

On the south east side of Claw Lake there is a heterogeneous mixture of gneissic to massive, fine- to medium-grained, gabbroic to tonalitic, hornblende-biotite intrusive and basaltic volcanic rocks (unit 31b). This agmatite zone is cut by numerous dykes of medium- to coarse-grained, equigranular to quartz-eye porphyritic, hornblende-biotite tonalite to granodiorite. Though mapping east of the map area indicates these dykes are related to a different phase of the Gants Lake batholith, on Preliminary Map 1992F-1 they are included in unit 31d. Unit 31b is not simply an intrusive breccia zone fringing the western margin of the Gants Lake batholith. Mapping to the east has shown that identical mafic intrusive rocks, without the volcanic lithologies, form irregularly spaced, north-orientated screens within a major granodiorite to granite phase. It appears that unit 31b, like the granodiorite gneisses within units 31c and 31d, contains remnants of older components of this batholith.

Unit 31a, which forms an elongate body in the northeast corner of the map area, consists of well foliated, buff, coarse grained, plagioclase porphyritic (1-2 cm), biotite-hornblende granodiorite. Portions of unit 31a adjacent to contacts with other units grade to feldspar augen schist. Contacts between unit 31a and units 31d and 31 c are considered to be faults. Where this fault is exposed just outside the map area east of Centre Lake, it consists of a 100 m wide zone of ribbon mylonites, including sheets of tectonized mafic supracrustal rocks. This mylonite zone, juxtaposing equivalents of unit 31a and 31c, has been traced southward within the batholith east of Claw Lake where it appears to be truncated by the granodiorite phase that is a component of unit 31b.

4. East Elbow Lake Tonalite

The East Elbow Lake stock (unit 30a) is an oval intrusion that covers an area of 10 km^2 just east of the northeast corner of Elbow Lake. Preliminary U-Pb results from this body indicate it is pre-Missi in age (1864 $\pm$ 3 Ma; P. Hunt, 1992 pers. com.).

This intrusion consists of white weathering, coarse grained quartz megacrystic (1-2.5 cm), biotite-hornblende tonalite that locally contains euhedral biotite books. No mappable lithological variation was identified. Foliation is generally weak and orientated east to northeast.

5. Elbow Lake Tonalite

This pluton (map unit 29) covers an area of 250 km^2, only about 25% of which is located within the map area (Fig. GS-8-1). Portions of the Elbow Lake pluton outside the map area have been described by Baldwin (1980) and Hunt (1970). McGlynn (1959) included this pluton in his quartz megacrystic tonalite unit, a unit that he considered to be the same age as other quartz-eye porphyritic plutons in the Flin Flon belt. Unit 29 does not contain the megacrystic quartz that is characteristic of other older subvolcanic tonalites, such as the Cliff Lake pluton and the East Elbow Lake tonalite (unit 30a). Preliminary U-Pb zircon results from this pluton suggest that it is pre-Missi in age (1869 +20/-7 Ma; P. Hunt 1991 pers. com.).

A remarkable feature of the mapped portion of this large intrusion is a lack of distinctive compositional or textural phases. However, there is some variation at outcrop scale in the size and abundance of euhedral biotite phenocrysts and in the degree and nature of alteration. Also, the northeastern portion of the pluton contains more prominent quartz phenocrysts or eyes.

Because of its compositional and textural homogeneity, it is difficult to recognize the existence of displacements along faults or shears within this pluton. However, mafic dykes or quartz stockworks, documented as cutting the pluton in areas of good exposure, cannot be traced even to immediately adjacent outcrops. This feature, the identification of a number of different directions of mylonitic zones, plus fault related displacements in pluton/wallrock contacts, indicate that this body is more structurally complex than is at first apparent.

Within the central portion of this pluton, there are areas of potassic alteration spatially associated with healed vein stockworks. These veins have 1 to 3 cm selvages that contain pink feldspar and large euhedral secondary biotite books. Also, the foliation in these areas is faint, apparently because alteration has overgrown or obscured the original foliation.

GEOCHEMISTRY

Preliminary major and trace element analyses have been completed on all plutons except for the Gants Lake batholith, which was first mapped and sampled during this field season. Some major features of this data are:

1. Although no modal analyses have yet been carried out, an indication of intrusive rock types present can be obtained from major element and normative mineral diagrams (Fig. GS-9-1). In Figures GS-9-1a and GS-9-1b, the Elbow Lake and East Elbow Lake tonalites, and also most Echo Lake and some Big Rat Lake pluton samples, plot in the tonalite field. Felsic phases of the Big Rat Lake pluton plot in the trondhjemite field and intermediate phases plot in the granodiorite field. In Figure GS-9-1c, felsic phases of the Big Rat Lake pluton plot in the granodiorite field and other plutons plot mainly in the tonalite field. These plots indicate the relatively quartz and K-feldspar poor character of these intrusions.
2. Silica in these plutons ranges from 60 to 69 wt.% with an average of 65%. Their compositional variation on an AFM diagram (Fig. GS-9-2), normative quartz-alkali feldspar-plagioclase plot (Fig. GS-9-1c) and Peacock (1931) classification diagram (not shown), indicate they belong to a calc-alkaline suite.
3. Chondrite normalized rare earth element plots for the various plutons and subunits within them are presented in Figure GS-9-3. The most remarkable feature of these plots is the similarity of their granitoid REE patterns are, *i.e.* moderately heavy relative to light rare element depleted with no Eu anomalies. Another significant feature is that the most felsic subunits within each pluton, that is unit 33e in the Echo Lake pluton (Fig. GS-9-3a) and units 33f, 33g and 33h in the Big Rat Lake pluton (Fig. GS-9-3b), have the least REE enriched and the most heavy, relative to light, rare earth element depleted patterns. This is not what would be predicted for phases which are related by fractional crystallization. Possibly fractionation was dominated by amphibole with relatively little plagioclase plus minor volumes of a REE-enriched accessory phase, such as allanite or sphene. Major plus trace element modelling will help resolve this problem.
4. Mafic dykes, which cut the various plutons, were also sampled with the object of characterizing mafic magmatism contemporaneous with different ages of granite magmatism. REE element patterns of mafic dykes cutting one of the older plutons (Elbow Lake tonalite) have relatively flat patterns (Fig. GS-9-3d). Mafic dykes cutting younger intrusions (Big Rat Lake and portions of Echo Lake plutons) have relatively steep heavy, relative to light, REE depleted patterns similar to their host rocks. Amygdaloidal basalt dykes that cut unit 33e of the Echo Lake pluton (probably the youngest phase in the map area) have less steep heavy, relative to light, REE depleted patterns identical to older granitic units in this pluton.
5. Based on their being metaluminous, sodic (Fig. GS-9-4) and amphibole-bearing, all these plutons can be readily classified as I-type granites derived from infracrustal sources. Their calc-alkaline character and classification by Pearce *et al.* (1984) Rb-Y and Y-Nb tectonic discrimination diagrams (not shown) indicate that they are volcanic-arc type granites. The predominance of tonalitic or potassium-poor compositions (Figs. GS-9-1 and GS-9-4) also relatively poor in incompatible elements such as found in primitive island arcs (Whalen, 1985), suggests they probably represent island-arc rather than Andean-type magmatism.
6. Preliminary Nd-Sm isotopic data (R. Stern, pers. com. 1992) indicates that the plutons were derived from juvenile or young sources. Oxygen isotopic values for these granites are also mantle like. These results, in conjunction their other geochemical characteristics, suggest that Elbow Lake plutons were either derived directly by melting of mantle above a subduction zone, or by remelting of underplated mantle-derived material at the base of an arc.
7. These granites are remarkably different from many granites of similar age elsewhere in the world. In Australia, 1880-1840 Ma granites are considerably more potassic and less sodic (Fig. GS-9-4). Based on data from Australian and other similar age granites elsewhere in the world, Wyborn (1988) has proposed a subduction free intracontinental tectonic model for Early Proterozoic granite magmatism.

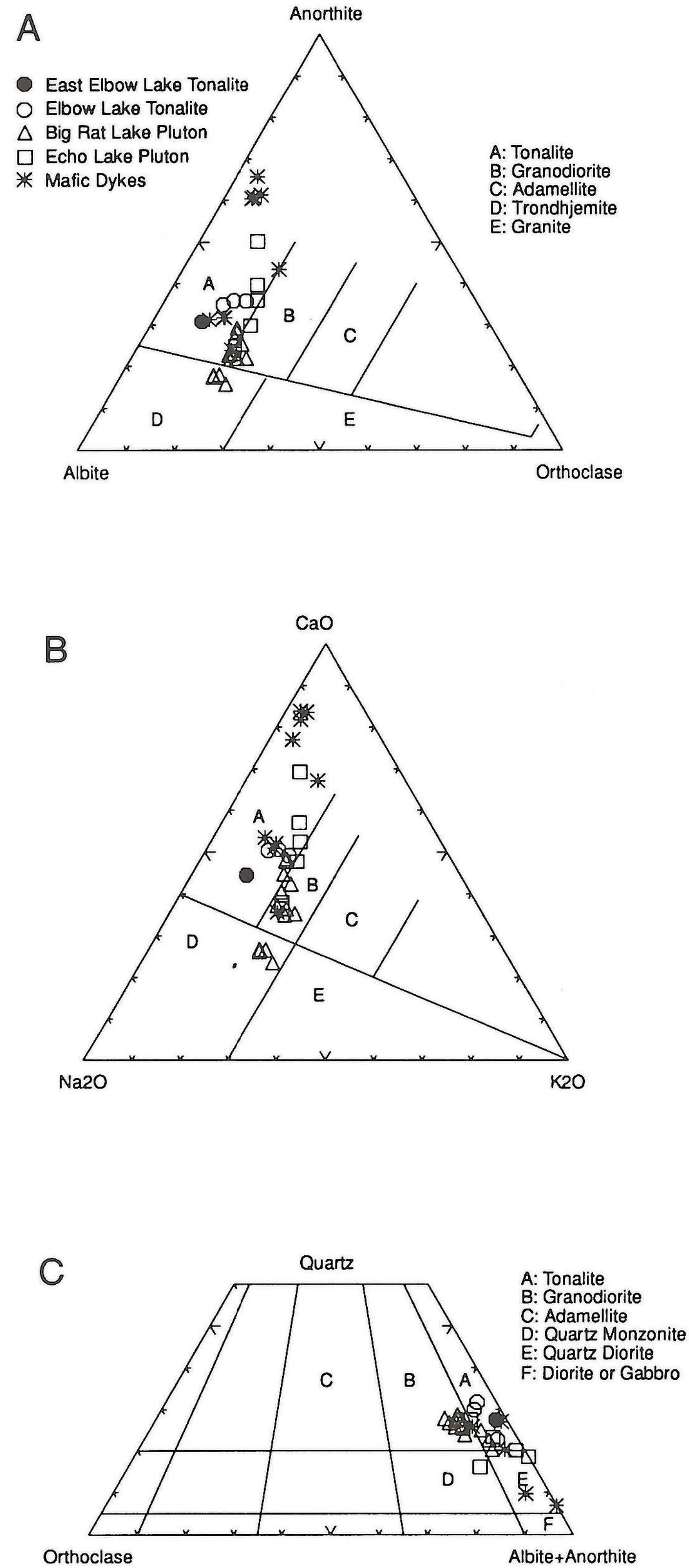


Figure GS-9-1: *Classification of Elbow Lake granitoids based on: (a) CIPW normative albite-anorthite-orthoclase diagram after O'Connor (1965); (b) Na_2O-CaO-K_2O (wt.%) plot after Glikson (1980); and (c) Mesonorm orthoclase-quartz-albite+anorthite data plotted in the modal K-feldspar-quartz-plagioclase diagram of Streckeisen (1973).*

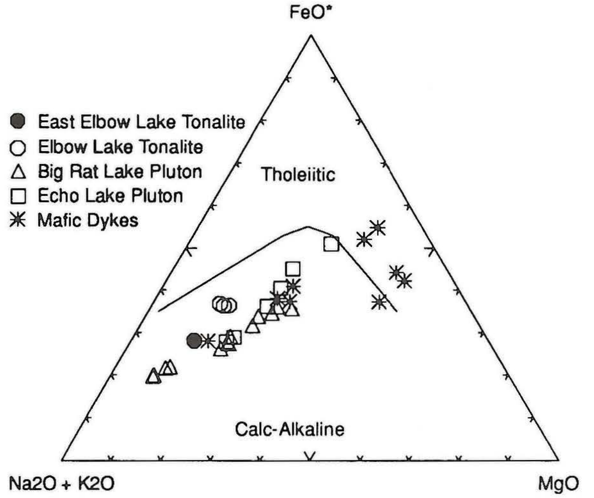


Figure GS-9-2: *AFM plot of Irvine and Baragar (1971) for Elbow Lake granitoids.*

Early Proterozoic underplating of Archean crust was followed by remelting of this underplate beneath ensialic sedimentary basins. K_2O-Na_2O values of Elbow Lake granites resemble Early Archean and Tertiary I-type granites, rather than Early Proterozoic Australian granites (Fig. GS-9-4). This, and other characteristics of these granites discussed above, suggests that subduction probably played a significant role in their formation.

ECONOMIC GEOLOGY

In general, the vastly improved quality of outcrop that resulted from the 1989 forest fire provides exposures of plutonic rocks cut by quartz and sulphide-bearing veins and by faults and shear zones. Unlike areas underlain by supracrustal rocks, such exposures usually exhibit no sign of having been prospected. Comparison between mineralization in the Phantom Lake stock, west of Flin Flon (Galley and Franklin, 1989; Thomas, 1990) and the Star Lake pluton in the La Ronge belt (Poulsen *et al.,* 1986), suggests that Elbow Lake area plutons have potential for gold and porphyry type mineralization. The presence of zones with potassic alteration, areas with rusty quartz vein stockworks, and mylonitic shear zones, makes the Elbow Lake pluton (unit 29) the intrusion with the best economic potential. The northeastern zoned portion of the Big Rat Lake pluton (units 32a to 32e) and the southeastern foliated portion of the Echo Lake pluton (units 33a to 33d) also merit attention, based on the presence of crosscutting faults and shear zones. Units 32f to 32h in the Big Rat Lake pluton and units 33f and 33g in the Echo Lake pluton are considered to have the poorest economic potential based on the paucity of veins and shear zones cutting these phases.

CONCLUSIONS

A diverse compositional and age spectrum of granitoid rocks are present in the Elbow Lake map area. It appears that two of the plutons are composite bodies that contain at least two distinct pulses of genetically unrelated magmas. In the Big Rat Lake pluton, an earlier diorite to granodiorite zoned intrusion (units 32a to 32e) was cut by various dykes prior to emplacement of granitic phases (units 32f to 32h). In the Echo Lake pluton, earlier gabbroic to granodioritic phases (units 33a to 33d) were penetratively deformed prior to emplacement of granodioritic to granitic phases (units 33e and 33f). The high level nature of units 33e and 33f, as indicated by porphyritic textures in the granodiorite and amygdales in crosscutting mafic dykes, suggests that there may have been significant uplift and unroofing between the two magmatic pulses.

1:20 000 and 1:50 000 mapping carried out to date on the Gants Lake batholith has demonstrated a diverse range of intrusive rock

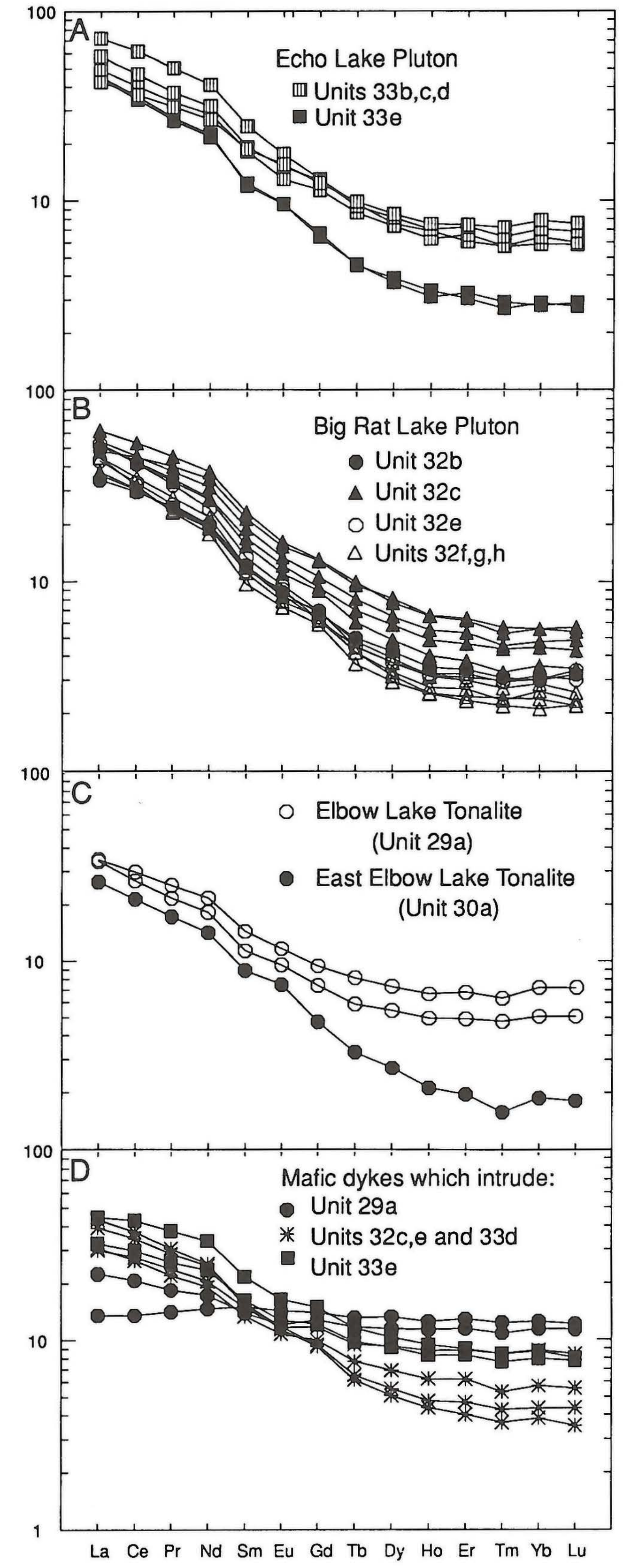


Figure GS-9-3: *Chondrite normalized rare earth element plots for different plutons and mafic dykes.*

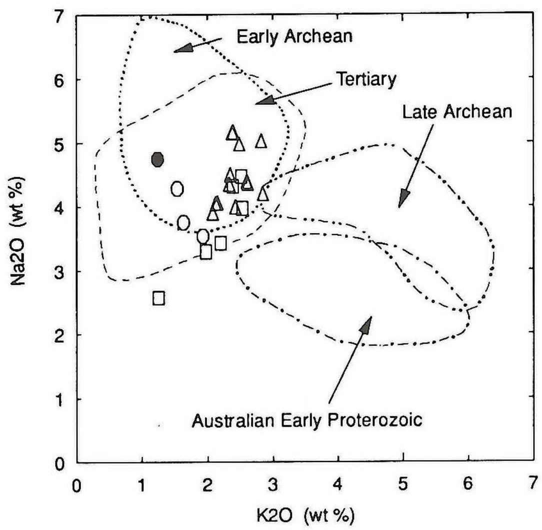


Figure GS-9-4: *Na_2O vs. K_2O plot for Elbow Lake plutons with comparison fields for other Precambrian and Proterozoic I-type granite batholiths. Field for Tertiary from data of Whalen (1985) and Whalen et al. (1982), other fields from Wyborn (1988).*

types, probably emplaced over an extended time period. It provides, within one body, a transect across the Flin Flon belt and into the Kisseynew belt. Batholiths that straddle major tectonic boundaries in the Appalachian orogen belt record within their constituent phases contrasting geochemical and isotopic signatures of lower crustal blocks that are tectonically juxtaposed at these boundaries (Whalen, in press). The Gants Lake batholith may record, within its phases, contrasts between basement to the Flin Flon belt versus the Kisseynew belt.

Geochemical and isotopic work in progress will help answer questions concerning the petrogenesis of these granitoids. Preliminary results indicate they are calc-alkaline volcanic-arc granites derived from juvenile I- (infracrustal) sources, possibly underplated basal arc material. These characteristics are in marked contrast to Early Proterozoic granites in Australia and elsewhere in the world, which have more evolved within plate granite characteristics.

REFERENCES

Baldwin, D.A.
1980: Porphyritic intrusions and related mineralization the Flin Flon volcanic belt; Manitoba Energy and Mines, Economic Geology Report ER79-4, 23p.

Galley, A.G., and Franklin, J.M.
1987: Geological setting of gold, copper, tungsten and molybdenum occurrences in the Phantom Lake region: **in** Summary of Investigations 1987, Saskatchewan Geological Survey; Saskatchewan Energy and Mines, Miscellaneous Report 87-4, p. 115-124.

Glikson, A.Y.
1980: Precambrian sial-sima relations: evidence for earth expansion; Tectonophysics, v. 63, p. 193-234.

Gordon, T.M., Hunt, P.A., Bailes, A.H., and Syme, E.C.
1990: U-Pb ages from the Flin Flon and Kisseynew belts, Manitoba: chronology of crust formation at an Early Proterozoic accretionary margin: **in** Lewry, J.F. and Stauffer, M.R., eds., The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 177-199.

Hunt, G.H.
1970: Geology of the Iskwasum Lake area (west half), Manitoba; Manitoba Mines Branch, Publication 65-3, 40p.

Irvine, T.N., and Baragar, W.R.A.
1971: A guide to the chemical classification of the common volcanic rocks: Canadian Journal of Earth Sciences, v. 8, p. 523- 548.

McGlynn, J.C.
1959: Elbow-Hemming Lakes area, Manitoba; Geological Survey of Canada, Memoir 305, 72p.

O'Connor, J.T.
1965: A classification of quartz rich igneous rocks based on feldspar ratios. U.S. Geological Survey Professional Paper 525B, p. 79-84.

Peacock, M.A.
1931: Classification of igneous rock series: Journal of Geology, v. 39, p. 54-67.

Pearce, J.A., Harris, N.B.W., and Tindle, A.G.
1984: Trace element discrimination diagrams for the tectonic interpretation of granitic rocks; Contributions to Mineralogy and Petrology, v. 25, p. 956-983.

Poulsen, K.H., Ames, D.E., and Galley, A.G.
1986: Gold mineralization in the Star Lake pluton, La Ronge belt, Saskatchewan: a preliminary report: **in** Current Research, Part A, Geological Survey of Canada, Paper 86-1A, p. 205-212.

Streckeisen, A.L.
1973: Plutonic rocks: classification and nomenclature recommended by the IUGS Subcommission on the systematics of igneous rocks: Geotimes, v. 18, p. 26-30.

Syme, E.C.
1990: Elbow Lake project (part of NTS 63K/15W): **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 49-57.
1991: Elbow Lake project - Part A: supracrustal rocks and structural setting: **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 14-27.

Thomas, D.J.
1990: New perspectives on the Amisk Group and regional metallogeny, Douglas Lake - Phantom Lake area, northern Saskatchewan: **in** Summary of Investigations 1990, Saskatchewan Geological Survey; Saskatchewan Energy and Mines, Miscellaneous Report 90-4, p. 13-20.

Whalen, J.B.
1985: Geochemistry of an island-arc plutonic suite: the Uasilau-Yau Yau intrusive complex, New Britain, P.N.G.; Journal of Petrology, v. 26, p. 603-632.
in press: Geology, petrography, and geochemistry of Appalachian granites in New Brunswick and Gaspesie, Quebec; Geological Survey of Canada, Bulletin 436.

Whalen, J.B., Britten, R.M., and McDougall, I.
1982: Geochronology and geochemistry of the Frieda River prospect area, Papua New Guinea; Economic Geology, v. 77, p. 592-616.

Wyborn, L.A.I.
1988: Petrology, geochemistry and origin of a major Australian 1880-1840 Ma felsic volcano-plutonic suite: a model for intracontinental felsic magma generation: Precambrian Research, v. 40/41, p. 37-60.

GS-10 SURFICIAL GEOLOGY MAPPING AND GLACIAL DISPERSION STUDIES AS AIDS TO GEOCHEMICAL EXPLORATION AND MINERAL TRACING IN THE ELBOW LAKE AREA (NTS 63K/15)

by Erik Nielsen

Nielsen, E., 1992: Surficial geology mapping and glacial dispersion studies as aids to geochemical exploration and mineral tracing in the Elbow Lake area (NTS 63K/15); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 52-55.

INTRODUCTION

Previous work in northwestern Manitoba indicates till samples collected for regional geochemical exploration should, where possible, be on approximately one kilometre centres (Kaszycki, 1989; Gobert, 1990; Gobert and Nielsen, 1991; Nielsen and Fedikow, 1987 and references therein). However, large lakes, Lake Agassiz clay cover, and poor access commonly dictates a sample density closer to one sample per 4 or 5 km^2. Only locally is a sampling density of one sample per km^2 achieved. Till sampling from hand-dug pits at one sample per 4 or 5 km^2 spacing conducted in the Kississing Lake, Herb Lake and File Lake area in 1989, 1990 and 1991 was continued in the Elbow Lake area during the past field season. Till and humus samples were collected at 185 sites (Fig. GS-10-1). Of these, 21 sites were northwest of File Lake thus completing the sampling in that area. Twenty sites were in the Limestone Point Lake area north of Elbow Lake.

SURFICIAL GEOLOGY

Glacigenic sediments comprising lee-side till and a basal till sheet are widespread throughout the area above an elevation of 300 m (1000 ft) above sea level. Below this elevation, in the eastern part of the area, Lake Agassiz clay is widespread and generally precludes till sampling from hand-dug holes. Above 300 m, till and bedrock outcrops interspersed with minor occurrences of clay, swamp and littoral sand and gravel deposits, are the common features of the landscape. Till deposits are generally thin. Sixty-six of the 185 samples were collected on the bedrock surface exposed in the bottom of the hand-dug holes. The thickest till accumulations are found on the down-ice, or lee-side of bedrock obstructions where thicknesses of 10 m or more may occur (Fig. GS-10-2). Unfortunately, in areas with high relief, such as at Elbow Lake, the till sheet has undergone extensive washing and reworking during the regression of Lake Agassiz (Fig. GS-10-3).

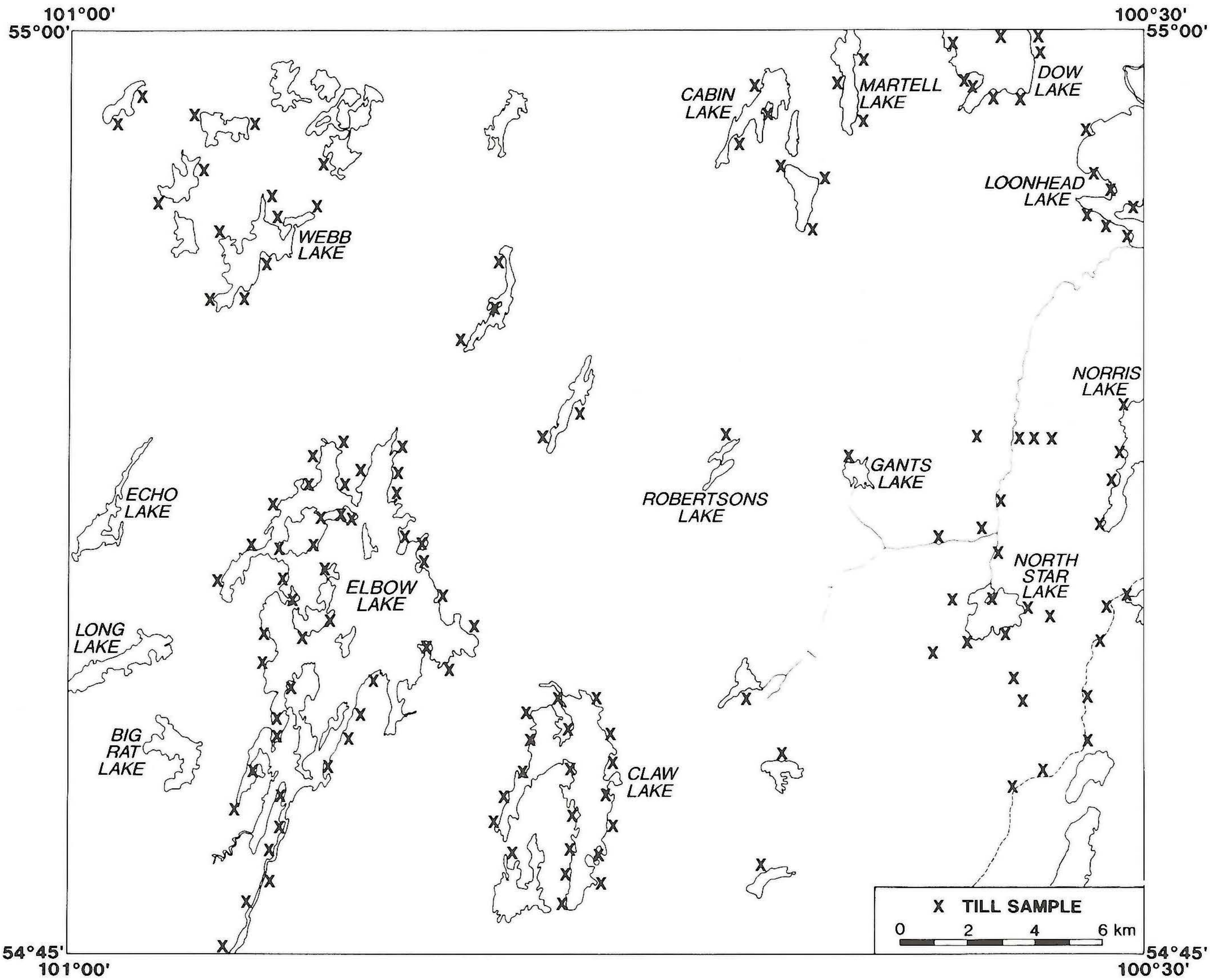


Figure GS-10-1: Till and humus sampling sites in the Elbow Lake area.

Figure GS-10-2: *Typical lee-side till deposit occurring behind a large bedrock obstruction at Elbow Lake. Ice flow was from right to left.*

Figure GS-10-3: *Boulder lag resulting from erosion of the till during the regression of Lake Agassiz in the Claw Lake area.*

Widespread littoral sand and gravel are therefore a major hindrance to surface sampling in this area.

ICE FLOW HISTORY

Striations measured in the Flin Flon-Snow Lake area record a complex history of ice flow events (Gobert and Nielsen 1991, McMartin per com, 1992; Kaszycki per com, 1992). Throughout the region ice flow directions approximate 270°, 210°, 190°, and 160°. In the Elbow Lake area the most commonly recorded ice flow is toward 204° with a less common direction toward 195°-198° (Fig. GS-10-4). Striae trending 280° were observed at one site as were those trending 118°. Age relations of striations were observed at a single site east of Northstar Lake where an early ice flow towards 192° preceded an advance towards 156° (Fig. GS-10-5). This is consistent with previous findings that indicate the last ice advance was toward approximately 160°. Although the striations record a complex history of ice flow, till sheets related to each of these events have not been recognized in the hand-dug pits or naturally exposed sections in the area.

GLACIAL DISPERSION

Paleozoic carbonate erratics discovered at Northstar Lake and Loonhead Lake prompted more detailed sampling and boulder tracing at Dow Lake and McGhee Lake located directly to the north. The till along the southeast side of Dow Lake is highly calcareous with up to an estimated 50% Paleozoic carbonate clasts. This is in sharp contrast to the west side of the lake where carbonate erratics are not present. On the other hand, at McGhee Lake located to the northeast, the till is highly calcareous along the west shore, but there are no carbonate

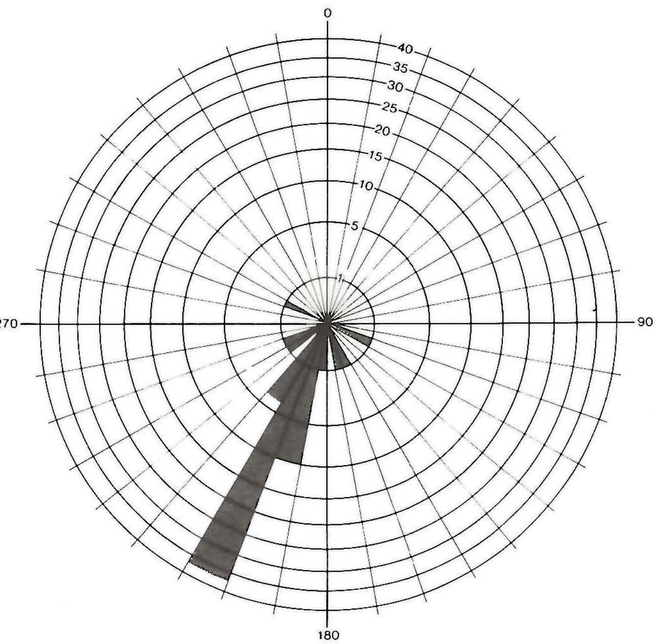


Figure GS-10-4: *Striation directions for the Elbow Lake area plotted on a frequency net.*

erratics along the east side of the lake (Fig. GS-10-6). The distribution of carbonate erratics in the Northstar and Loonhead lakes area, and calcareous till at Dow and McGhee lakes, indicates the carbonate was derived from the small Paleozoic carbonate outlier at Limestone Point Lake to the north. Furthermore, the distribution of calcareous till suggests the dispersion train is relatively narrow and fans out at an angle of only 22°. The trend of the dispersion train is approximately 185°, which is more southerly than the predominant 190° to 210° ice flow directions indicated by glacial striae. The reason for this difference is unclear at present, but these observations underscore the need for understanding both the regional ice flow history, as indicated by striations, and for undertaking case studies of glacial dispersion from known sources (see for example Nielsen and Fedikow, 1987).

GEOCHEMISTRY

The <2 micron fraction of the till samples and the -10 mesh fraction of the humus samples will be analysed by ICP-atomic emission spectroscopy for 28 elements. The <63 micron fraction will be analysed for "Gold+33" elements by neutron activation. These analytical schemes are consistent with those used for the 1991 File Lake and Herb Lake samples, as well as those employed for other till geochemical studies in the Shield Margin NATMAP area. Heavy mineral concentration and gold grain counts, which have been routine procedures in previous studies, are not planned for these samples because of the prohibitive cost.

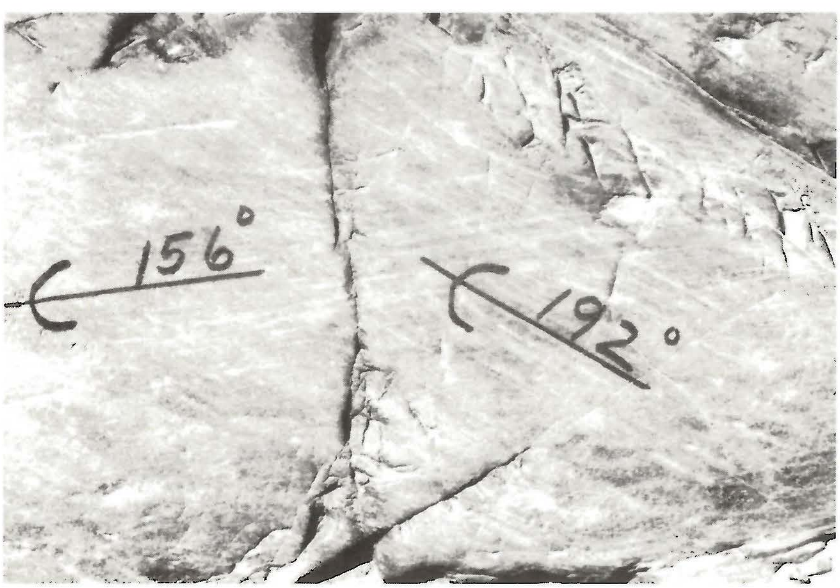


Figure GS-10-5: *Crossing striae showing ice flow towards 192° followed by an advance towards 156° east of North Star Lake.*

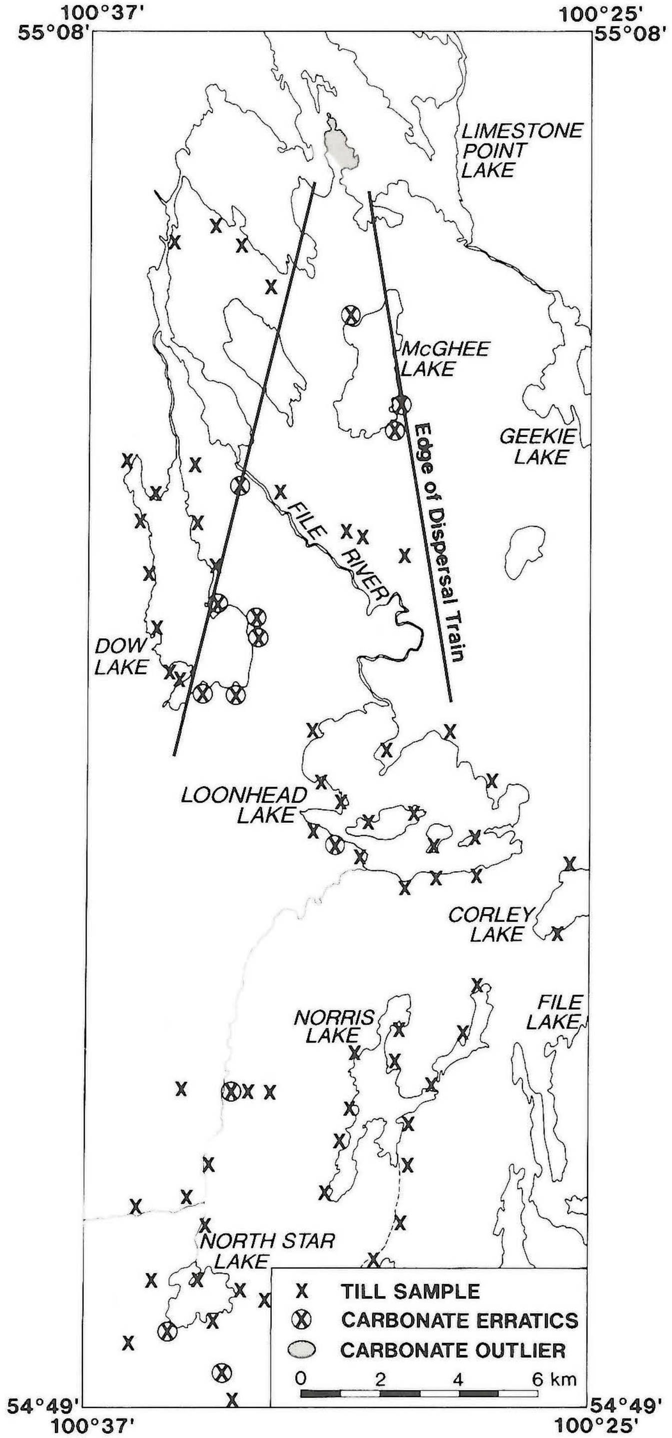


Figure GS-10-6: Carbonate dispersion train trending towards 185° from the Paleozoic bedrock outlier at Limestone Point Lake.

REFERENCES

Gobert, G. and Nielsen, E.
1991: Till geochemistry of the Snow Lake-File Lake area (NTS 63K/16, 63J/13); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 47-48.

Gobert, G.
1990: Till geochemistry of the Snow Lake area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1990, p. 72-73.

Nielsen, E. and Fedikow, M.A.F.
1987: Glacial dispersal of trace elements in Wisconsinan till in the Dot Lake-MacLellan Mine area, Manitoba; Manitoba Energy and Mines, Open File Report OF87-2, 73p.

Kaszycki, C.A.
1989: Surficial geology and till composition northwestern Manitoba; Geological Survey of Canada, Open File 2118, 48p.

GS-11 WEKUSKO LAKE (NORTH) PROJECT (NTS 63J/13SW)

by Alan H. Bailes

Bailes, A.H., 1992: Wekusko Lake (North) project (NTS 63J/13SW); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 56-64.

INTRODUCTION

The Wekusko Lake (North) Project entails 1:20 000 mapping of 160 km^2 of Early Proterozoic metavolcanic, metasedimentary and intrusive rocks at the east end of the Flin Flon metavolcanic belt. This mapping program is a continuation of 1:20 000 scale mapping begun during the previous Chisel-Morgan Lakes Project (Bailes, 1987, 1988) and Chisel-Anderson Project (Bailes, 1990), and adjoins mapping currently underway in the Wekusko Lake (South) area by Gilbert (GS-13, this volume). These mapping projects provide 1:20 000 coverage of all of NTS area 63K/16SE (Preliminary Map 1992S-1) and the west portion of 63J/13SW (Preliminary Map 1992S-2), and include most of the strata known to contain significant base metal mineralization in the Snow Lake area (Fig. GS-11-1 and -2).

Mapping in the Wekusko Lake (North) area was conducted during the 1991 and 1992 field seasons, in conjunction with joint federal-provincial 1:5 000 mapping of the volcanic strata that host the Cu-Zn base metal deposits near Anderson and Stall lakes (Bailes and Galley, 1990, 1991, 1992). The 1:20 000 and 1:5 000 mapping provide an improved geological data base for future mineral exploration in the Snow Lake area, a better definition of the stratigraphic setting of known mineral deposits, and a geological framework for data collected under the federal EXTECH (Exploration Science and Technology) program that was initiated in 1990. Joint 1:5 000 mapping with A. Galley of the Geological Survey of Canada forms the basis of the 1:20 000 map (Preliminary Map 1992S-2) north of the Berry Creek fault.

GEOLOGICAL SETTING

The Early Proterozoic rocks of the Flin Flon belt comprise an island arc assemblage (Amisk Group), a turbidite submarine fan complex, calc-alkaline plutons, and an unconformably overlying sequence of terrestrial sedimentary rocks (Missi Group). At Snow Lake U-Pb zircon ages of these rocks date a rhyolite breccia from the Amisk Group at 1892 Ma (Machado and David, 1992), the calc-alkaline plutons at between 1836-1830 Ma (Gordon *et al.*, 1990: Bailes *et al.*, 1990) and a rhyolite unit intercalated with the Missi group at 1832 Ma (Gordon *et al.*, 1990); detrital zircons from the submarine fan/turbidite greywacke complex are in the process of being dated (Machado and David, pers com.). Snow Lake area rocks underwent polyphase deformation and reached peak metamorphic conditions at about 1810 Ma (Machado and David, 1992).

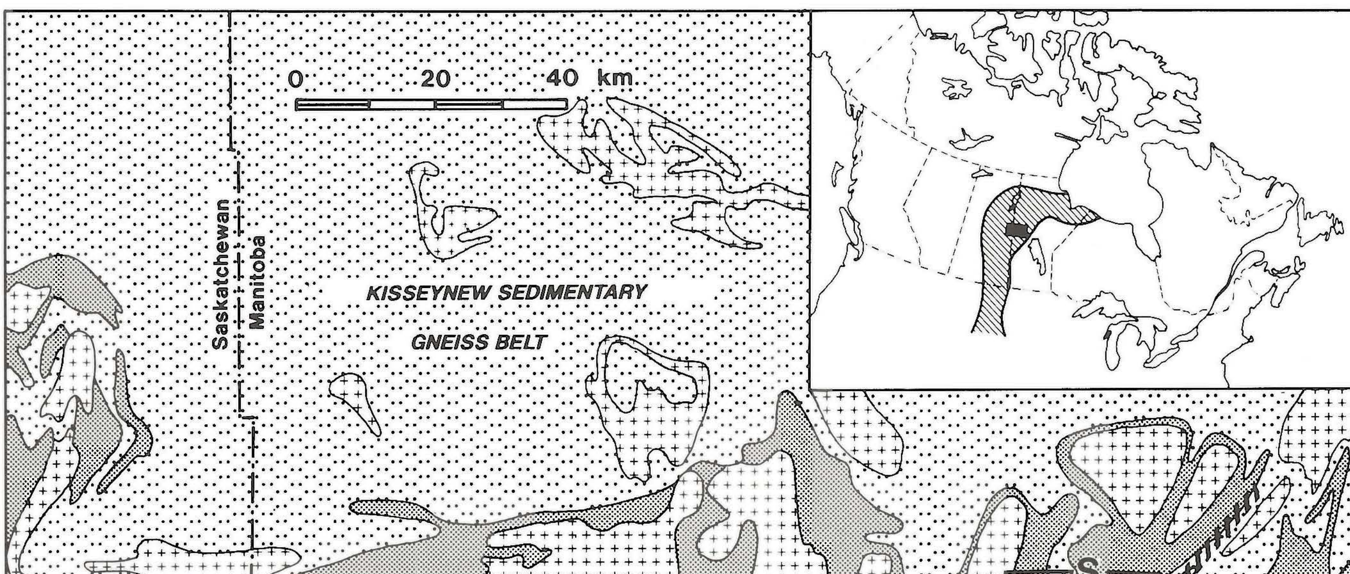


Figure GS-11-1: Location of the Snow Lake area on a simplified geological map of the Flin Flon belt, showing metavolcanic rocks (grey), granitoid plutons (+), metasedimentary rocks (dots), and Berry Creek fault (BCF). Inset location diagram shows location of the main figure within the Trans-Hudson Orogen (diagonal lines).

The Amisk Group island arc assemblage at Snow Lake is intruded by the Sneath Lake and Richard Lake tonalite plutons that have U-Pb zircon ages of 1886 Ma and 1889 Ma respectively (Figure GS-11-2; Bailes *et al.*, 1988, 1990); these ages are consistent with the interpretation that these tonalite plutons are synvolcanic (Walford and Franklin, 1982; Bailes, 1986, 1987). Nd-Sm isotopic studies on those Snow Lake area rhyolite flows that are associated with base metal deposits, and on the Sneath Lake and Richard Lake synvolcanic plutons indicate that all these rocks are isotopically primitive and that there may be a strong relationship between emplacement of mantle-derived felsic magmas and the generation of Cu-Zn base metal deposits (Stern *et al.*, 1992).

The Wekusko Lake (North) area is divided into two distinct geological domains by the northeast-trending Berry Creek fault (Preliminary Map 1992S-2; Fig. GS-11-1 and -2). The southern half, termed the Wekusko domain, consists of isoclinally folded greywacke-siltstone-mudstone turbidites of the submarine fan complex. The northern half, referred to as the Anderson domain, consists of more openly folded Amisk Group volcanic rocks that host significant Cu-Zn massive sulphide deposits. Metamorphosed equivalents of the turbidite sequence that dominates the Wekusko domain, are also exposed at the north edge of the map area, where they are sandwiched between the Snow Lake and McLeod Road faults, and occur as structurally intercalated slices(?) in the Korman's Lake area of the Anderson domain. Rocks of the Wekusko and Anderson domains are intruded by the 1830-1836 Ma calc-alkaline plutonic suite.

The Snow Lake area exhibits a complex interplay of several deformational episodes. Past studies, in particular Froese and Moore (1980), have interpreted the deformation in terms of two major folding events. The first, F_1, is reflected in isoclinal folds that are well developed in the Wekusko domain greywacke turbidite suite and less prominently in the Anderson domain volcanic assemblage. F_1 folds are characterized by a prominent axial planar schistosity, S_1. The second fold event, F_2, consists of a series of major north-northeast-trending broad warps that fold the geological formations, the earlier formed S_1 foliation and related fabrics, and some of the major faults. F_2 folds commonly display a prominent axial planar foliation, S_2, and are interpreted to have overlapped peak P-T metamorphic conditions. Metamorphic mineral assemblages formed during this peak metamorphic episode increase from middle greenschist, at the south boundary of the Wekusko Lake (North) map sheet, to lower almandine-amphibolite facies, at the north boundary.

Three major faults, the McLeod Road, the Snow Lake and the Berry Creek cut rocks of the Wekusko Lake (North) area (Figure GS-11-2). In addition there are numerous parallel subsidiary faults that appear to have involved only minor structural offsets relative to the more major fault structures. The McLeod Road fault has been interpreted by Froese and Moore (1980) to be a thrust fault synchronous with F_1. The Snow Lake fault is quite similar to the McLeod Road fault and probably the same age. The Berry Creek fault is a structure of regional extent with a strike length of over 150 km. It cuts across the 1834 Ma Wekusko Lake pluton (Gordon *et al.*, 1990) and offsets regional metamorphic isograds formed during the 1810 Ma event (Machado and David, 1992). Because of the regional scale of the Berry Creek fault and the fact that it separates two geological domains of quite disparate geology it provides a natural subdivision of the Wekusko Lake (North) area into north and south domains. Volcanic rocks and contained base metal mineralization of the north portion of the area, the Anderson domain, have been mapped at 1:5 000 and are described in detail in Bailes and Galley (GS-12, this volume).

This contribution emphasizes the geology of the southern half, the Wekusko domain, as well as a brief discussion of the timing of some of the deformational and metamorphic events. A study of the structure of the Snow Lake area is currently underway by J. Kraus, University of New Brunswick. This study is part of a Ph.D. study funded under Lithoprobe and being carried out in conjunction with NATMAP.

UNIT DESCRIPTIONS, WEKUSKO DOMAIN

The Wekusko Lake domain is underlain by a thick succession of interbedded greywacke, siltstone and mudstone (unit 17) that has been isoclinally folded and subsequently intruded by two large granite bodies, the Wekusko Lake and Tramping Lake plutons (unit 28). The granites and the greywacke, siltstone and mudstone sequence are cut by nondeformed, fine grained mafic to intermediate dykes (unit 26).

Greywacke, siltstone and mudstone (unit 17)

The greywacke, siltstone and mudstone sequence on Wekusko Lake is important because it can be traced to the north into paragneisses of the Kisseynew sedimentary belt, and because, 20 km northeast of the map area, it hosts Zn-Cu (Bur Zone) and Zn-Pb-Ag (Kobar/Ruby) massive sulphide deposits (Fedikow, 1991). It is identical in most of its features to the File Lake formation, exposed 35 km to the west-northwest (Bailes, 1980).

Unit 17 consists of interbedded lithic greywacke, feldspathic greywacke, siltstone, mudstone and local pebble-bearing greywacke. They contain well preserved primary sedimentary structures and features that indicate these rocks were deposited by subaqueous mass-sediment gravity flows, mainly turbidity currents. The rocks are isoclinally F_1 folded (Fig. GS-11-3) and openly buckled about northeast-trending F_2 fold structures (Fig. GS-11-4). The intensity of metamorphic recrystallization increases from lower greenschist facies in the southwest portions of the Wekusko domain to lower almandine-amphibolite facies at its extreme northwest corner.

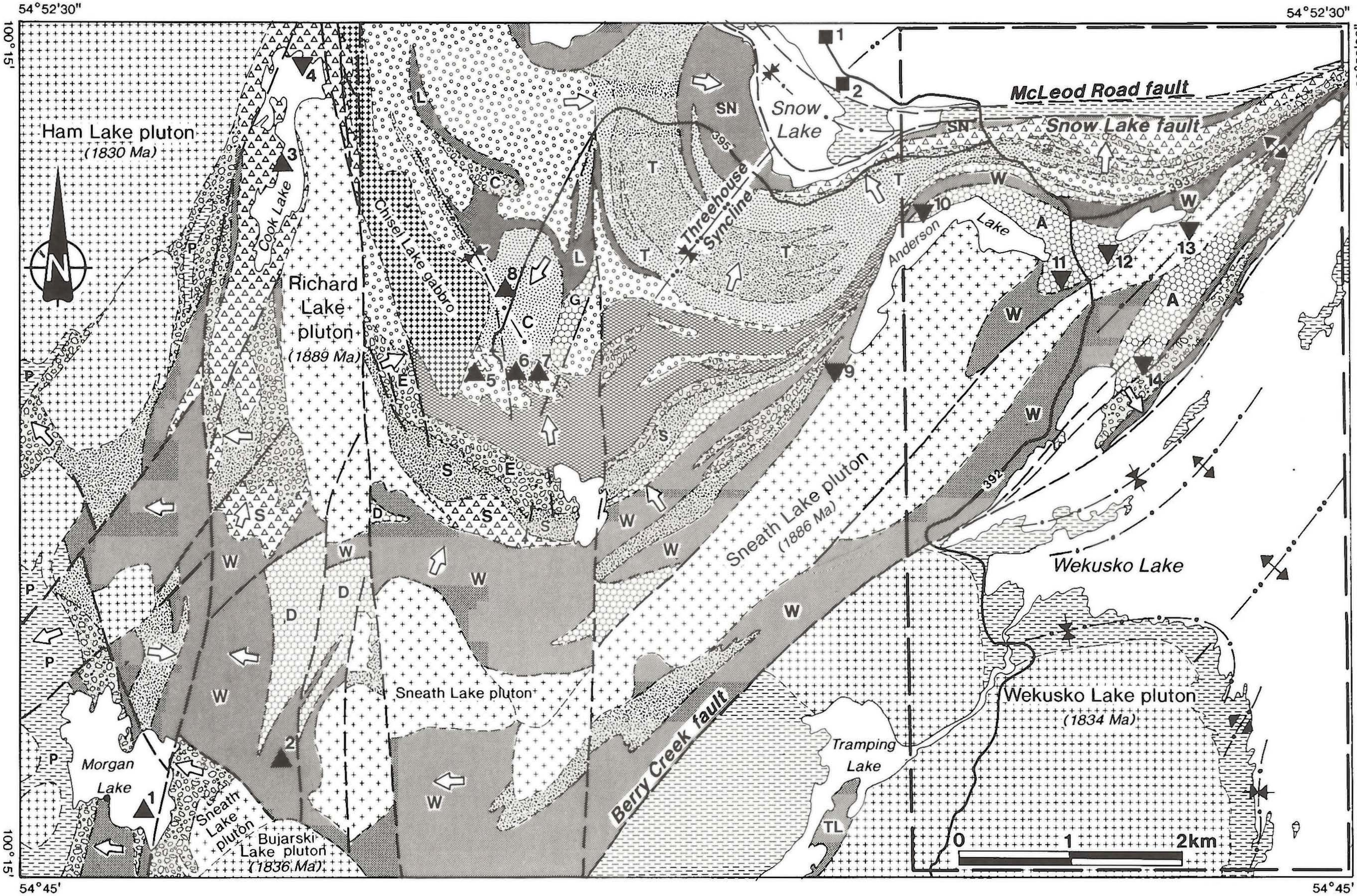
The greywacke and siltstone comprise mainly A and AB Bouma zoned beds, many with E division mudstone tops. Normal size grading, scour channels, load structures, rip ups and calcareous concretions are ubiquitous (Fig. GS-11-5 to 8). Slump folds, flame structures, sandstone dykes and soft sediment deformation structures are locally present. Greywacke and coarse siltstone are composed dominantly of felsic volcanic rock fragments (Fig. GS-11-9) and volcanic quartz and plagioclase crystal fragments, and lesser amounts of intermediate volcanic detritus. The fragments are typically angular to subrounded. No metamorphic or obviously deep-seated plutonic fragments were observed. This, along with the textural and compositional immaturity of the detritus, suggests derivation from a nearby volcanic terrane.

In the File Lake area, a similar sequence of greywacke, siltstone and mudstone turbidites was interpreted by Bailes (1980) to have been deposited in a submarine fan environment and to have been derived from contemporaneous volcanoes of the Flin Flon belt. This interpretation is presently being tested by dating detrital zircons from greywacke from Wekusko Lake and File Lake. The large gap in age between Amisk Group volcanic rocks (1892 Ma) and overlying Missi Group rocks (1832 Ma), leaves an extended time period during which the greywacke turbidite sequence could have been formed, raising some doubt about the reliability of the interpretation of them as being contemporaneous with Amisk volcanism.

Wekusko Lake and Tramping Lake plutons (unit 28)

The Wekusko Lake pluton is an oval, 8 km diameter, late tectonic granite (1834+8/-6 Ma, Gordon *et al*, 1990) that cuts across F_1 folded greywacke, siltstone and mudstone of unit 17. It occupies the core of a large, northeast-trending F_2 antiform. Sedimentary rocks within several metres of the pluton are recrystallized to lower almandine-amphibolite facies mineral assemblages and are variably bleached and altered along fracture-controlled domains. In some instances this bleaching has obscured the original character of the sediments. The granite varies from reddish pink to light pink, and is typically coarse grained (5-10 mm). It is nonfoliated, homogeneous and characterized by prominent oscillatory zoned plagioclase crystals. Hornblende (3-7%), partly altered to biotite, makes up the mafic phase. Near the contact the pluton is commonly full of xenoliths of the host greywacke (Fig GS-11-10). Away from the contact these xenoliths are rarely preserved due to strong recrystallization and assimilation.

The Tramping Lake granite is similar to the Wekusko Lake granite with the exception that it is slightly finer grained, more potassic, and somewhat lighter pink to buff weathering; the higher potassium content



54°52'30"
54°52'30"
100°15'
99°52'30"
McLeod Road fault
Snow Lake fault
Snow Lake
Ham Lake pluton
(1830 Ma)
Cook Lake
Richard Lake pluton
(1889 Ma)
Chisel Lake gabbro
Threehouse Syncline
Anderson Lake
Sneath Lake pluton
(1886 Ma)
Sneath Lake pluton
Wekusko Lake
Wekusko Lake pluton
(1834 Ma)
Berry Creek fault
Tramping Lake
Morgan Lake
Sneath Lake pluton
Bujarski Lake pluton
(1836 Ma)
0
1
2km
100°15'
99°52'30"
54°45'
54°45'

LEGEND

INTRUSIVE ROCKS

- Chisel Lake gabbro
- Felsic plutons
- Synvolcanic tonalite

SUPRACRUSTAL ROCKS

- Greywacke, siltstone, mudstone
  - P - Parisian formation (pebbly mudstone)
- Felsic volcanic rocks/breccia
  - S – Stroud Lake felsic breccia
- Rhyolite
  - G - Ghost Lake
  - D - Daly Lake
  - A – Anderson
- Powderhouse dacite
- Chisel basin / Threehouse mafic volcaniclastics
  - T - Threehouse
  - C - Chisel basin
- Mafic breccia
  - E - Edwards Lake
  - C – Chisel basin
- Moore Lake fractionated basalt flows
- Porphyritic mafic flows
  - T - Threehouse
  - S - Snell Lake
- Aphyric mafic flows
  - W - Welch Lake
  - SN – Snow Creek
  - L – Lalor
  - TL – Tramping Lake

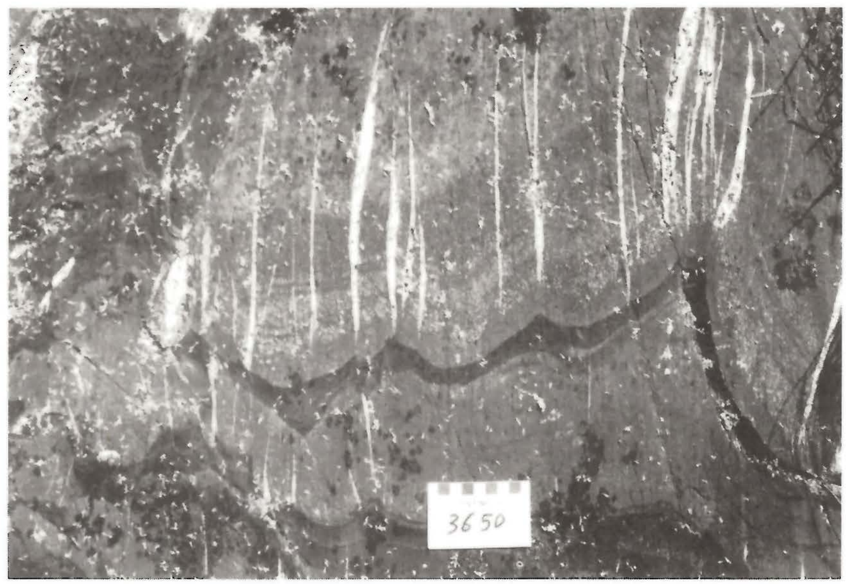
SYMBOLS

- Facing direction of strata
- Fault
- Fold, syncline (•F1,••F2)
- 392 Road
- Massive sulphide deposit (Cu-Zn, Zn-Cu)
  - 1 - Morgan Lake
  - 2 - Pot Lake
  - 3 - Bomber
  - 4 - Cook Lake
  - 5 - Chisel Lake mine
  - 6 - Lost Lake mine
  - 7 - Ghost Lake mine
  - 8 - North Chisel
  - 9 - Joannie
  - 10 - Anderson Lake mine
  - 11 - Ram
  - 12 - Stall Lake mine
  - 13 - Rod mine
  - 14 - Linda
- Gold deposit
  - 1 - NorAcme
  - 2 - Bounter

Figure GS-11-2: General geology of the Snow Lake area with the Wekusko (North) area outlined by bold dashed line.

Figure GS-11-3: *Isoclinally F_1 folded interbedded greywacke and mudstone (unit 17), Donogh Island*

Figure GS-11-4: *Open F_2 fold of interbedded greywacke and mudstone (unit 17), small island off Wedge Point. Note graded bedding in greywacke beds and tension gash quartz veins formed by dilation of F_2 axial planar S_2 foliation.*



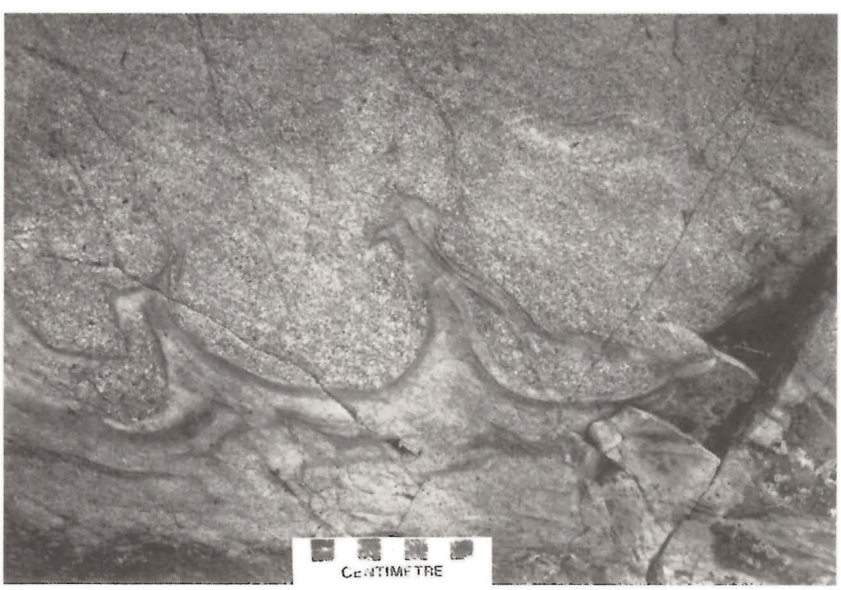
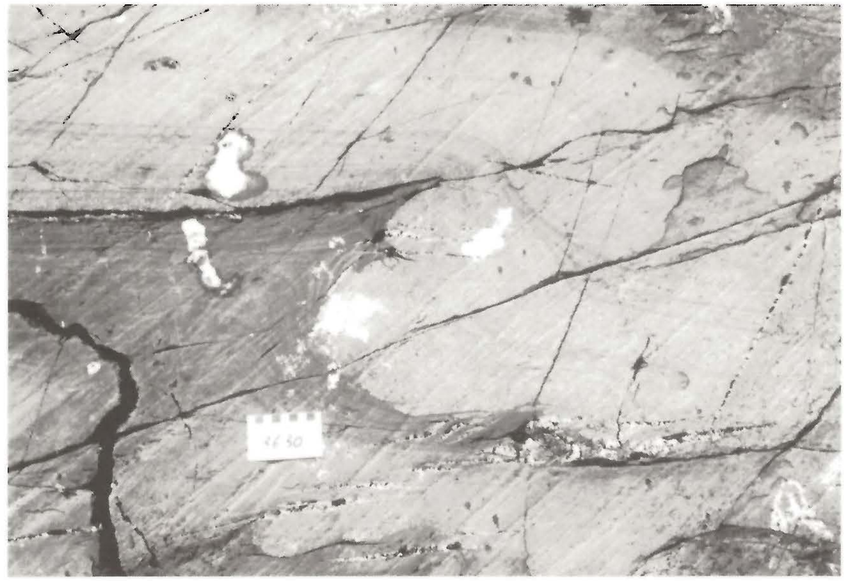


Figure GS-11-5: *Load structures at base of normal graded greywacke bed (unit 17).*

Figure GS-11-6: *Large scour structure (unit 17).*



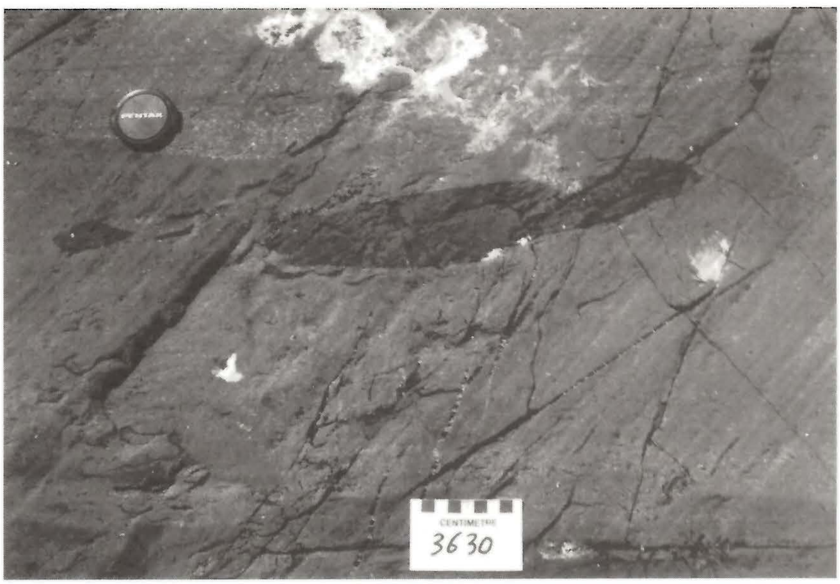


Figure GS-11-7: *Mudstone rip-ups near top of normal graded Bouma A greywacke bed (unit 17).*

Figure GS-11-8: *Metamorphically recrystallized carbonate concretions in massive, thick greywacke bed (unit 17), Snow Bay. Carbonate in concretions reacted during metamorphism with silicate material, within and adjacent to concretions, to form zoned calc-silicate mineral assemblages characterized by acicular actinolite porphyroblasts.*

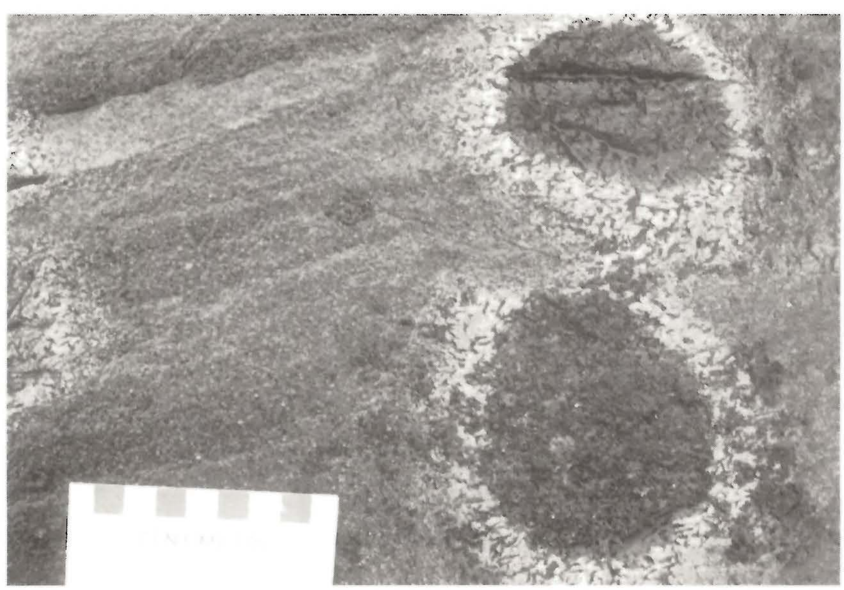
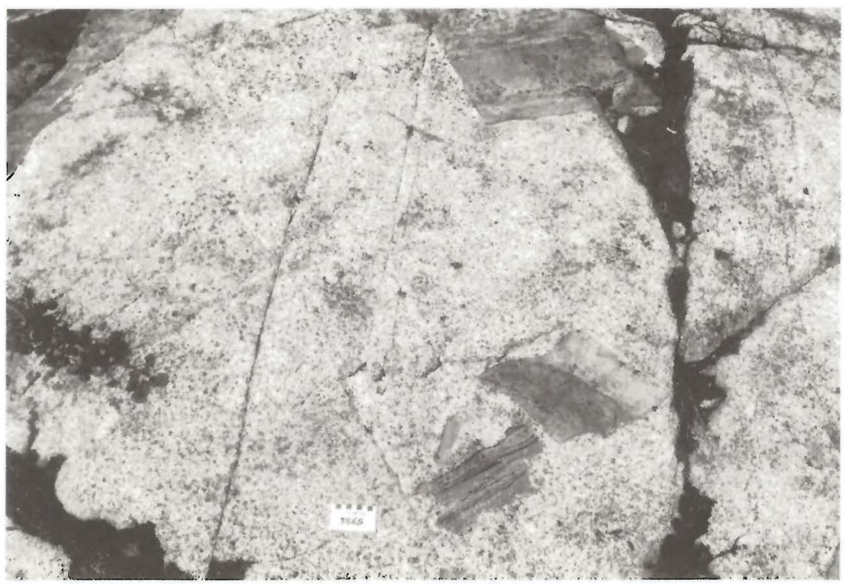


Figure GS-11-9: Subrounded cobble of quartz phyric rhyolite in greywacke. Macroscopic and microscopic felsic volcanic rock fragments are common in greywacke (unit 17).

Figure GS-11-10: Angular xenoliths of interbedded greywacke, siltstone and mudstone (unit 17) in granodiorite (unit 28), Wekusko Lake pluton.



is also evident from an airborne radiometric survey that covered the two plutons (Rob Shives, GSC, pers. com). The northern contact of the Tramping Lake pluton is abruptly truncated by the Berry Creek fault. A prominent cliff escarpment, along which there is very little evidence of any deformation, is the only expression of this fault.

The Wekusko and Tramping Lake plutons are cut by linear dykes (unit 26) that follow fractures and faults. The fault-controlled character of the dykes is most clearly recognizable along the boundary of the Wekusko Lake pluton where the contact of the pluton is offset by the dyke-hosting structures (Preliminary Map 1992S-2).

Posttectonic dyke rocks (unit 26)

Posttectonic dykes (unit 26) include plagioclase phyric mafic intrusions that are emplaced along faults and fractures in the Wekusko Lake pluton (unit 28), coarsely quartz amygdaloidal intermediate to mafic dykes that cut the Wekusko Lake turbiditic greywacke suite (unit 17), and quartz diorite intrusions spatially associated with the Berry Creek fault.

Plagioclase phyric mafic dykes, emplaced along fractures and faults in the Wekusko Lake and Tramping Lake plutons, vary in width from under a metre to over 15 m. They typically trend east-southeast and have been followed continuously for up to 1 km along strike. A large, irregular intrusion related to the dykes occurs just south of the map near highway 392; this intrusion displays a prominent aeromagnetic gradiometer high. The dykes contain 2 to 20%, 2 to 16 mm plagioclase phenocrysts contained in a fine grained mafic groundmass. The dykes cut across F_1 folds developed in greywacke, siltstone and mudstone (unit 17) and appear to be undeformed by F_2 folds.

Coarsely quartz amygdaloidal intermediate to mafic dykes cut the greywacke, siltstone and mudstone sequence (unit 17) in three localities. These dykes may be related to the plagioclase phyric mafic dykes that cut the granite plutons but their amygdaloidal character, different orientation (northeast trending) and foliated character suggest they may belong to a different intrusive event. The largest of these dykes occurs on Eureka Island. It is over 60 m in width, quartz diorite in composition and contains 10 to 15%, 3 to 12 mm quartz and carbonate amygdales; it is locally plagioclase glomerophyric. The foliated character of these dykes suggest that they were emplaced before the nonfoliated plagioclase phyric mafic dykes that cut the Wekusko Lake and Tramping Lake plutons.

Quartz diorite dykes are locally associated with the Berry Creek fault. These dykes, which typically trend subparallel to the fault, include both foliated and nonfoliated varieties. They are similar to the amygdaloidal quartz diorite dykes emplaced in the greywacke, siltstone and mudstone sequence, but amygdaloidal varieties were not observed.

Rice Island Gabbro

Disseminations and stringers of nickeliferous pyrrhotite and chalcopyrite are associated with a medium grained, nonfoliated gabbro intrusion on Rice Island (Russell, 1957; Froese and Moore, 1980; Fedikow *et al.,* in prep.). An over 10 km long northeast-trending aeromagnetic gradiometer anomaly, associated with this intrusion, suggests that this gabbro body is a dyke, or alternatively a linear plug exposed in the core of an F_1 anticline. The nonfoliated character of the intrusion indicates it may be related to the dykes described in the previous section. Russell (1957) reports that the quartz diorite dyke on Eureka Island also contains Ni-Cu sulphides.

STRUCTURAL GEOLOGY, WEKUSKO DOMAIN

At least two phases of folding have affected the greywacke, siltstone and mudstone sequence on Wekusko Lake. These include a series of isoclinal F_1 folds that are particularly well exposed along the west shore of Wekusko Lake (adjacent to the Wekusko Lake pluton) and on Donogh Island. The F_1 folds are broadly folded about a major, upright, open F_2 antiform that extends northeast from the Wekusko Lake pluton towards Herb Bay. Minor F_2 folds are locally crosscut by a north-northeast-trending crenulation cleavage and small scale F_3 folds; no major folds have been observed in association with the F_3 event.

F_1 structures typically do not have associated minor folds. They are identified by abrupt reversals in facing direction of greywacke beds in unit 17. F_1 fold culminations, where observed, are isoclinal (Fig. GS-11-3). Northeast- and east-northeast-trending F_1 fold axial traces are commonly characterized by an increased abundance of quartz veins. The significance of this is not known, but because northeast-trending F_2 structures also display an increase in abundance of quartz veins along their axial plane (Fig GS-11-4), this phenomenon is probably unrelated to development of either the F_1 or F_2 folds. F_1 folds on the west shore of Wekusko Lake are slightly more open than their counterparts on Donogh Island. They also do not normally have a macroscopically visible axial planar S_1 cleavage as do F_1 folds on Donogh Island. This is probably due to tightening of the northeast-trending F_1 folds on Dologh Island during F_2 folding and to the higher intensity of metamorphic recrystallization of more northerly portions of the greywacke sequence. F_1 folds on the west shore of Wekusko Lake are clearly not coaxial with the northeast-trending F_2 fold about which they are folded. A minimum age for the F_1 fold event is 1834 Ma, because they are cut by the Wekusko Lake pluton (1834+6/-8 Ma).

The only major F_2 fold in the Wekusko Lake domain is the northeast-trending F_2 anticlinal structure cored by the Wekusko Lake pluton. However, minor F_2 folds are abundant, particularly on islands in Snow Bay. Minor folds are dominantly Z-asymmetrical, consistent with them being parasitic folds on the northwest limb of the major F_2 anticline. Minor F_2 folds on Snow Bay are upright, closed to open, and have a prominent axial planar S_2 schistosity. They are characterized by axial planar tension gash quartz veins that occur selectively in the greywacke beds of alternating mudstone-greywacke sequences (Fig. GS-11-4). The presence of an axial planar schistosity for both F_1 and F_2 folds creates some ambiguity as to the age of schistosities where only one can be observed. This is a common problem for outcrops on Snow Bay where the angle between these two schistosities is very small making it very difficult to distinguish between them. Most of the schistosities measured in greywacke beds on Snow Bay are probably S_2, but this is impossible to verify.

Small F_3 chevron folds and kink bands have been observed in outcrops where the rocks have a well developed S_2 schistosity. These folds, and an associated S_3 crenulation cleavage, observed throughout the Snow Lake area, are most prominently developed in mudstone beds where the S_2 cleavage has refracted to a more easterly strike. The axial plane of the F_3 folds and the strike of the S_3 crenulation cleavage is typically between 310° and 350°.

Metamorphic textures suggest that peak regional metamorphic conditions (1810 Ma, Machado and David, 1992) in the Snow Lake area overlapped the F_2 folding event; this is consistent with observations by Froese and Moore (1980). F_3 structures, not identified by Froese and Moore, 1980), postdate peak metamorphism.

BERRY CREEK FAULT

The Berry Creek fault, which can be traced on gradiometer maps for over 100 km to the southwest and 25 km to the northeast of the Wekusko Lake (North) area, is a structure of regional significance. In the Wekusko Lake area the fault separates two domains of disparate geology; a dominantly sedimentary domain to the south and a volcanic terrain to the north. The fault clearly postdates the Tramping Lake pluton, which is probably similar in age to the 1834 Ma Wekusko Lake pluton, and has offset metamorphic isograds generated during the 1810 Ma peak regional metamorphism. However pre- and post-metamorphic movement, and ductile and brittle deformation indicate a complex history for the fault.

The late brittle deformation on the fault is clearly recognized by associated concentrations of hematized, carbonate-filled fractures and by offset of the regional metamorphic isograds. Offset during the brittle faulting is sinistral and dominantly strike slip. Premetamorphic deformation is less easily recognized because it is overprinted by fault-associated alteration and by fabrics and textures produced during subsequent regional metamorphism. Many of the rocks between the main Berry Creek fault and the splay that runs a few hundred metres inland on Wekusko Lake have been affected by intense premetamorphic shearing. These rocks are characterized by tectonic lamination, abundant tectonic boudins and tectonically dismembered quartz veins, and are overgrown by actinolite porphyroblasts generated during regional metamorphism. Orientation of quartz vein boudins indicates a component of sinistral offset during fault movement that produced these rocks.

ECONOMIC GEOLOGY

The Wekusko domain has not generally been considered a prime exploration target for base metals; most exploration in the area has concentrated on the volcanic rocks such as those of the Anderson domain. However the recent discovery of the Bur Zn-Cu massive sulphide zone and the placement of the Kobar/Ruby Zn-Pb-Ag sulphide mineralization in the more metamorphosed equivalents of the greywacke, siltstone and mudstone suite that underlies Wekusko Lake (Fedikow *et al.,* in prep.) indicates that this terrain has greater potential for base metals than previously recognized. The sedimentary environment of deposition of the Bur and Kobar sulphide mineralization is completely different from that of volcanic-hosted base metal deposits of the Flin Flon belt and this may require some adjustment to the type of exploration program used in exploration for this type of deposit. Fedikow *et al.* (in prep.) indicate that there is no alteration pipe or conduit observed in association with the Bur deposit, but they did note a spatial association with zones of calc-silicate-rich rocks.

The Rice Island Ni-Cu occurrence is associated with a gabbro intrusion exposed only on Rice Island. The gradiometer survey indicates that this intrusion is likely a long linear body, possibly a dyke, up to 10.5 km long. Because most of the length of this Ni-Cu bearing intrusion is covered by the water in Wekusko Lake it is possible that the economic potential of this intrusion may not have been fully investigated.

REFERENCES

Bailes, A.H.

1980: Geology of the File Lake area; Manitoba Energy and Mines, Geological Report 78-1, 134p.

1986: Chisel-Morgan Lakes project; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1986, p. 70-76.

1987: Chisel-Morgan Lakes Project, Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1987, p. 70-79.

1988: Chisel-Morgan Lakes project, Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 53-61.

1990: Chisel-Morgan-Anderson (NTS 63K\16SE); Manitoba Energy and Mines, Preliminary Map 1990S-1, 1:20˘000.

Bailes, A.H., Gordon, T.M. and Hunt, P.A.
1988: U-Pb geochronology of the Richard Lake tonalite, a possible synvolcanic pluton in the Snow Lake area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 63-65.

Bailes, A.H., Hunt, P.A. and Gordon, T.M.
1991: U-Pb zircon dating of possible synvolcanic plutons in the Flin Flon belt at Snow Lake, Manitoba; Geological Survey of Canada, Radiogenic age and isotopic studies; Report 4, p. 35-43.

1990: U-Pb dating of synvolcanic plutons in the Flin Flon belt at Snow Lake, Manitoba; Geological Survey of Canada, Radiogenic age and isotopic studies; Report 3, p. 35-44.

Bailes, A.H. and Galley, A.G.
1991: Geological setting of base metal mineralization in the Anderson Lake area (NTS 63K/16SE and 63J/13SW); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 8-13.

Fedikow, M.A.F.
1991: Sediment-hosted Zn-Cu (Bur Zone) and Zn-Pb-Ag (Kobar/Ruby) massive sulphide type deposits, Snow Lake area (NTS 63J/13); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 43-46.

Fedikow, M.A.F., Athayde, P. and Galley, A.
in prep: Mineral deposits and occurrences in the Wekusko Lake area (NTS 63J/13); Manitoba Energy and Mines, Mineral Deposit Series Report No. 14, p.

Froese, E., and Moore, J.M.
1980: Metamorphism in the Snow Lake area, Manitoba, Geological Survey of Canada, Paper 78-27, 16p.

Gordon, T.M., Hunt, P.A., Bailes, A.H., and Syme, E.C.
1990: U-Pb zircon ages from the Flin Flon and Kisseynew belts, Manitoba: Chronology of crust formation at an Early Proterozoic accretionary margin, **in** Lewry, J.F. and Stauffer, M.R., eds., The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 177-199.

Machado, N. and David, J.
1991: U-Pb geochronology of the Reindeer-Superior transition zone and of the Snow Lake area: preliminary results; Lithoprobe Trans-Hudson Orogen Transect, Report No. 26, p. 40-42.

Russell, G.A.
1957: Structural studies of the Snow Lake-Herb Lake area; Manitoba Mines and Natural Resources, Mines Branch, Publication 55-3, 33 p.

Stern, R.A., Syme, E.C., Bailes, A.H., Galley, A.G., Thomas, D.J., and Lucas, S.B.
in press: Nd-isotopic stratigraphy of the Early Proterozoic Amisk Group metavolcanic rocks from the Flin Flon belt; Radiogenic Age and Isotopic Studies: Report 5, Geological Survey of Canada.

Walford, P.C. and Franklin, J.M.
1982: The Anderson Lake Mine, Snow Lake, Manitoba; in Precambrian Sulphide Deposits (R.W. Hutchinson, C.D. Spence and J.M. Franklin, eds.); Geological Association of Canada, Special Paper 25, p. 481-523.

GS-12 GEOLOGY OF THE KORMANS LAKE AREA (63J/13SW)

by Alan H. Bailes and Alan G. Galley[1]

Bailes, A.H. and Galley, A.G., 1992: Geology of the Kormans Lake area (NTS 63J/13SW); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 65-74.

INTRODUCTION

In 1992, the Kormans Lake area was mapped at 1:5 000 scale. This mapping was undertaken to address structural and stratigraphic problems left unresolved by previous 1:5 000 mapping in the Anderson Lake and Stall Lake area (Preliminary Maps 1991S-2 to 5; Bailes and Galley, 1991)). The combined 1: 000 scale geology of the Anderson Lake, Stall Lake and Kormans Lake areas (Fig. GS-12-1) has been reduced to 1:10 000 and released as Preliminary Map 1992S-3.

The 1:5 000 mapping was undertaken jointly by the provincial and federal governments as part of the federally funded EXTECH project. The objective of this mapping was to provide an improved geological data base for future exploration in the Anderson Lake, Stall Lake and Kormans Lake area, as well as to contribute to a better understanding of the depositional environment of base metal deposits throughout the Snow Lake area.

In 1992, a one month period was used to update and complete mapping in the Anderson Lake and Stall Lake areas, and to extend the 1:5 000 map coverage eastward to include 12 km^2 in the Kormans Lake area (Fig. GS-12-2). The resulting 1:10 000 map (Preliminary Map 1992S-3) plus a 1:5 000 scale map of the Chisel Lake area (Preliminary Map 1989S-2) covers most of the economically significant base metal deposits known to occur in the Snow Lake area. Results of the previous study of the Chisel Lake area are presented in Bailes and Galley (1989). A discussion of the setting of base metal deposits in the Anderson Lake and Stall Lake area is given by Bailes and Galley (1991).

GEOLOGICAL SETTING

The Kormans Lake area occurs 6 km east of the town of Snow Lake and is underlain by rocks of the Early Proterozoic Flin Flon belt. In the Snow Lake area the Flin Flon belt includes a 1892 Ma island arc assemblage (Amisk Group), 1899 to 1886 Ma synvolcanic tonalite plutons, a turbidite submarine fan complex of uncertain age, 1830 to 1836 Ma calc-alkaline plutons, and an unconformably overlying sequence of 1832 Ma terrestrial sediments (Missi Group) (Gordon *et al.*, 1990; Bailes *et al.*, 1990; Machado and David, 1992). Snow Lake area rocks underwent polyphase deformation and reached peak metamorphic conditions at about 1810 Ma (Machado and David, 1992).

Nd-Sm isotopic studies on Snow Lake area rhyolite flows that host base metal deposits, and on associated synvolcanic tonalite plutons, indicate that all these rocks are isotopically primitive. This suggests that there could be a strong relationship between emplacement of mantle-derived felsic magmas and the generation of Cu-Zn base metal deposits (Stern *et al.*, 1992).

The Kormans Lake area is important because it contains the eastern extension of the Anderson felsic complex, which is the host rock of the Anderson, Stall and Rod Cu-Zn massive sulphide deposits (Fig. GS-12-1 and 2). The area is also important because it is the site of a major F_1 antiform (Coates *et al.*, 1970; Jeffrey, 1982, unpublished; Zaleski, 1990; Bailes and Galley, 1991); the presence of a major F_1 antiform in the Kormans Lake area has implications for base metal exploration in the Snow Lake region.

The Kormans Lake area (Fig. GS-12-2) is divided into two distinct geological domains by the northeast-trending Berry Creek fault. The southeast half consists of isoclinally folded greywacke-siltstone-mudstone turbidites, described by Bailes (GS-11, this volume). The northwest half of the Kormans Lake area contains dominantly volcanic rocks, described in this report. This report also discusses problems related to tracing rocks that host base metal massive sulphide deposits.

DESCRIPTION OF UNITS

The Kormans Lake area contains along strike equivalents of units exposed to the west in the Stall Lake area, but a higher degree of deformation and recrystallization obscures many features that normally permit conclusive identification of rock lithologies. This, combined with folding of strata, numerous fault offsets and numerous fine grained intrusions, makes determination of the stratigraphy and structure of this area difficult. Nevertheless, the overall distribution of units supports the presence of a major F_1 fold that has been disrupted by local northeast-trending faults (Preliminary Map 1992S-3, Fig. GS-12-2). The volcanic units are generally thick and do not record any minor F_1 folds. F_2 minor folds are common in rocks with a well developed S_1 fabric.

The area northwest of the Berry Creek fault is characterized by lensoid, discontinuous units that are interpreted to be a consequence of the major F_1 antiform, combined with offsets along northeast-trending faults. Some of these faults are likely related to the F_1 folding event, but others clearly involve post F_1 movements. The narrow slice of greywacke-siltstone-mudstone (unit 15a) south and southwest of Kormans Lake (Preliminary Map 1992S-3: Fig GS-12-2) is interpreted to have a faulted northwest contact with the adjacent volcanic rocks. This fault, termed the Bartlett fault, has very little expression in outcrop, but was encountered during drilling of an EM conductor by Hudson Bay Exploration and Development (HBED); it is a long continuous graphitic shear zone (Gerry Kitsler, HBED, pers. com., 1992). The Bartlett fault marks a natural division between rocks, to the northwest, that are clearly related to the base metal hosting volcanic strata of the Anderson Lake and Stall Lake area and those, to the southeast, that are of uncertain affinity to the main volcanic sequence.

ROCKS NORTHWEST OF THE BARTLETT FAULT

Structure and stratigraphy of rocks northwest of the Bartlett fault are important because these rocks are along strike from those that contain base metal deposits in the adjacent Anderson and Stall lakes area (Fig. GS-12-2). Unfortunately, younging directions are only available for rocks north of Highway 393, along strike facies changes occur in the volcanic sequence, strata-parallel faults are present, and intrusions are abundant. Despite these impediments to determining structure and stratigraphy, the overall distribution of rock units strongly suggests the presence of a major, F_1 fold that both trends and closes to the northeast. Thus rocks north of Highway 393 are on the northwest limb of this fold, those west and southwest of Kormans Lake are in the fold hinge and top to the northeast, and those south of Kormans Lake are on the fault-abbreviated south limb and top to the southeast. Units on the northwest limb of the fold, in the best preserved rocks, are from top to base as follows:

Top (Snow Lake Fault)
- Snow Creek basalt (unit 1)*
- Felsic volcanic rocks (10, 10c, 11a, c))
- Heterolithologic mafic breccia, mafic wacke (units 13b and 12b)
- Porphyritic mafic flows (unit 6a)
- Welch basalt-andesite (unit 1a, 1d)
- Anderson felsic volcanic rocks (unit 8)

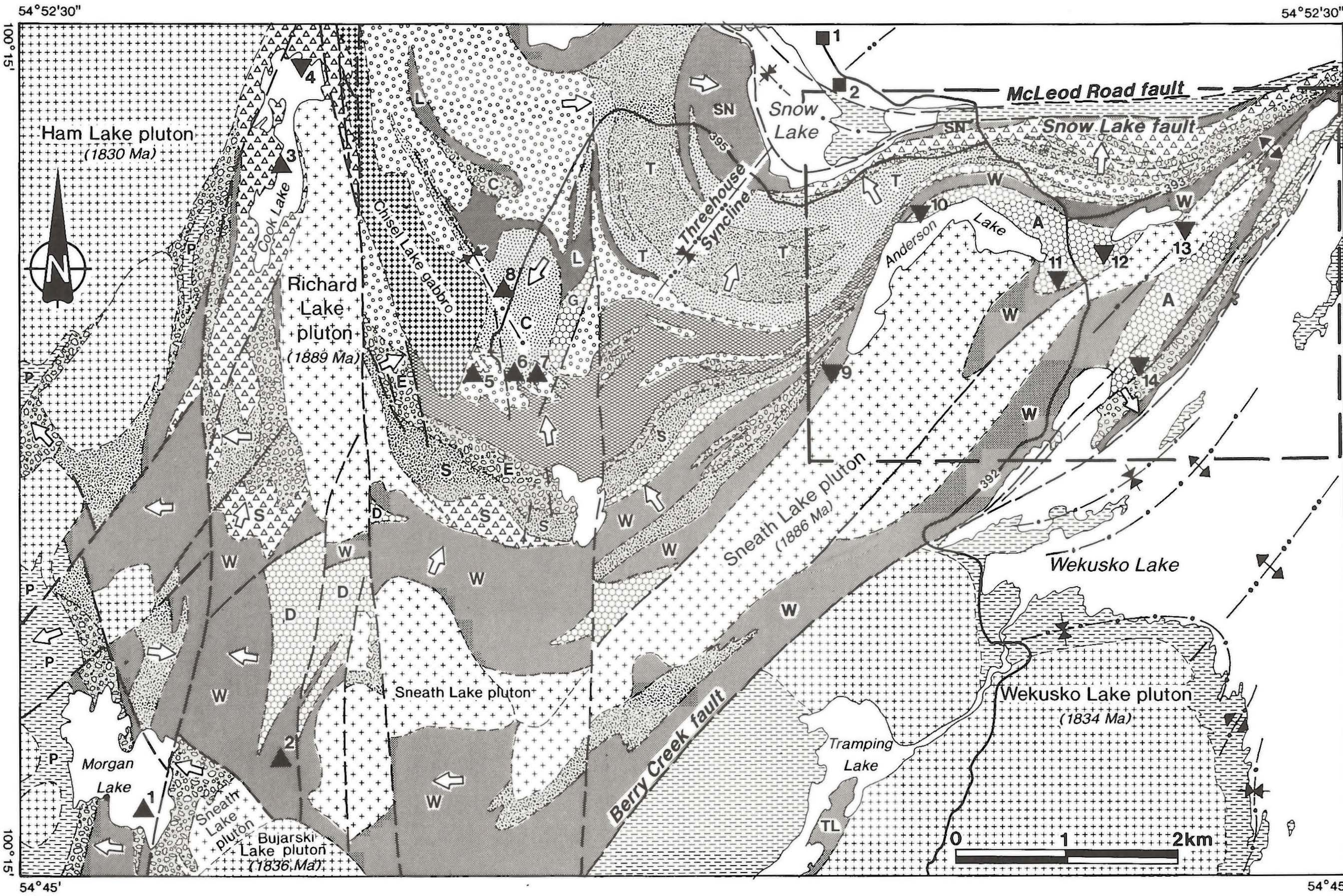
Base (F_1 fold axial trace)

* Unit numbers refer to Preliminary Map 1992S-3

Anderson felsic volcanic rocks (unit 8)

The Anderson felsic volcanic rocks (unit 8) are important because they host the Anderson Lake, Stall Lake, Rod and Linda Cu-Zn massive sulphide deposits, as well as numerous other smaller Cu-

1 Geological Survey of Canada


54°52'30"
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McLeod Road fault
Snow Lake fault
Snow Lake
Ham Lake pluton
(1830 Ma)
Cook Lake
Richard Lake pluton
(1889 Ma)
Chisel Lake gabbro
Threehouse Syncline
Anderson Lake
Sneath Lake pluton
(1886 Ma)
Wekusko Lake
Wekusko Lake pluton
(1834 Ma)
Berry Creek fault
Tramping Lake
Morgan Lake
Sneath Lake pluton
Bujarski Lake pluton
(1836 Ma)
395
393
392
SN
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0 1 2km
54°45'
54°45'
100°15'
99°52'30"

LEGEND

INTRUSIVE ROCKS

- Chisel Lake gabbro
- Felsic plutons
- Synvolcanic tonalite

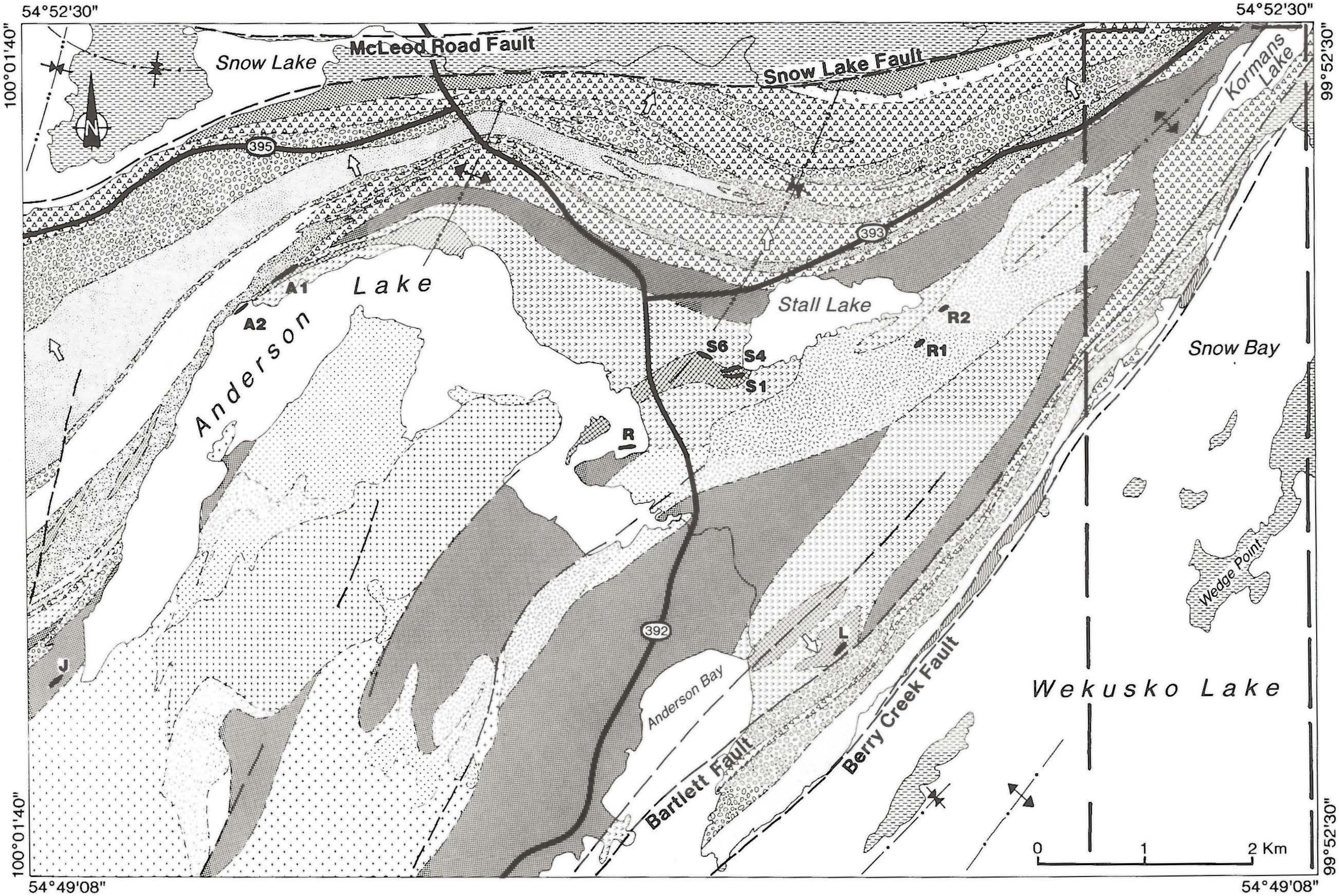
SUPRACRUSTAL ROCKS

- Greywacke, siltstone, mudstone
  - P - Parisian formation (pebbly mudstone)
- Felsic volcanic rocks/breccia
  - S – Stroud Lake felsic breccia
- Rhyolite
  - G - Ghost Lake
  - D - Daly Lake
  - A – Anderson
- Powderhouse dacite
- Chisel basin / Threehouse mafic volcaniclastics
  - T - Threehouse
  - C - Chisel basin
- Mafic breccia
  - E - Edwards Lake
  - C – Chisel basin
- Moore Lake fractionated basalt flows
- Porphyritic mafic flows
  - T - Threehouse
  - S - Snell Lake
- Aphyric mafic flows
  - W - Welch Lake
  - SN – Snow Creek
  - L – Lalor
  - TL – Tramping Lake

SYMBOLS

- Facing direction of strata
- Fault
- Fold, syncline (•F1,••F2)
- 392 Road
- Massive sulphide deposit (Cu-Zn, Zn-Cu)
  - 1 - Morgan Lake
  - 2 - Pot Lake
  - 3 - Bomber
  - 4 - Cook Lake
  - 5 - Chisel Lake mine
  - 6 - Lost Lake mine
  - 7 - Ghost Lake mine
  - 8 - North Chisel
  - 9 - Joannie
  - 10 - Anderson Lake mine
  - 11 - Ram
  - 12 - Stall Lake mine
  - 13 - Rod mine
  - 14 - Linda
- Gold deposit
  - 1 - NorAcme
  - 2 - Bounter

Figure GS-12-1: General geology of the Snow Lake area with the Anderson Lake-Stall Lake-Kormans Lake 1:5 000 mapping outlined by bold dashed line.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54°49'08"
N
Snow Lake
McLeod Road Fault
Snow Lake Fault
Kormans Lake
395
393
392
A1
A2
Lake
Anderson
Stall Lake
S6
S4
S1
R2
R1
R
Snow Bay
Wedge Point
L
J
Anderson Bay
Bartlett Fault
Berry Creek Fault
Wekusko Lake
0
1
2 Km

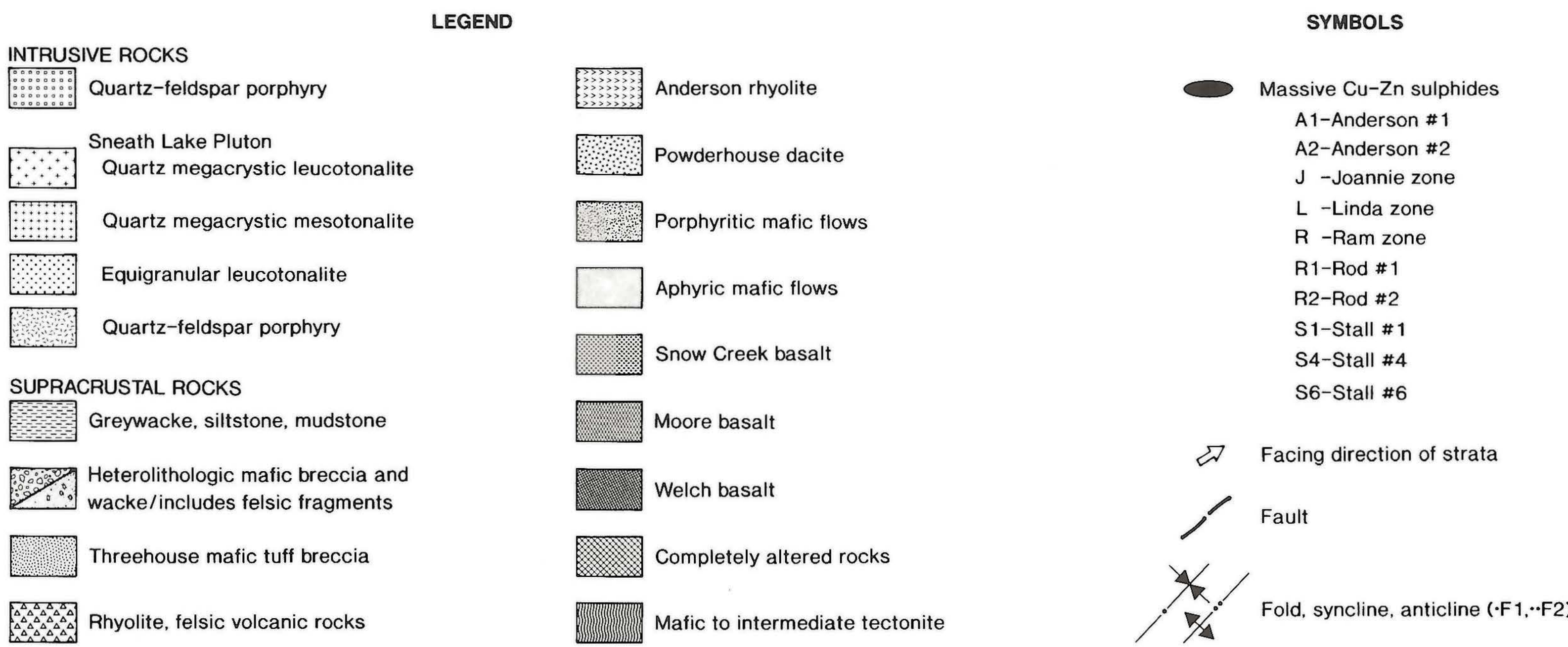


Figure GS-12-2: Simplified geology of the Anderson Lake-Stall Lake-Kormans Lake 1:5 000 map area with the Kormans Lake area outlined by bold dashed line.

Zn showings. Near the Anderson Lake and Stall Lake deposits this sequence has a readily defined internal stratigraphy that progresses up-sequence from aphyric massive rhyolite (unit 8c) at the base, to quartz phyric rhyolite (unit 8b), to an upper unit of quartz megaphyric rhyolite and felsic breccia (unit 8a). The Stall Lake Cu-Zn deposit occurs at the contact between units 8c and 8b. In the Kormans Lake area, the Anderson felsic volcanic rocks occur only in isolated small exposures in the core of the F_1 fold, and no stratigraphy was identified for this important unit.

The Anderson felsic volcanic rocks are intruded in the Kormans Lake area by a quartz porphyritic tonalite (unit 16b), a phase of the 1886 Ma synvolcanic Sneath Lake tonalite (Bailes *et al.,* 1990). The occurrence of clasts of the Sneath Lake tonalite in felsic breccia in the Anderson felsic volcanic rocks (Bailes and Galley, 1991) confirms that the Sneath Lake pluton is synvolcanic, as does the age of 1892 Ma (Machado and David, 1992) for a Snow Lake area felsic unit, the Stroud Lake breccia. Isotopic studies by Stern *et al.* (1992) suggest that the Daly Lake rhyolite, which occurs at the same stratigraphic interval as the Anderson felsic volcanic rocks, is isotopically similar to the Sneath Lake pluton. Both the Daly Lake rhyolite and the Sneath Lake pluton are among the most isotopically juvenile, within their stratigraphic sequences; this suggests these magmas are the most likely to have been mantle derived (Stern *et al.*, 1992).

The fact that the Anderson felsic volcanic rocks are folded back on themselves (Fig GS-12-2) limits the exploration potential in the Kormans Lake area, if one assumes that Cu-Zn deposits are restricted to this favourable unit. However it does increase potential for base metal deposits on the south limb of this fold, south of the Sneath Lake pluton. This structural/stratigraphic interpretation supports the view that the Linda Cu-Zn deposit occurs in the Anderson felsic volcanic sequence (Coates *et al.,* 1970; Jeffrey, 1982; Zaleski, 1989). The occurrence of this deposit at the contact between aphyric and quartz phyric phases of the Anderson felsic sequence places it at a similar stratigraphic position as the Stall Lake Cu-Zn deposit, but on the opposite limb of the F_1 fold.

Welch Lake basaltic andesite and andesite (unit 1a, 1d)

The Welch Lake formation is an over 3 km thick sequence of pillowed to sparsely pyroxene phyric basalt, basaltic andesite and andesite flows within which there are local domes and complexes of aphyric to quartz phyric rhyolite. The Anderson felsic volcanic complex is the largest of the felsic units in the Welch Lake formation. The upper 500 m of the Welch Lake formation is typically pervasively silicified (Fig. GS-12-3); this zone of silicification has been followed for over 16 km along strike in the Snow Lake area.

In the Kormans Lake area the Welch Lake basaltic andesites and andesites display prominent domains of silicification, particularly in outcrops on the southeast limb of the F_1 fold. Where highly deformed, silicified basalts are difficult to distinguish from similar looking aphyric felsic volcanic rocks of the Anderson formation.

The degree of metamorphic recrystallization of Welch Lake formation mafic rocks increases to the north in the Kormans Lake area. Near the north boundary of the map area these rocks have been completely recrystallized to fine grained, massive, featureless amphibolites (unit 1a, d) that are virtually indistinguishable from spatially associated fine grained diorites (unit 17).

Porphyritic mafic flows (unit 6a)

The Welch Lake formation is overlain by a complex sequence that includes intercalated porphyritic mafic flows (unit 6a), mafic volcanic wacke (unit 12b), heterolithologic mafic breccia (unit 13b), and felsic volcanic rocks (units 10 and 11). The porphyritic mafic flows (unit 6a) are well exposed west of the Kormans Lake area, but only occur in a couple of isolated outcrops just north of Highway 393. In these outcrops, pillows and a flow-top autoclastic breccia are well preserved. This unit apparently pinches out along strike because it is not observed to the northeast or on the southeast limb of the F_1 fold structure.

A thick, gabbroic textured flow (unit 6d) is associated with the porphyritic flow in the Stall Lake area. This unit was not observed in the Kormans Lake area; if it were present it would be almost indistinguishable from the fine grained gabbro (unit 17) exposed along Highway 393.

Heterolithologic mafic breccia and mafic wacke (units 13 and 13b)

West of the Kormans Lake area heterolithologic mafic breccia (unit 13) and mafic wacke (unit 13b) occur as thick, lenticular, laterally discontinuous units intercalated within a dominantly felsic volcanic sequence (units 10 and 11); they are also locally intercalated with scoria tuff and tuff breccia (unit 12b). In the Kormans Lake area the strike length of these units is too short to observe their lensoid, discontinuous character. However, the absence of these units on the southeast limb of the F_1 fold suggests they pinch out to the northeast.

The Kormans Lake exposures of unit 13 consist largely of coarsely plagioclase phyric mafic fragments within a crystal-rich volcaniclastic matrix. This unit locally contains distinctive beds composed largely of popcorn-sized silicified scoria clasts. Small isolated expo-

Figure GS-12-3: Deformed and silicified, pillowed Welch Lake mafic flow north of Stall Lake mine.

sures of heterolithologic mafic breccia also occur in the Welch Lake formation.

Felsic volcanic rocks (units 10, 10c, 11a, c))

Felsic volcanic rocks (units 10 and 11a, c) occur throughout the sequence that overlies the Welch Lake formation (unit 1a), but are most abundant above the heterolithologic breccia (unit 13). Unit 10 consists of creamy white weathering, massive, aphyric, recrystallized fine grained felsic volcanic rocks that to the northeast become gneissic in appearance and contain scattered garnet porphyroblasts. Quartz phyric felsic breccia (unit 11a, c) is characterized by 5%, 1 to 2 mm quartz phenocrysts.

South and east of Kormans Lake felsic volcanic rocks (unit 10c) are featureless, massive, aphyric, recrystallized, leucocratic quartzofeldspathic rocks that contain ubiquitous fine grained biotite; many of them also have a gneissic appearance and contain garnet porphyroblasts. These rocks are considered to be the along strike equivalent of the felsic volcanic rocks that overlie unit 13 northeast of Highway 393. This implies that post-Welch Lake formations have changed along strike across the F_1 fold structure into a sequence dominated by felsic rocks. Unit 10c has no known associated base metal sulphide deposits or showings. However 100 m northeast of the north boundary of the map area, along the abandoned railway track, this unit contains a small Fe-Mg alteration zone that is associated with a larger area of rusty weathering.

Snow Creek basalt (unit 1)

Snow Creek basalt flows (unit 1) are characterized by uniform grey-green weathering, virtual absence of vesicles, thin selvages on pillows, gabbroic-textured massive flows and lack of epidozite alteration masses (a common feature in most basalt flows in the Snow Lake area). The Snow Creek basalt flows are also chemically distinct from other basalts in the Snow Lake area with signatures similar to that of back-arc basalts rather than the more typical arc tholeiite chemistry.

Gabbro, diorite (unit 17)

The Kormans Lake area contains numerous fine grained gabbro and diorite intrusions (units 17, 17a) that are locally difficult to separate from massive mafic flows. These bodies are generally semiconformable and have significant lateral continuity.

The largest of the gabbro bodies, located on the south shore of Kormans Lake, has a strike length of over 7 km, and extends an unknown distance beyond the north boundary of the map area. At its southwest end it is conformable with other units and has, in the past, been mapped as a massive mafic flow (Zaleski, 1989). In the area due south of Kormans Lake this body clearly intrudes felsic volcanic rocks (unit 10). At its southwest end it has an abrupt termination within 50 m of the Linda massive sulphide deposit, and cuts across altered rocks associated with this deposit. The gabbro is a fine grained, featureless rock that locally contains oval epidotized patches and invariably displays a prominent mineral lineation defined by amphibole.

The body of fine grained gabbro (unit 17) that runs parallel to Highway 393 is texturally similar to the Kormans Lake body and may be equivalent. This is supported by the fact that this sill-like intrusion is emplaced near the upper contact of the Welch Lake formation, the same stratigraphic interval occupied by the Kormans Lake body.

ROCKS BETWEEN BARTLETT FAULT AND WEKUSKO LAKE

Rocks south of the Bartlett fault are of uncertain stratigraphic affinity to those that occur to the northwest (Fig. GS-12-2). In broad terms they resemble the sequence of rocks that occurs north of Highway 393, and thus could be a faulted segment of the southeast limb of the F_1 fold. The units in this fault slice are truncated to the northeast, at a shallow angle, by the Berry Creek fault.

There are no reliable top indications in this succession of rocks, but some heterolithologic mafic breccia debris flow beds (unit 13) display poorly developed size grading to the southeast. A southeast facing direction is supported by the fact that some breccias in unit 13c contain clasts of felsic rocks of unit 11a, c (Zaleski, 1989). The sequence of units from southeast (top?) to northwest (base?) is:

Top (Berry Creek Fault)
Mafic tectonites (unit 4e)*
Fault
Felsic rocks (unit 11)
Aphyric mafic flows (unit 4b, c)
Felsic monolithologic breccia (unit 10b)
Heterolithologic mafic breccia and mafic wacke (units 13, 13b, 13a, c)
Felsic breccia (unit 11a, c)
Fault?
Metagreywacke (unit 15a)
Base (Bartlett Fault)

* Unit numbers refer to Preliminary Map 1992S-3

Metagreywacke (unit 15a)

Thin- to medium-bedded greywacke, siltstone and mudstone containing staurolite porphyroblasts (Fig. GS-12-4) outcrop south of the east end of Kormans Lake in a unit (15a) up to 75 m thick. This unit is the more highly metamorphosed equivalent of turbidites (unit 15)

Figure GS-12-4: Staurolite porphyroblastic metamudstones, southwest of Kormans Lake, affected by Z-asymmetrical F_2 folds.

that occur on Wekusko Lake south of the Berry Creek fault. Metamorphic recrystallization has commonly obscured graded bedding (characteristic in less metamorphosed turbidites), but tops are still locally preserved. The presence of both northwest- and southeast-topping beds in the metagreywackes indicates that unit 15a is isoclinally F_1 folded. In addition open, Z-asymmetrical, minor F_2 folds (Fig. GS-12-4) are common on most outcrops.

This thin sliver of metagreywacke clearly indicates the presence of a major fault along its northwest margin, a fact substantiated by drilling by HBED of a graphitic shear zone along this contact. This fault, known as the Bartlett fault, truncates gabbro intrusions (unit 17) to the northwest and juxtaposes them against metagreywacke that is completely devoid of any intrusive phases. The southeasterly extension of the Bartlett fault cuts through rocks in the immediate hanging wall to the Linda Cu-Zn massive sulphide deposit (Preliminary Map 1992S-3: Fig. GS-12-2). Although drill holes through this contact at the Linda deposit show no sign of this fault (Howard Stockford, pers com., 1992; Zaleski, 1989) shearing and carbonate alteration are observed in outcrops on Anderson Bay along the extension of the fault structure. The nature of the southeast boundary of the metagreywacke is uncertain, but it may also be a fault.

Staurolite porphyroblasts up to 30 mm, which are most abundant in mudstone beds in the greywacke, siltstone and mudstone (unit 15a) are present even in the most southerly exposures. This is significant because the first appearance of staurolite in the turbiditic greywacke, siltstone and mudstone (unit 15) on Wekusko Lake is at the extreme northeast end of Snow Bay. This indicates a sinistral component of offset of the metamorphic isograds by the Berry Creek fault, a direction of movement confirmed by kinematic indicators on the fault.

Felsic breccia (unit 11a, c)

Immediately southeast of the metagreywacke (unit 15a) is a 75 m thick unit of felsic quartz megacrystic breccia (unit 11a, c). The breccia is characterized by coarsely quartz phyric felsic clasts. The fragments and the matrix typically contain 10 to 15%, 3 to 10 mm quartz phenocrysts and phenoclasts. Some fragments look identical to the quartz phyric phase (unit 16b) of the Sneath Lake tonalite. Where least deformed the breccia is clearly heterolithologic. The presence of possible Sneath Lake tonalite fragments in this breccia strongly suggests that this unit, and the sequence it occurs in, are related to the Anderson Lake and Stall Lake volcanic sequence, in which the Sneath Lake pluton occurs.

Heterolithologic mafic breccia and mafic wacke (units 13, 13b, 13a, c)

A 100 m thick unit of heterolithologic mafic breccia (unit 13) outcrops southeast of the felsic breccia (unit 11a, c). In the Kormans Lake area the lower one third of this unit (13a, c) contains up to 10% quartz megacrystic felsic fragments, similar to the underlying felsic breccia (unit 11a, c); it also contains some fragments of quartz megacrystic tonalite that are texturally indistinguishable from, and likely derived from, the Sneath Lake pluton (Fig. GS-12-5). Up to 25 m of mafic wacke (unit 13b) is present at the base of the heterolithologic mafic breccia in exposures north of the road that runs southeast of the Rod mine site to Wekusko Lake.

The heterolithologic breccia contains a wide variety of 1 to 10 cm, angular to subangular, matrix-supported mafic fragments. The breccias are dominated by plagioclase phyric mafic volcanic clasts, with less common aphyric mafic volcanic fragments and rare aphyric and porphyritic felsic volcanic clasts. Clast size grading is common, but bed contacts are only rarely exposed. Southeast tops based on size grading is indicated where complete beds have been observed. On many outcrops a combination of extremely poor exposure and strong metamorphic recrystallization has completely obscured the fragmental character of the rocks. These rocks are distinguished from unit 4b aphyric mafic rocks by their plagioclase phyric character.

Felsic monolithologic breccia (unit 10b)

Up to 30 m of pale buff weathering, monolithologic, felsic breccia (unit 10b) overlies the heterolithologic mafic breccia (unit 13). Fragments in this unit are strongly deformed and cigar shaped. The interfragment matrix is foliated with 5 to 7% biotite and locally up to 8% garnet and actinolite porphyroblasts.

Aphyric mafic flows (unit 4b, c)

This 75 m thick unit consists of fine grained aphyric mafic rocks that locally have a gabbroic texture. Generally these rocks are massive and featureless, but locally they contain a few quartz amygdales. Southwest of the Kormans Lake area this unit locally contains amoeboid pillow breccia that attests to its extrusive nature.

This basalt was tentatively correlated with the Snow Creek basalt that occurs in a similar but northwest-facing sequence of rocks north of Highway 393 (Bailes and Galley, 1991). However, the two basalts have distinctly different chemistry; the Snow Creek basalt has higher rare earth (REE) element contents and higher Ni and Cr. The

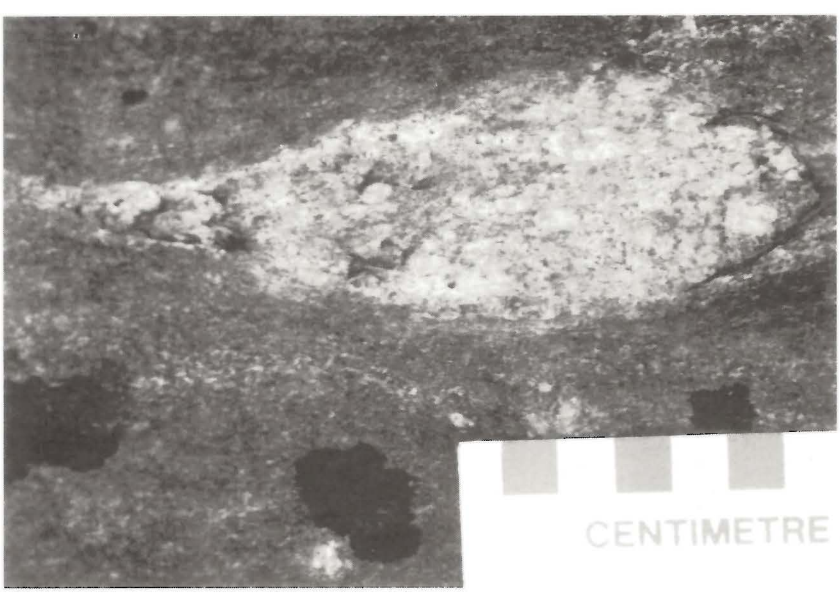


Figure GS-12-5: Cobble of quartz megacrystic tonalite in heterolithologic mafic breccia southwest of Kormans Lake. Cobble is similar to one of the phases of the Sneath Lake tonalite.

high Ni and Cr values of the Snow Creek basalt distinguishes this basalt from all others in the Snow Lake area.

Mafic tectonites (unit 4e)

A series of strongly foliated mafic to intermediate rocks, overgrown by 1 to 4 mm actinolite porphyroblasts, outcrops along much of the Wekusko Lake shoreline in the Kormans Lake area. These strongly deformed rocks are characterized by discontinuous layering, interpreted as tectonic in origin, and by tectonic breccias. The most recognizable tectonic breccias contain 20 to 30%, 2 to 3 cm disaggregated boudins of quartz vein material. The proximity of these tectonites (unit 4e) to the Berry Creek fault suggests that there may have been premetamorphic movement on this fault.

STRUCTURE

The volcanic rocks of the Anderson Lake, Stall Lake and Kormans Lake area are bounded by the Berry Creek fault on the south, and the Snow Lake fault on the north (Fig. GS-12-2). The Berry Creek and Snow Lake faults have postmetamorphic offsets. The Berry Creek fault includes a sinistral component of offset of the staurolite-forming isograd reaction in units 15 and 15a. The Snow Lake fault offsets the aluminosilicate-forming isograd reaction. Altered volcanic rocks south of the Snow Lake fault contain kyanite whereas the greywacke, siltstone and mudstone sequence (unit 15a) contains no aluminosilicate until 5 km north of the fault (Froese and Moore, 1980). Sillimanite is the aluminosilicate present in the greywacke north of the fault. This suggests not only an offset of the paleo-isotherm, but that the northern fault slice may have formed under a slightly different P-T regime.

Numerous faults occur in the Snow Lake area, in addition to the Berry Creek and Snow Lake faults. They vary from prominent (McLeod Road fault, Bartlett fault) to minor ductile shears that cross the Sneath Lake pluton. These faults range from pre-, syn- to late-metamorphic, overprinted by metamorphic porphyroblasts, to later postmetamorphic brittle structures that in some instances include pseudotachylyte. Many of the fault structures appear to merge at Bart Lake, 1.7 km northeast of Kormans Lake. This makes Bart Lake a key area because it is also the probable hinge area for the northeast-trending major F_1 antiformal structure. This raises questions regarding the interplay between the folding and faulting. For example, do the faults postdate F_1 folding and simply truncate and offset the hinge area of this structure or are some faults early structures that developed in association with, or are even folded by the F_1 fold structure? Resolution of this issue is complicated by the fact that some of the early faults may have been reactivated during later deformation.

One of the keys to unravelling the structure of the Kormans Lake and Barts Lake area lies in several structural slivers of metagreywacke (unit 15a). Initial examination of these slivers suggests that they are themselves F_1 isoclinally folded as they display variable facing directions (J. Krause, 1992, pers com.). They also appear to be out of stratigraphic position and this suggests that they are fault bounded. The most likely interpretation is that the slivers of greywacke are fault slices produced by postmetamorphic fault movements, but there is a possibility that they could be tight F_1 fold keels with a thrust faulted base. Zaleski and Halden (unpublished paper, 1990) have suggested that the McLeod Road fault may have been folded by the F_1 fold and repeated on the south side of the greywacke sliver southwest of Kormans Lake.

F_2 folds are prominent in all rocks of the Kormans Lake area that contain a prominent S_1 schistosity. These folds are invariably Z-asymmetrical; this suggests that they are developed on the northwest limb of a major F_2 antiform. A similar Z-asymmetrical geometry of F_2 folds was observed in greywackes on Snow Bay, south of the Berry Creek fault (GS-11, this volume).

ECONOMIC GEOLOGY

The main objective of mapping the Kormans Lake area was to establish the control of major structures on the disposition of base metal-hosting formations at this locality. The first objective was to determine whether a major northeast-trending F_1 fold had affected rocks at Kormans Lake. A subsidiary objective was to determine if the area is crosscut by major faults that could offset formations that host base metal deposits. The presence of either structure has significant implications, not only for base metal potential at Kormans Lake, but also in adjacent areas.

Distribution of major lithologies in the Kormans Lake area clearly supports the presence of a large northeast-trending F_1 fold (Fig. GS-12-2). The significance of this fold structure to base metal exploration in the Kormans Lake area is that the base metal-hosting Anderson felsic volcanic rocks are exposed in a fold nose and are folded back on themselves toward the Linda deposit. A corollary of this is that any structural thickening of associated sulphides in the F_1 fold nose would make this structure a viable exploration target. The other implication for the Kormans Lake area is that, although there are considerable felsic volcanic rocks in the area, most correlate with felsic volcanics of the stratigraphic hanging wall that, to date, have no associated base metal deposits.

On a regional scale the presence of a major F_1 fold at Kormans Lake means that the base-metal hosting Anderson felsic volcanic succession is repeated south of the Sneath Lake pluton. This implies that all felsic volcanic units exposed south of the pluton, in the area between Tramping Lake and Morgan Lake, deserve attention as possible exploration targets.

Faults also appear to play a role in offsetting base metal-hosting strata, although the implications of this to locating new areas with base metal potential are not apparent. The clearest example of a fault affecting a base metal deposit is the Bartlett fault located just south of the Linda deposit (Fig. GS-12-2). This fault was identified in the Kormans Lake area and traced to the south, parallel to stratigraphy. It is not clear whether the offset is regionally significant, but it could have implications for exploration on the Linda property.

REFERENCES

Bailes, A.H.

1986: Chisel-Morgan Lakes project; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1986, p. 70-76.

1987: Silicification, Fe-Mg metasomatism and synvolcanic plutonism, Snow Lake, Manitoba; Geological Association of Canada-Mineralogical Association of Canada, Joint Annual Meeting, Program with Abstracts, v. 12, p. 22.

Bailes, A.H., Gordon, T.M. and Hunt, P.A.

1988: U-Pb geochronology of the Richard Lake tonalite, a possible synvolcanic pluton in the Snow Lake area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 63-65.

Bailes, A.H. and Galley, A.G.

1989: Geological setting of and hydrothermal alteration below the Chisel Lake massive Zn-Cu sulphide deposit; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989, p. 31-37.

1991: Geological setting of base metal mineralization in the Anderson Lake area (NTS 63K/16SE and 63J/13SW); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 8-13.

Bailes, A.H., Hunt, P.A. and Gordon, T.M.

1991: U-Pb zircon dating of possible synvolcanic plutons in the Flin Flon belt at Snow Lake, Manitoba; Geological Survey of Canada, Radiogenic age and isotopic studies Report 4, p. 35-43.

Coats, C.J.A., Clark, L.A., Buchan, R. and Brummer, J.J.

1970: Geology of the Copper-Zinc deposits of Stall Lake Mines Ltd., Snow Lake area, N. Manitoba; Economic Geology, vol. 65, p. 970-984.

Froese, E., and Moore, J.M.
1980: Metamorphism in the Snow Lake area, Manitoba, Geological Survey of Canada, Paper 78-27, 16p.

Gordon, T.M., Hunt, P.A., Bailes, A.H., and Syme, E.C.
1990: U-Pb zircon ages from the Flin Flon and Kisseynew belts, Manitoba: Chronology of crust formation at an Early Proterozoic accretionary margin, **in** Lewry, J.F. and Stauffer, M.R., eds., The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 177-199.

Jeffrey, B.D.
1982: Evaluation Report, Corporation Falconbridge Copper. Linda-McKayseff properties, Snow Lake, Manitoba, unpublished, 41p.

Machado, N. and David, J.
1991: U-Pb geochronology of the Reindeer-Superior transition zone and of the Snow Lake area: preliminary results; Lithoprobe Trans-Hudson Orogen Transect, Report No. 26, p. 40-42.

Stern, R.A., Syme, E.C., Bailes, A.H., Galley, A.G., Thomas, D.J., and Lucas, S.B.
1992: Nd-isotopic stratigraphy of the Early Proterozoic Amisk Group metavolcanic rocks from the Flin Flon belt; **in** Radiogenic Age and Isotopic Studies: Report 5, Geological Survey of Canada, in press.

Walford, P.C. and Franklin, J.M.
1982: The Anderson Lake Mine, Snow Lake, Manitoba; **in** R.W. Hutchinson, C.D. Spence and J.M. Franklin, eds., Precambrian Sulphide Deposits; Geological Association of Canada, Special Paper 25, p. 481-523.

Zaleski, E.
1989: Metamorphism, structure and petrogenesis of the Linda massive sulphide deposit, Snow Lake, Manitoba, Canada; University of Manitoba, Ph.D. Thesis (unpublished), 344p.

Zaleski, E. and Halden, N.M.
1990: Microstructures in porphyroblastic schists at the Linda deposit, Snow Lake, Canada, unpublished paper.

GS-13 GEOLOGICAL INVESTIGATIONS IN THE SOUTHWEST WEKUSKO LAKE AREA (NTS 63J/12)

by H. Paul Gilbert

Gilbert, H.P., 1992: Geological investigations in the southwest Wekusko Lake area (NTS 63J/12); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 75-83.

INTRODUCTION

A detailed geological mapping program was initiated in the Snow Lake area by Manitoba Energy and Mines in 1985 (Bailes, 1985). Most of the supracrustal rocks in the vicinity of Snow Lake have since been mapped at a scale of 1:20 000 or better. Extensive forest fires in the summer of 1989 resulted in an increase in the amount and quality of bedrock exposure in many areas, including the area directly west of Wekusko Lake.

The area to be mapped in southwest Wekusko Lake extends from the south extremity of the lake north to latitude 54° 45', and west to longitude 100° 00'. The project was initiated in May, 1992 in response to the continuing need for detailed geological information in all parts of the Snow Lake greenstone belt, to support exploration for economic mineral deposits upon which the future of Snow Lake depends. This project extends the area of new detailed mapping south from the previous limit (Preliminary Map 1991S-1). Several other factors have contributed to the establishment of the current project:

(a) the improved quality of rock outcrop following the 1989 forest fires; this enhancement will diminish within a few years as the forest and lichen become re-established;
(b) the presence of base metal mineralization in the area, near the south end of Wekusko Lake (Copper-Man Mines Ltd., *et al.*); and
(c) the presence of a significant amount of rhyolite, which is a conspicuous lithology in most base metal mines in the district (A.H.Bailes, unpublished data).

A 4-week field season was conducted in June and July, during which detailed mapping was carried out east of Goose Bay (Fig. GS-13-1), and a limited amount of reconnaissance was undertaken in the west and southeast parts of the project area. Field mapping will continue in the summer of 1993. The project area is within a region of

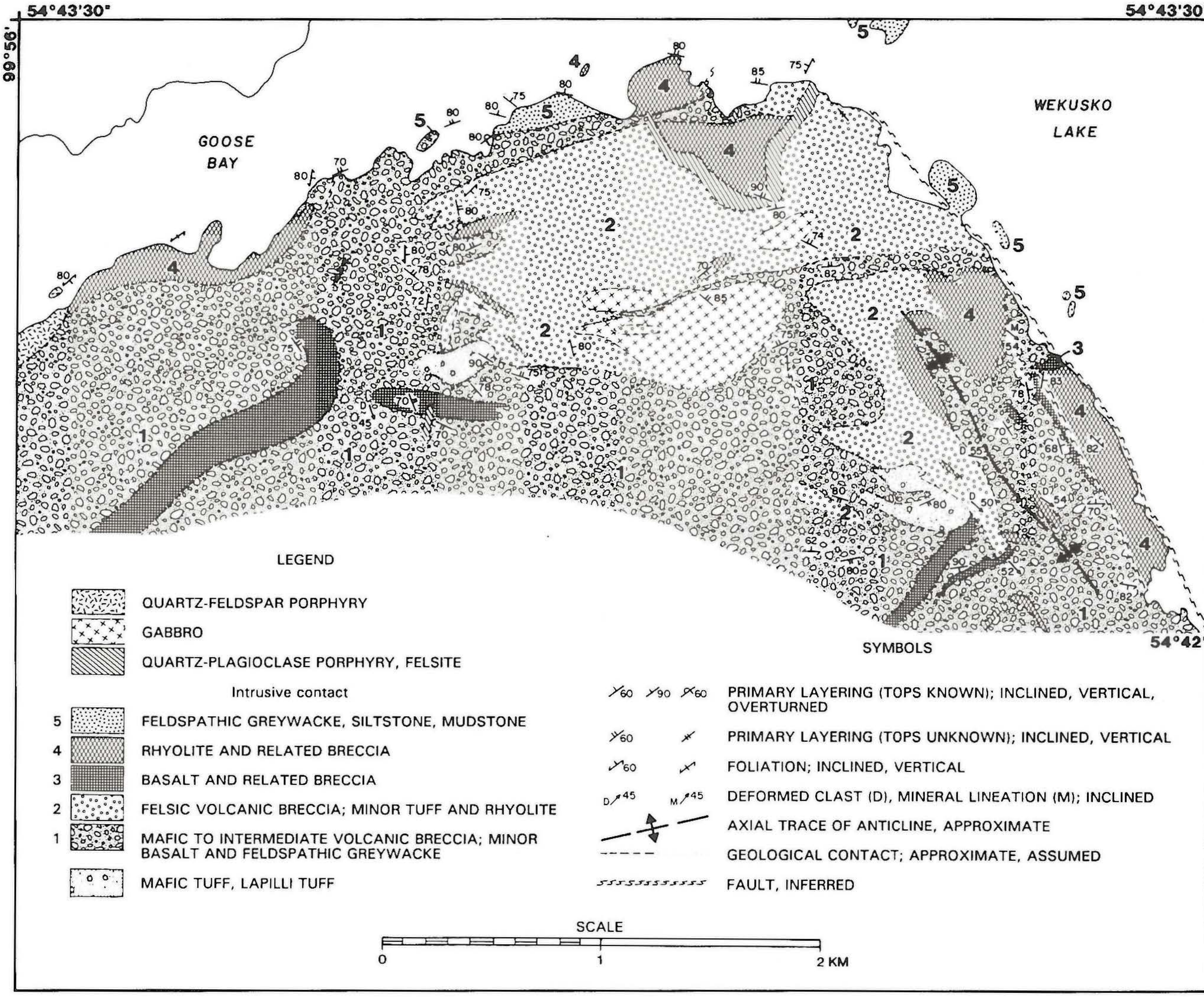


Figure GS-13-1: Geological map of the north-central part of the southwest Wekusko Lake project area.

current active diamond exploration ("Orapro, Shannon seek Manitoba diamonds"; Northern Miner, July 13, 1992).

The objectives of the project are:

(a) to provide a detailed 1:20 000 geological map of supracrustal rocks in the area;
(b) to investigate the geochemistry of Amisk Group volcanic rocks with a view to their origin and economic potential, and to integrate this information with the existing geochemical database in the Flin Flon-Snow Lake greenstone belt;
(c) to study the structural and metamorphic history of the area; and
(d) to investigate all occurrences of mineralization with a view to their economic potential.

STRATIGRAPHY

Mafic to intermediate volcanic breccia; minor tuff, basalt and feldspathic greywacke (1, Fig. GS-13-1)

Mafic to intermediate volcaniclastic rocks (unit 1, Table GS-13-1) are the most abundant rock types, and constitute at least 25% of the mapped area. These rocks are locally intercalated with massive to pillowed basalt flows and related breccias, with which they are partly gradational, and feldspathic greywacke. The volcaniclastic rocks (1) are interpreted to be debris flows derived from penecontemporaneous extrusive rocks. The available data indicate unit 1 is at least 0.5 km thick

Table GS-13-1
Stratigraphic units in the southwest Wekusko Lake area

Thickness	Unit number	Lithology
>500 m	5	Feldspathic greywacke, siltstone, mudstone
200 m	4	Rhyolite and related breccia
50 m	3	Basalt and related breccia
>300 m	2	Felsic volcanic breccia; minor tuff and rhyolite
>500 m	1	Mafic to intermediate volcanic breccia; minor tuff, basalt and feldspathic greywacke

Mafic to intermediate volcanic breccia (1) is typically heterolithic, and contains mafic to felsic fragments that display various textures (aphyric or porphyritic; amygdaloidal; and rarely, flow banded). Mafic fragments are generally predominant and compose 30 to 75% of the fragment population; some breccia units are essentially mafic, monolithic, with only sporadic felsic fragments (<3%). Rare, quartz-eye tonalite and coarse quartz-feldspar porphyry blocks occur, together with a wide range of volcanic types, in a >60 m thick intermediate breccia unit in the southeast part of the mapped area; these fragments are interpreted to be derived from synvolcanic intrusions. Rare large blocks (0.5-1 m) of intermediate volcanic breccia occur in several deposits of unit 1 breccia; at one locality in the west part of the mapped area, a 30 x 9 m enclave of massive and fragmental rhyolite has been incorporated into breccia (1) that is interpreted to be an avalanche deposit.

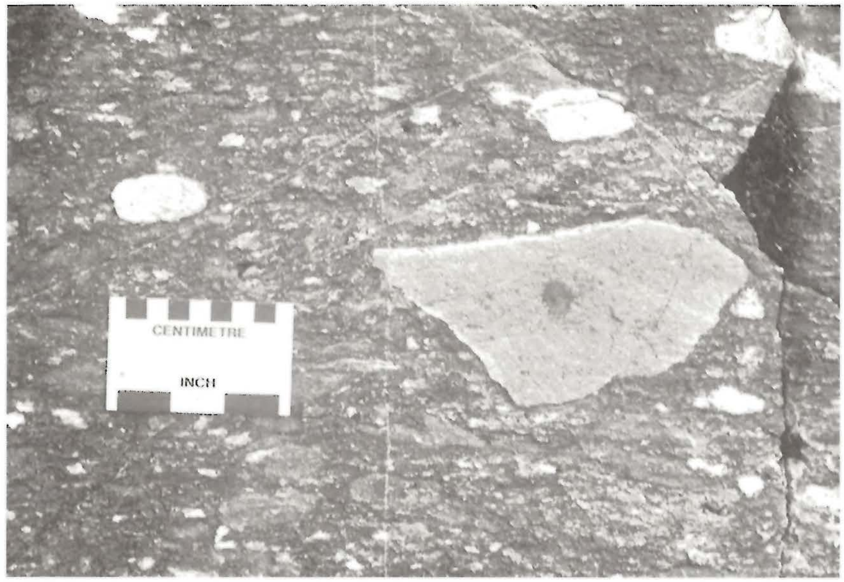
Fragments are mostly angular to subangular (locally subrounded) and unsorted; they constitute 35 to 75% of the breccia and are generally 1 to 15 cm in diameter, with sporadic blocks up to 30 x 20 cm. At the south end of Wekusko Lake, the breccia is unusually coarse (Fig. GS-13-2). Tabular to crescentic fragments may be derived from the chilled margins of cooling mafic flows or pillows. Some fragments are characterized by pale altered rims (Fig. GS-13-3) that are truncated in broken fragments, suggesting alteration preceded, or was contemporaneous with deposition of the breccia. The compositional diversity of fragments in unit 1 breccia is attributed, in part, to early localized silicification of the mafic extrusive rocks inferred to be the main source of the material contained in the debris flows. Postdepositional alteration includes further silicification, which was initiated in the cores of fragments in some units. This alteration is locally pervasive through the breccia, and associated with feldspathization (Fig. GS-13-4). The breccia matrix has been selectively carbonatized in several units.

Most mafic to intermediate volcaniclastic rocks (1) are poorly sorted to unsorted; some units display 1 to 5 m thick layers defined by variable clast size or type. Finer layering (0.1-1 m) is displayed in several 1 to 30 m thick volcaniclastic units that alternate with mafic flows in the southeast part of the mapped area. These units are characterized by reverse to normal grading, with the largest fragments located in the central parts of the beds, and thinly laminated upper zones (2-15 cm). Several massive unsorted breccia deposits (1) contain zones (8-15 cm wide) characterized by relatively small fragments, less than 4 cm in diameter, and diffuse lamination (Fig. GS-13-5). These zones extend laterally for several metres, and are interpreted to be the result of differential movement within the breccia during emplacement by mass flow.

A 120 m thick unit of mafic tuff and lapilli tuff occurs in the inferred upper part of unit 1, where it is overlain by felsic volcaniclastic rocks (2) in the southeast part of the mapped area. The mafic tuff is medium to dark green, very fine- to fine-grained, or medium grained with lithic granules. This lithology is gradational to mafic, monolithic

Figure GS-13-2: Heterolithic volcanic breccia (1) with unsorted, mafic to felsic lapilli and blocks.

Figure GS-13-3: *Mafic to intermediate volcanic breccia (1) that contains an angular block with pale, altered rims.*



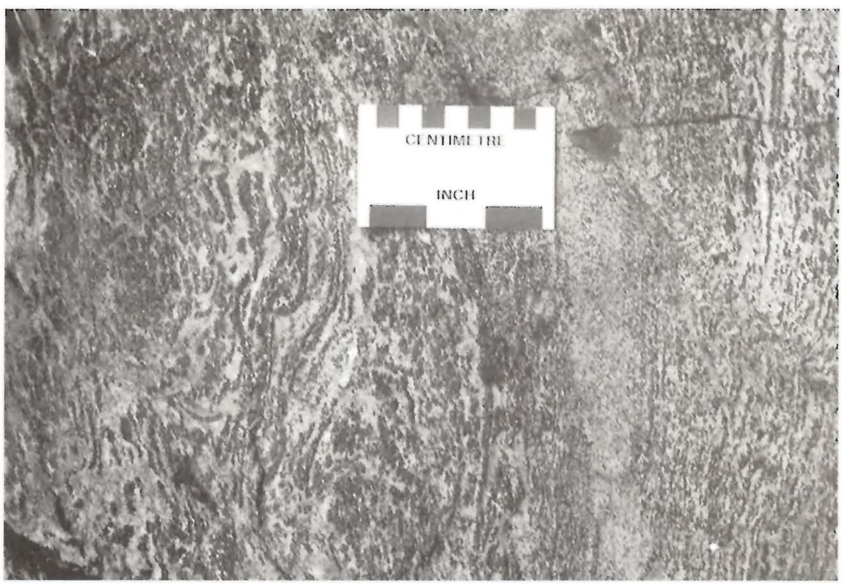


Figure GS-13-4: *Mafic to intermediate volcanic breccia (1), attenuated and pervasively altered.*

Figure GS-13-5: *Narrow, partly laminated tuffaceous zone within mafic volcanic breccia (1), attributed to differential movement and granulation during mass flow.*

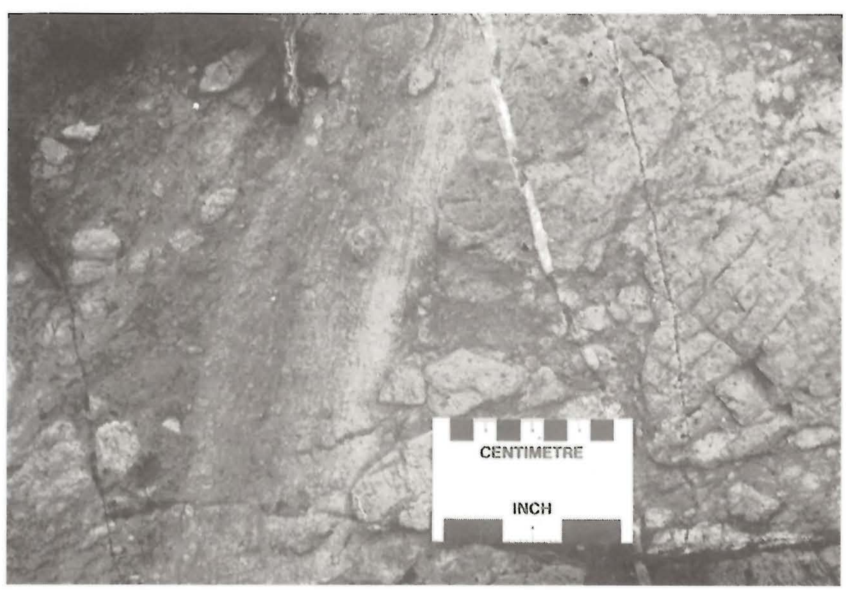


Figure GS-13-6: *Massive mafic tuff with quartz-plagioclase porphyry dyke, partly disrupted by inferred mass flow.*

lapilli tuff with subangular to subrounded fragments. The tuff is massive to finely layered (0.5-15 cm laminae), and locally contains minor plagioclase phenoclasts, and/or stratabound actinolite porphyroblasts. Synvolcanic quartz-plagioclase porphyry dykes in the tuff have been partly disrupted (Fig. GS-13-6); lateral gradation of massive dykes into zones of derived felsic fragments suggests the disruption is due to mass flow prior to consolidation of the host rock.

Felsic volcanic breccia; minor tuff and rhyolite (2, Fig. GS-13-1)

Felsic volcaniclastic rocks (2) and associated minor rhyolite flows compose approximately 10% of the mapped area. These units are 5 m to over 100 m thick, and are distinguished from rhyolite flow-breccia (4) by their heterolithic composition, localized crude sorting and layering, and stratigraphic relationships. The felsic volcaniclastic rocks (2) mainly overlie mafic to intermediate fragmental rocks (1), and are locally intercalated with the latter. Both units 1 and 2 are interpreted as mass flows.

Fragments in felsic volcanic breccia are mostly angular to subrounded felsic lapilli and blocks that display the same range of textures noted in unit 4 rhyolite (described below), *i.e.* porphyritic, vesicular and flow banded (Fig. GS-13-7). Magnetite is conspicuous in some fragments. Felsic fragments typically compose 40 to 65% of the breccia (2), and subordinate mafic to intermediate fragments constitute 5 to 10%, locally up to 20% of the rock. The matrix is generally felsic, with plagioclase and/or quartz phenoclasts (1-3 mm, up to 30% of the breccia). Sporadic, ovoid to amoeboid rhyolite lobes up to 75 cm long (Fig. GS-13-8), and elongate screens of massive rhyolite suggest the breccia is derived, in part, by mass flow of partly consolidated autoclastic breccia at the margins of rhyolite flows. Blocks of autoclastic breccia (4) have locally been incorporated into a unit of felsic volcanic breccia (2) in the west part of the mapped area. Diffuse mafic stringers in one unit are interpreted to be the result of internal movement during emplacement of the breccia.

Felsic volcanic breccia is unsorted or poorly sorted, with >1 m thick breccia layers, locally intercalated with subordinate, 2 to 30 cm felsic tuff and lapilli tuff layers that compose up to 15% of the breccia units. Grading occurs locally toward the margins of felsic volcanic breccia (2). In the southeast part of the mapped area, a 25 m thick felsic tuff unit (2) contains 5 to 15% rhyolite lapilli in layers up to 1 m thick; these layers are graded (reverse to normal), and the top 10 cm of the tuff unit is finely laminated. Calc-silicate metasomatism was locally pervasive in this area, where felsic volcaniclastic rocks contain up to 70% actinolite in irregular zones.

Figure GS-13-7: *Contorted flow lamination in a block of porphyritic rhyolite, in felsic volcanic breccia (2).*

Figure GS-13-8: Amoeboid rhyolite lobe within a felsic debris flow (2), probably derived from the breccia facies at the front of a felsic flow.

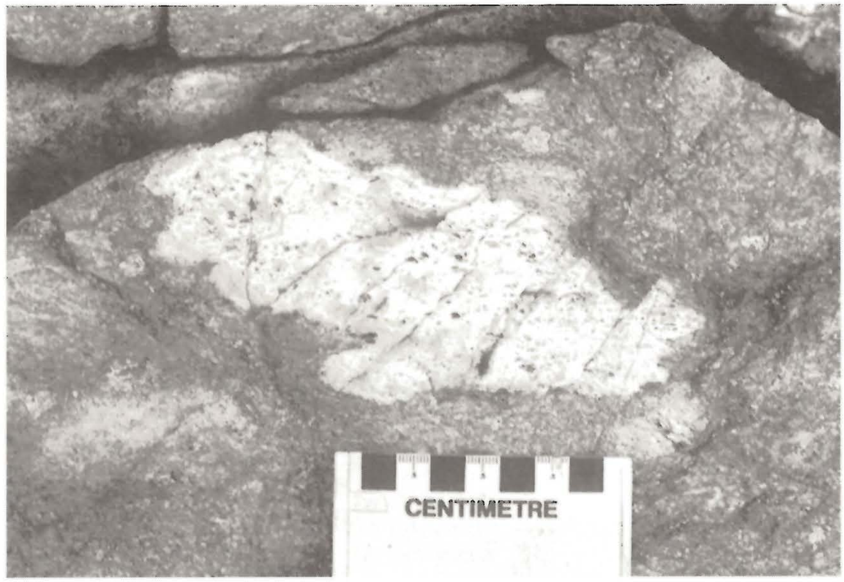


Figure GS-13-9: Isolated pillow breccia close to the top of a basalt flow; both the matrix and the ovoid to amoeboid pillows have been partly silicified.

Basalt and related breccia (3, Fig. GS-13-1)

A 50 m thick basalt unit (3) occurs between mafic to felsic volcaniclastic rocks (1, 2) and rhyolite (4) in the southeast part of the mapped area; similar basalt units (3 to 75 m thick) occur within unit 1 in the same area, and to the west. Basalt is aphyric to sparsely porphyritic, with up to 10% plagioclase and pyroxene phenocrysts (altered to hornblende). Amygdales of quartz, plagioclase, hornblende and (less common) carbonate locally constitute up to 15% of basalt. Amygdales are most abundant toward the margins of mafic flows. Polygonal cooling fractures (10-25 cm polygons) and zones of parallel cooling fractures (defined by wispy epidotic stringers spaced at 5-20 mm) occur in one massive unit. Rare flow lamination was also observed. Some basalt flows are pillowed, but facing directions could not be determined from the pillows.

Basaltic flow breccia constitutes over half of a 50 m thick basalt unit in the southeast part of the mapped area (Table GS-13-2), but generally breccia is a minor component of mafic flow units. Flow breccia is typically 1 to 8 m thick and matrix supported, with 20 to 60% fragments; the breccia commonly occurs at or near the top of flows. Isolated pillow breccia was observed near the top of one unit (Fig. GS-13-9). Silicification and carbonatization are locally pervasive in basalt and result in pale green to grey weathering. Alteration is commonly localized in the upper parts of mafic flows. Flow breccia contains variably altered fragments that range from dark green to white (silicified), suggesting that alteration was penecontemporaneous with volcanism. The matrix of some breccia units is selectively carbonatized. Epidotic alteration in irregular zones, sporadic epidosite bodies and epidotic stringers occur locally in basalt.

Table GS-13-2
Vertical section (SW-NE) through a 50 m thick basalt unit (3) in the southeast part of the mapped area

NORTHEAST (Top)

Thickness	Lithology
200 m	RHYOLITE AND RELATED BRECCIA
(12 m	~~~ no outcrop ~~~)
5 m	MASSIVE BASALT
10 m	CARBONATIZED AND SILICIFIED MASSIVE BASALT AND BRECCIA
6 m	MASSIVE BASALT AND BRECCIA
6 m	AMOEBOID PILLOW BRECCIA
15 m	FLOW BRECCIA AND SUBORDINATE MASSIVE BASALT
15 m	MASSIVE BASALT
2 m	QUARTZ OR CARBONATE AMYGDALOIDAL, SPARSELY PYROXENE PHYRIC BASALT
0.15 m	VERY FINE GRAINED AMPHIBOLITE WITH ALTERNATING FELDSPATHIC AND HORNBLENDIC LAMINAE
>25 m	FELSIC VOLCANIC BRECCIA (DEBRIS FLOW)

SOUTHWEST

Figure GS-13-10: Part of a rhyolite lobe at the brecciated margin of a rhyolite flow; note spalling of fragments at the highly irregular margins of the lobe.

Rhyolite and related breccia (4, Fig. GS-13-1)

A 200 m thick rhyolite unit (4) extends along the shore of Wekusko Lake at the east end of Goose Bay, and in the southeast part of the mapped area, where a northwest-trending fault is inferred to truncate the felsic unit. Minor felsic flows (5-50 m thick) also occur within mafic to intermediate volcaniclastic rocks (1) and felsic volcaniclastic rocks (2) in the central part of the mapped area. Felsic volcanic rocks include massive and fragmental (autoclastic) types, typically intercalated and gradational within the same unit.

A homogeneous massive rhyolite zone over 90 m wide occurs in the felsic volcanic unit in the southeast part of the mapped area. The rhyolite is white to pale beige-grey weathering, locally pale blue-grey or green-grey. Sheared rhyolite is yellow due to secondary sericite and epidote. Rhyolite is generally quartz- and plagioclase-phyric (0.5-3 mm phenocrysts, 5-20% of the rock), and is commonly amygdaloidal, with carbonaceous or micaceous amygdales (1-2 mm, 10% of the rock). Flow lamination (1 to 3 mm) occurs locally toward the margins of flows or rhyolite lobes within felsic breccia. Diffuse, dark contamination streaks, and anastomosing micaceous fractures due to cataclasis, are common in massive rhyolite.

Rhyolite breccia consists of angular to ovoid felsic lapilli and blocks, and quartz and plagioclase phenoclasts in a fine- to coarse-grained rhyolitic matrix. The breccia is unsorted and matrix supported; contacts with massive flows are sharp or gradational through zones of *in situ* brecciated rhyolite. The felsic volcanic unit in the north-central part of the mapped area is characterized by alternating layers (0.5-2 m thick) of massive and fragmental rhyolite, and also contains thicker breccia units (up to 20 m). Ovoid lenses and irregular, amoeboid lobes of rhyolite are common in felsic breccia. In the west-central part of the mapped area, rhyolite breccia with large (>2 m) lobes occurs at the southeast margin of a massive flow (Fig. GS-13-10); the breccia is attributed to fragmentation of the flow front, suggesting a southeast flow direction. The ovoid, irregular shape of large felsic lenses and lobes indicates they were still hot and plastic after detachment from the flow, in contrast to smaller angular blocks, and fragments spalled off the chilled margin that constitute the breccia matrix.

Feldspathic greywacke, siltstone, mudstone (5, Fig. GS-13-1)

Volcanic-derived sedimentary rocks (5) extend along the shore of southwest Wekusko Lake, and further north into the north part of the lake (Preliminary Map 1991S-1). This unit is at least 0.5 km thick, and is interpreted to overlie felsic volcanic rocks (4), but contact relationships have not been observed. The well layered feldspathic greywacke, siltstone and mudstone (5) display many features diagnostic of turbidites, and mark an abrupt change of facies type from the underlying sequence of volcanic debris flows intercalated with mafic and felsic lavas (1 to 4).

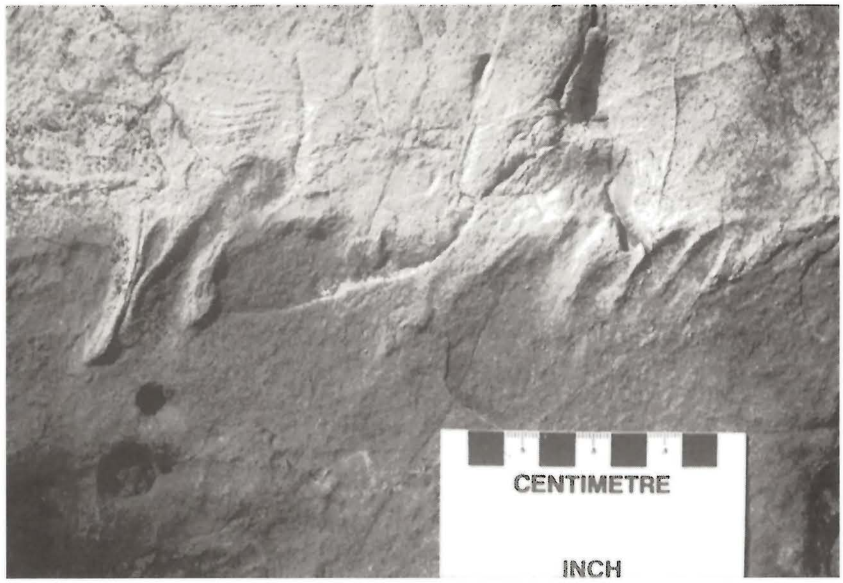
Unit 5 sedimentary rocks display rhythmic layering at a scale of 0.1 to 4 m. Medium- to coarse-grained greywacke (Bouma division A) is locally scoured into the underlying bed. Normal graded bedding occurs locally in the lower and upper parts of turbidite units.

Less commonly, reverse grading occurs in the basal 20 to 30 cm of turbidites; some units also contain sporadic pebbles 0.5 to 1 m above the base. A 25 cm thick zone of basalt pebble conglomerate represents division A in one turbidite unit. Sporadic angular to tabular siltstone rip-ups, up to 0.4 m long, occur locally in division A. Fine lamination (1-10 mm) is typical of the upper felsic to mafic siltstone or mudstone division (E). Thin (3 cm) carbonate-rich laminae and/or carbonate porphyroblasts occur in some units.

Syndepositional slump folds and minor faults, flame structures (Fig. GS-13-11), and rare ball and pillow structure are locally characteristic of the turbidites. Sandstone dykes up to 20 cm thick, roughly normal to bedding, are emplaced in sedimentary rocks (5) near the east end of Goose Bay (Fig. GS-13-1 and GS-13-12).

Subordinate greywacke-siltstone turbidite units occur locally within mafic to intermediate debris flows (1). These minor units (<3% of the total amount of unit 1) display scour, flame structure, and disrupted bedding with load casts (Fig. GS-13-13).

Figure GS-13-11: Flame structures in greywacke-siltstone turbidite (5).



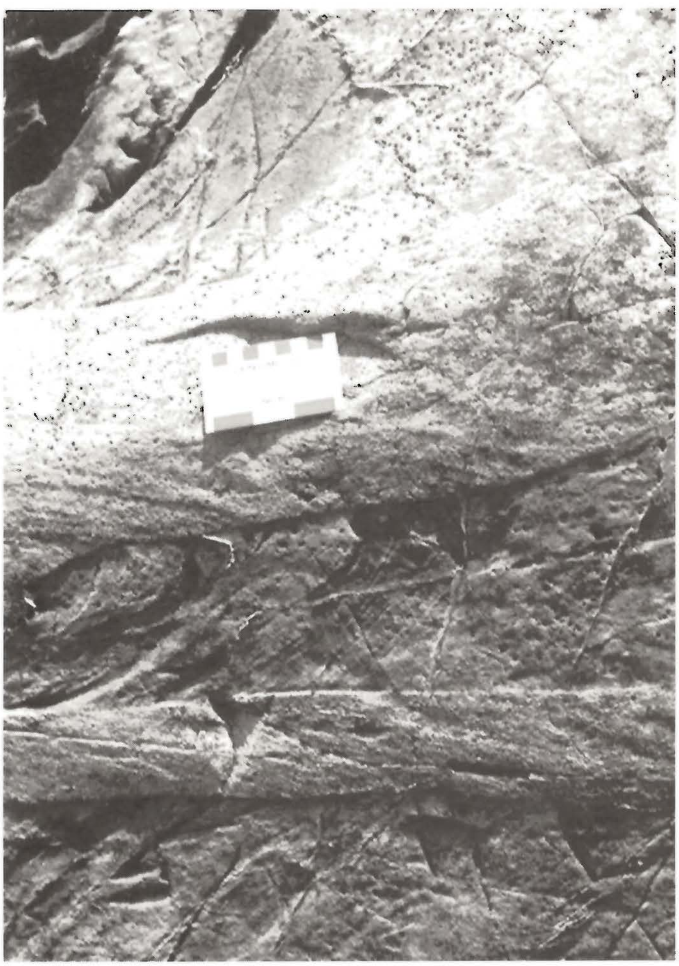


Figure GS-13-12: Sandstone dykes in greywacke-siltstone turbidite (5).

INTRUSIVE ROCKS

A small gabbro stock was emplaced in volcaniclastic rocks (1, 2) in the centre of the mapped area. The gabbro is massive, medium grained and equigranular; porphyritic gabbro at the margin of the intrusion contains up to 20% subhedral hornblende crystals. Minor diabase dykes also occur at the gabbro margin.

Leucocratic to melanocratic gabbro intruded mafic volcanic rocks 4 km south of the west end of Goose Bay, at the inferred contact between Amisk Group supracrustal rocks to the east, and plutonic rocks to the west (Armstrong, 1939). Medium- to coarse-grained leucogabbro locally contains 5 to 10% pyroxene oikocrysts. Coarsely porphyritic gabbro occurs at a roadcut 2 km north of the junction between PR 391 and 392; plagioclase phenocrysts up to 5 x 2 cm compose 40 to 65% of the rock. This phase is intruded by younger equigranular gabbro. Medium grained gabbro to hornblendite, locally with subhedral hornblende up to 3 cm, occurs at the same locality. The gabbroic intrusions contain up to 5% partly assimilated basalt xenoliths and less common felsic xenoliths. Minor intrusions in the same area include intermediate feldspar porphyry, quartz diorite, leucotonalite and granodiorite, and diabase; quartz veins are prominent at a few localities.

An elongate, northeast-trending quartz-feldspar porphyry intrusion extends along the south shore of Goose Bay (Armstrong, 1939). The rock is medium grained, massive to slightly foliated and contains 4 mm quartz and 2 mm plagioclase phenocrysts (20% and 10% of the rock, respectively).

A 60 m wide quartz-plagioclase porphyry dyke, inferred to be synvolcanic, is emplaced in felsic fragmental rocks (2) in the north part of the mapped area (Fig. GS-13-1). The dyke is lithologically similar to porphyritic rhyolite (4), and is distinguished from the feldspar porphyry sill at Goose Bay by finer grained phenocrysts and matrix. Similar synvolcanic quartz-plagioclase porphyry and felsite dykes occur sporadically in mafic to intermediate volcaniclastic rocks (1), and mafic flows.

Volcanic fragmental rocks (1, 2) and mafic flows also host diabase dykes. The dykes apparently include both synvolcanic and younger intrusions that truncate quartz-plagioclase porphyries, and are interpreted to be related to post Amisk Group gabbro intrusions. The mafic dykes are typically 0.5 to 2 m wide (up to 20 m) and aphyric to porphyritic. Plagioclase or pyroxene (altered to hornblende) phe-

Figure GS-13-13: Disrupted bedding with load casts in a greywacke-siltstone turbidite unit within mafic to intermediate breccia (1).

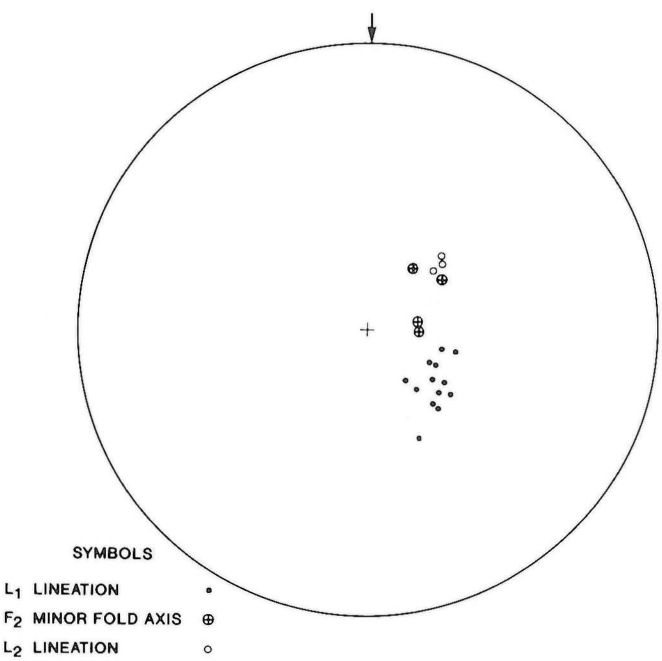


Figure GS-13-14: Lower hemisphere stereographic plot of minor fold axes and linear structures in the north-central part of the southwest Wekusko Lake project area.

nocrysts are 1 to 5 mm long, and constitute up to 15% of porphyritic diabase. Dyke margins are locally finely banded and/or amygdaloidal. Several dykes contain minor (1-2%) pyrite ± chalcopyrite, concentrated along joints or at the margins of feldspathic veins.

STRUCTURE

Several fold structures are recognized in the north-central part of the project area (Fig. GS-13-1). In the southeast part of the mapped area, a major SE-trending anticline is indicated by stratigraphic units that define a fold closure. Deformed clasts and mineral lineations plunging southeast at 50° to 60° are interpreted as L_1 structures (Fig. GS-13-14), related to the anticline, and assumed to be contemporaneous with the foliation (S_1). In the west part of the mapped area, a similar fold closure is indicated by bedding trends, and the irregular contact between units 1 and 2, which is interpreted to be folded (Fig. GS-13-1).

Minor open folds that plunge east or northeast at 50° to 70° (Fig. GS-13-14) deform the foliation and parallel metamorphic layering that is defined by stratabound actinolite (Fig. GS-13-15). These folds and coincident lineated clasts occur in both the west and east parts of the mapped area, and are interpreted to be F_2 structures. Limited evidence suggests the F_2 axial planes are approximately vertical.

The configuration of stratigraphic units 4 and 5, which wrap around the shoreline of Wekusko Lake in the north part of the mapped area (Fig. GS-13-1), is tentatively interpreted to be a result of F_2 folding.

Northeast- to northwest-trending faults are common, and locally associated with carbonatization, chloritic alteration and quartz veining in 0.5 to 3 m wide zones. The amount of displacement observed at a few localities ranges from 0.5 to 2 m. A major fault is inferred parallel to the northwest-trending shoreline of Wekusko Lake, at the contact between unit 5 and units 1 to 4 (Fig. GS-13-1). The faulting apparently postdates F_2 folding.

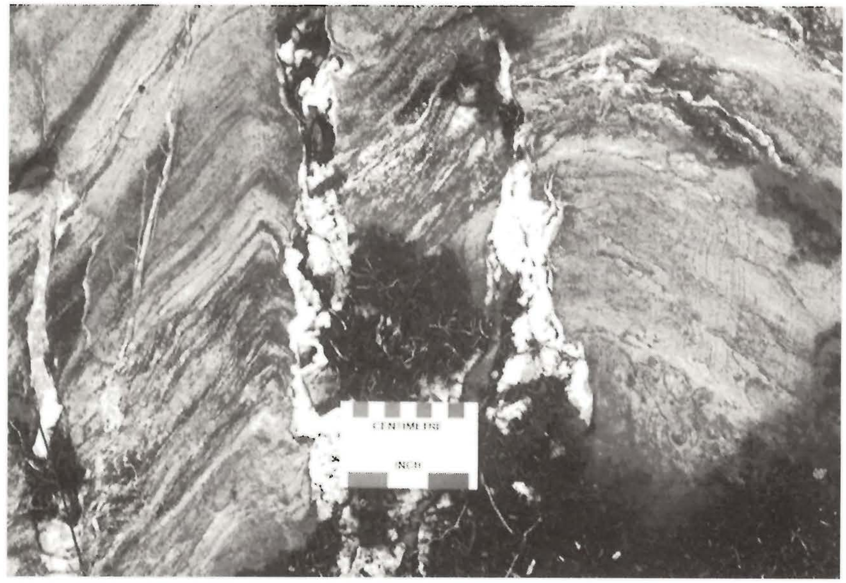


Figure GS-13-15: F_2 minor folds in altered mafic tuff (1); note the traces of bedding at right, actinolite-rich metasomatic laminae parallel to the foliation at left, and quartzofeldspathic veining along F_2 axial planes .

REFERENCES

Armstrong, J.E.

1939: Wekusko Lake, Manitoba; Geological Survey of Canada, Map 665A.

Bailes, A.H.

1985: Geological investigations in the Chisel Lake-Reed Lake areas; **in** Manitoba Energy and Mines, Geological Services, Mines Branch, Report of Field Activities, 1985, p. 48-50.

Copper-Man Mines Ltd.

Consolidated Lebel Ore Mines Ltd.; Manitoba Basin Mining Co. Ltd.; Sherritt Gordon Mines Ltd.; Western Nuclear Mines Ltd.: NW 12, 63J; Corporation Files, Manitoba Energy and Mines, Minerals Division.

GS-14 GEOCHEMICAL DATA FROM THE HOST ROCKS TO THE BUR ZONE ZN-CU DEPOSIT, SNOW LAKE AREA, MANITOBA (NTS 63J/13)

by M.A.F. Fedikow

Fedikow, M.A.F., 1992: Geochemical data from the host rocks to the Bur Zone Zn-Cu deposit, Snow Lake Area, Manitoba (NTS 63J/13): **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 84-89.

INTRODUCTION

The depositional environment for the Bur Zone Zn-Cu sedimentary rock hosted massive sulphide type deposit represents a departure from that for past and presently producing base metal massive sulphide deposits in the Snow Lake mining camp. Prior to the Bur Zone discovery, base metal massive sulphide type deposits in the Snow Lake area have been demonstrated to occur within felsic to mafic volcanic and volcaniclastic rocks (*cf.* Fedikow, 1991). The Bur Zone deposit is hosted by Amisk Group greywacke and siltstone characterized by long and short strike length ground EM conductors. The geological setting of this deposit has been described by Fedikow (1991).

A suite of 31 core samples were collected from DDH Bur-183 and give a representative geological cross section through the deposit (Fig. GS-14-1). The samples were collected to examine the extent of, and the chemical elements diagnostic of, mineralization-related alteration associated with the deposit. To date, only neutron activation (NA) data is available; these data are presented in Table GS-14-1. Profiles along DDH Bur-183 based on the NA data are given in Figures GS-14-2, -3 and -4 along with stratigraphic units logged in the drill core. Samples that represent near solid to solid sulphide mineralization were not analyzed.

RESULTS

Mineralization-related alteration, as indicated by elemental flux on Figures GS-14-2, -3, and -4, commences within approximately 25 m of the mineralized zone in structurally overlying rocks. This pattern of increased concentrations persists in the rocks to the bottom of the drillhole. Marked increases in As, Ni, Co, Fe, Hg, Rb, Sb, Th, U, Zn, and REE are observed. Sb appears to be the most extensive halo-forming element with a departure from a generally flat (0.1 - 0.3 ppm) pattern to highs of 3.7 and 3.8 ppm at or near the mineralized zone. The pattern for Na indicates an erratic but identifiable zone of depletion (1.50 - 2.40% Na in relatively unaltered to less then 1.0% Na in altered rocks) of approximately 40m in section; this depletion crosscuts stratigraphic boundaries and persists in the rocks to the base of the section (Fig GS-14-2). Au, Ag, Ba, Br, Se, Ta, Sr, Sn, Ce, Ca, Cs, Hf, and Ir are ineffective for the identification of mineralization-related alteration. The absence of identifiable chemical variation in this profile with proximity to the granodiorite intrusion may suggest the passive role of the intrusion with respect to deposit formation. The increase in rare earth element concentration corresponds to increases in the graphite content of the rocks.

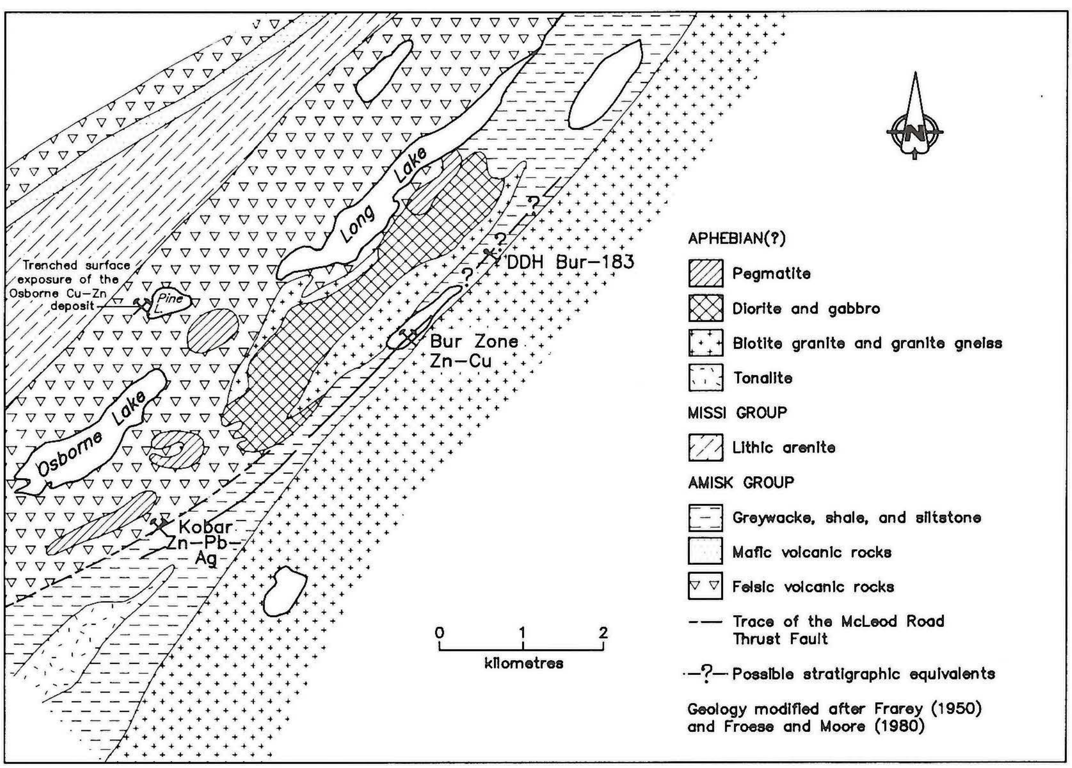


Figure GS-14-1: Regional geological setting of the Bur Zone Zn-Cu, Kobar Zn-Pb-Ag and Osborne Cu-Zn massive sulphide type deposits, Snow Lake area.

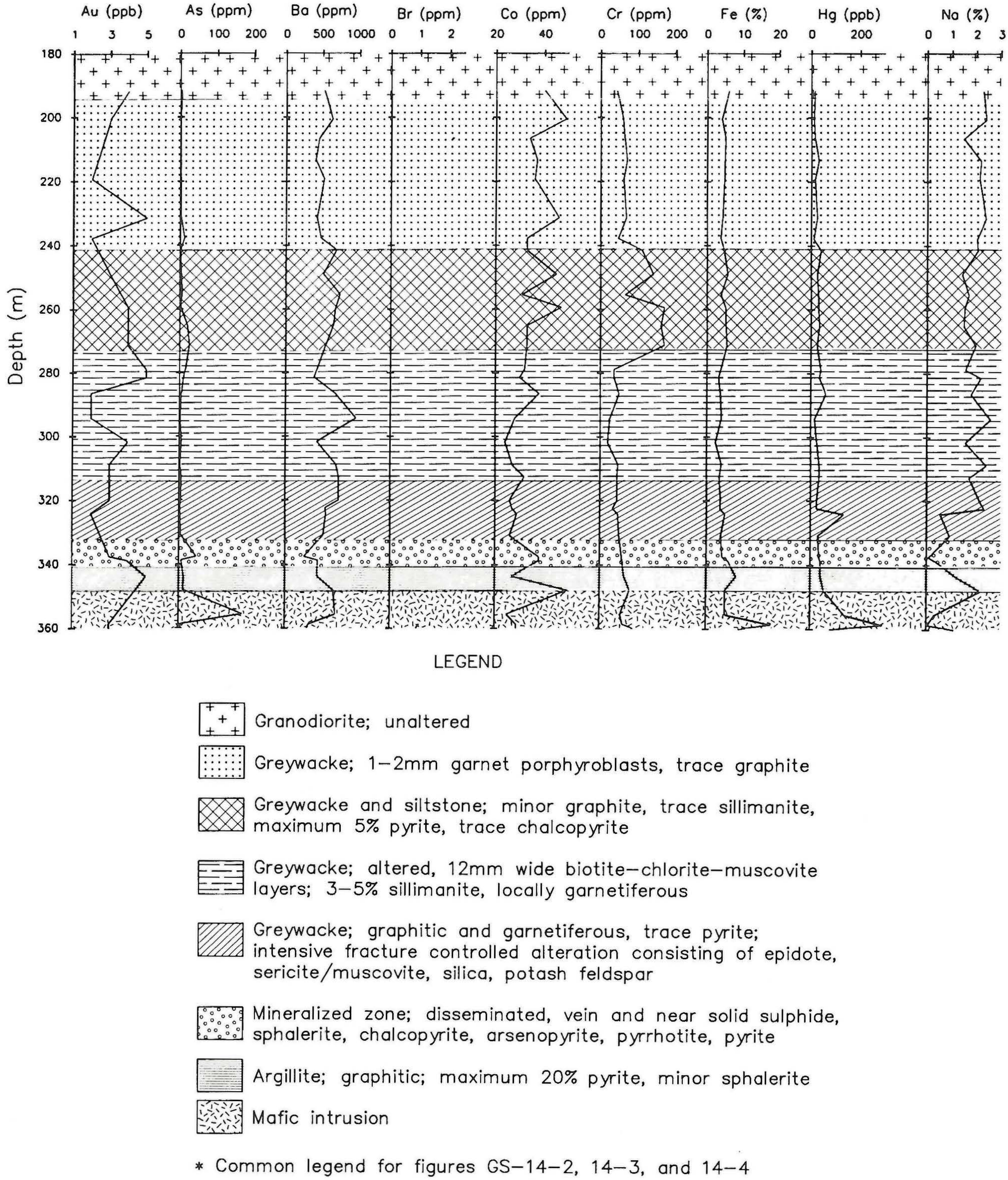


Figure GS-14-2: Rock geochemical profiles for Au, As, Ba, Br, Co, Cr, Fe, Hg, and Na, DDH Bur 183, Bur Zone Zn-Cu deposit.

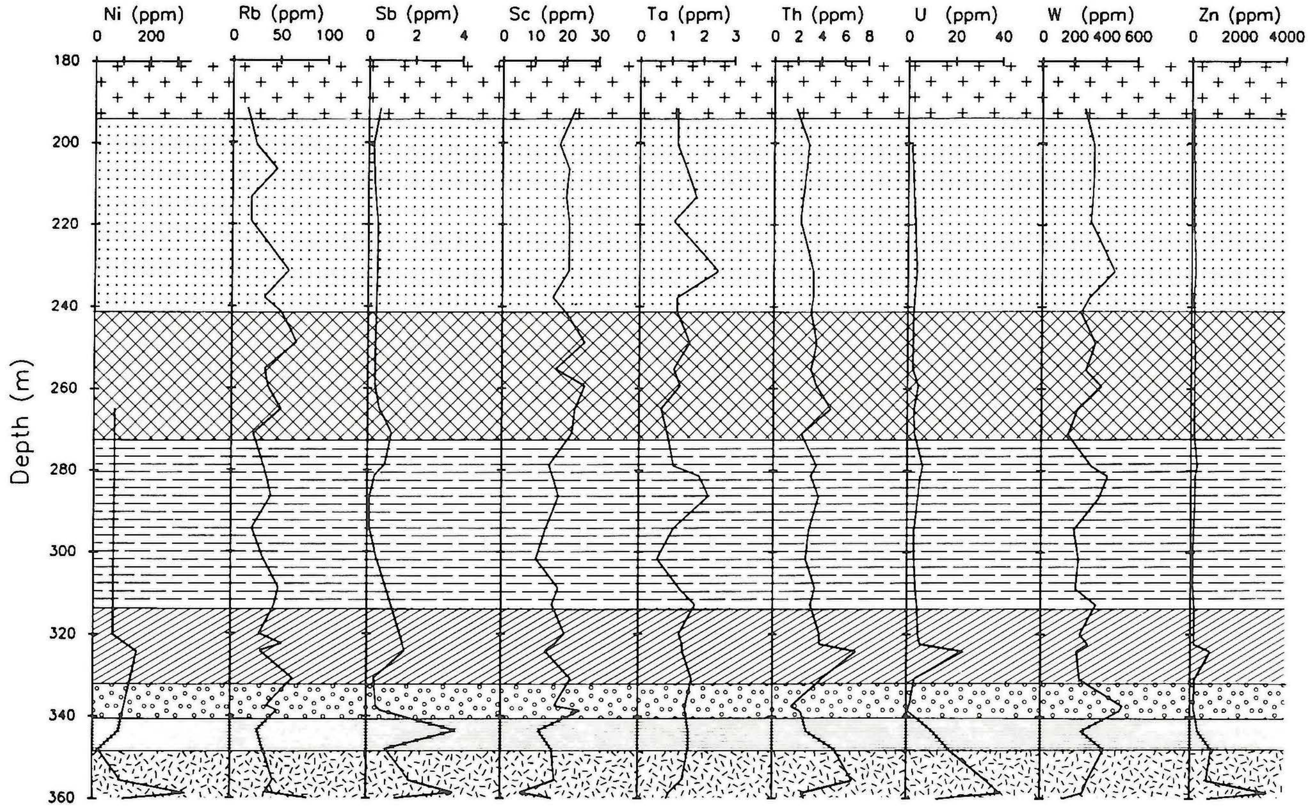


Figure GS-14-3: *Rock geochemical profiles for Ni, Rb, Sb, Sc, Ta, Th, U, W, and Zn, DDH Bur 183, Bur Zone Zn-Cu deposit.*

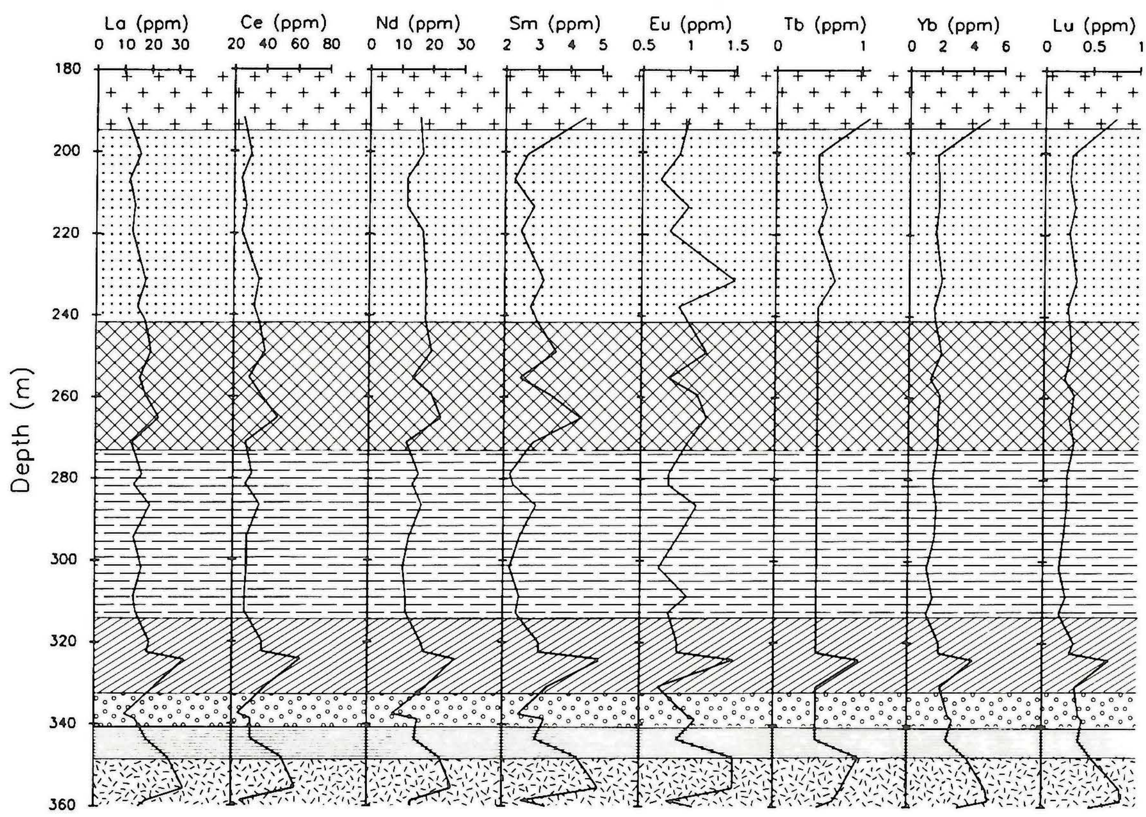


Figure GS-14-4: *Rock geochemical profiles for La, Ce, Nd, Sm, Eu, Tb, Yb, and Lu, DDH Bur 183, Bur Zone Zn-Cu deposit.*

Of note in these profiles is enrichment of Hg with proximity to mineralization (15 to 50 ppb Hg in structural hanging wall versus 25 to 295 ppb Hg in mineralization). This observation suggests that in the absence of a surface expression to the mineralization a mercury - vapour approach to exploration could be informative. The application of a Hg survey, integrated with ground geophysical techniques, might generate drill targets thereby precluding extensive programs of "fill in" diamond drilling to test long strike length ground EM conductors.

ACKNOWLEDGEMENTS

Hudson Bay Mining and Smelting Co. Ltd. is acknowledged for access to company information regarding the Bur Zone. Jerry Kitsler, Hudson Bay Exploration and Development Co. Ltd., Snow Lake, is thanked for discussions regarding the depositional environment for the deposit.

REFERENCES

Fedikow, M.A.F.
1991: Sediment-hosted Zn-Cu(Bur Zone) and Zn-Pb-Ag (Kobar/Ruby) massive sulphide type deposits, Snow Lake area (NTS 63J/13); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p.43-46.

Table GS-14-1 overleaf

Table GS-14-1
Neutron activation data from core samples (n=31) collected from DDH bur-183

Sample Number	Sample Interval (Metres)	Midpoint	Au PPB	Ag PPM	As PPM	Ba PPM	Br PPM	Ca %	Co PPM	Cr PPM	Cs PPM	Fe %	Hf PPM	Hg PPB	Ir PPB	Mo PPM	Na %	Ni PPM	Rb PPM
	Lower Limit of Detection =		2	5	0.5	50	0.5	1	1	5	1	0.01	1	1	5	1	0.01	20	5
03636	191.5-191.7	191.60	4	5	4.1	520	0.5	4	40	42	1	6.06	4	15	5	1	2.27	20	15
03637	200.5-200.6	200.55	3	5	0.9	630	0.5	2	49	59	2	4.03	3	10	5	1	2.41	20	25
03638	206.5-206.6	206.55	2	5	1.1	450	2.1	3	34	63	2	5.04	2	15	5	1	1.49	20	47
03639	213.2-213.4	213.30	2	5	0.5	400	0.5	4	37	70	1	4.90	3	30	5	1	2.19	20	20
03640	219.2-219.3	219.25	2	5	0.5	520	0.5	3	36	60	2	4.77	2	15	5	3	2.13	20	20
03641	231.2-231.3	231.25	5	5	2.5	420	0.5	2	46	68	3	4.34	3	25	5	2	2.40	20	60
03642	237.7-237.8	237.75	2	5	12.0	480	0.5	3	33	46	2	3.78	3	10	5		2.04	20	34
03643	241.3-241.5	241.40	2	5	1.7	690	0.5	2	33	110	2	4.73	3	40	5	1	2.08	20	52
03644	248.8-248.9	248.85	3	5	0.5	510	0.5	2	45	140	3	5.73	3	25	5		1.43	20	68
03645	255.2-255.3	255.25	2	5	5.9	740	0.5	3	31	65	1	3.84	2	30	5		1.71	20	35
03646	259.3-259.4	259.35	4	5	2.4	680	0.5	3	47	170	2	5.15	3	30	5	5	1.54	20	38
03647	265.0-265.1	265.05	2	5	20.0	650	0.5	2	33	160	3	5.25	3	35	5	1	1.50	76	52
03648	271.0-271.2	271.10	4	5	26.0	550	0.5	5	33	170	1	5.55	2	25	5	2	1.99	20	23
03649	278.8-279.0	278.90	5	5	16.0	430	0.5	2	32	35	2	3.84	3	40	5	5	1.57	20	34
03650	281.3-281.5	281.40	5	5	11.0	390	0.5	3	30	36	2	3.30	2	35	5	1	2.20	20	37
06359	286.4-286.5	286.45	2	5	5.0	680	0.5	3	38	49	2	3.77	3	60	5	4	1.80	20	42
06360	294.2-294.4	294.30	2	5	1.9	960	0.5	2	28	25	1	4.05	2	15	5		2.59	20	22
06361	301.6-301.8	301.70	4	5	5.4	430	0.5	3	24	20	1	2.43	2	25	5		1.56	20	34
06362	308.7-308.8	308.75	3	5	1.9	690	0.5	3	27	47	1	4.07	2	35	5		2.42	20	50
06363	312.7-312.8	312.75	2	5	5.8	730	0.5	2	32	44	2	3.44	3	35	5	3	1.72	20	46
06364	319.9-320.1	320.00	3	5	4.1	730	0.5	2	26	45	2	3.87	3	25	5		2.16	72	30
06365	324.1-324.2	324.15	2	5	2.8	560	0.5	2	29	47	2	5.07	4	135	5	25	0.55	160	31
06366	330.8-330.9	330.85	2	5	5.1	520	0.5	1	26	50	3	3.95	3	30	5	4	0.94	20	65
06367	322.3-322.5	322.40	2	5	2.4	550	0.5	2	27	33	2	3.70	3	25	5		2.34	20	54
06368	337.5-337.6	337.55	3	5	46.0	260	0.5	1	38	5	1	4.43	2	35	5	3	0.09	20	38
06369	338.7-338.8	338.75	4	5	5.9	450	0.5	1	38	5	2	6.06	2	40	5	4	0.37	20	49
06371	343.5-343.7	343.60	5	5	13.0	440	0.5	1	27	64	1	8.21	2	40	5	16	1.21	93	28
06372	347.9-348.1	348.00	2	5	11.0	660	0.5	2	50	79	2	5.14	4	55	5	10	2.19	20	34
06373	355.5-355.6	355.55	2	5	170.0	690	0.5	2	25	55	2	5.30	4	140	5	41	0.31	100	45
06374	358.6-358.7	358.65	3	5	6.2	330	1.0	1	29	61	1	18.10	2	295	5	55	0.04	340	37
06375	360.1-360.2	360.15	3	5	3.4	300	0.9	1	29	92	5	8.34	3	65	5	19	1.20	93	85

Sample Number	Sample Interval Metres)	Sb PPM	Sc PPM	Se PPM	Sn PPM	Sr PPM	Ta PPM	Th PPM	U PPM	W PPM	Zn PPM	La PPM	Ce PPM	Nd PPM	Sm PPM	Eu PPM	Tb PPM	Yb PPM	Lu PPM	Mass g
Lower Limit of Detection =		0.1	0.1	5	100	500	0.5	0.2	0.5	1	50	0.5	3	5	0.1	0.2	0.5	0.2	0.05	0.00
03636	191.5-191.7	0.5	23	5	100	500	1.2	1.9	0.5	270	115	11.0	26	16	4.5	1.0	1.1	5.1	0.75	28.88
03637	200.5-200.6	0.2	18	5	100	500	1.2	3.0	1.5	330	76	16.0	31	17	2.7	0.9	0.5	1.8	0.29	31.43
03638	206.5-206.6	0.1	21	5	100	500	1.5	2.8	2.1	330	131	12.0	25	12	2.3	0.7	0.5	1.9	0.27	30.83
03639	213.2-213.4	0.3	20	5	100	500	1.8	2.5	2.6	320	127	14.0	28	12	2.9	1.0	0.6	1.9	0.32	27.02
03640	219.2-219.3	0.4	21	5	100	500	1.1	2.3	0.5	310	101	13.0	25	17	2.5	0.8	0.5	1.7	0.26	28.92
03641	231.2-231.3	0.4	21	5	100	500	2.5	3.4	3.9	460	195	18.0	36	18	3.2	1.5	0.7	2.1	0.34	19.94
03642	237.7-237.8	0.1	16	5	100	500	1.2	3.4	2.9	300	110	15.0	33	18	2.8	0.9	0.5	1.6	0.25	26.12
03643	241.3-241.5	0.1	20	5	100	500	1.2	3.2	2.5	250	127	18.0	36	18	3.0	1.0	0.5	1.7	0.27	30.46
03644	248.8-248.9	0.1	26	5	100	500	1.6	3.7	2.4	340	170	20.0	40	20	3.6	1.2	0.5	2.1	0.29	24.46
03645	255.2-255.3	0.3	17	5	100	500	1.1	3.2	2.4	280	172	16.0	30	14	2.5	0.8	0.5	1.4	0.22	26.52
03646	259.3-259.4	0.3	26	5	100	500	1.3	3.7	4.7	380	165	18.0	37	20	3.4	1.1	0.5	2.0	0.32	29.84
03647	265.0-265.1	0.5	23	5	100	500	0.7	4.9	2.8	230	154	23.0	48	23	4.4	1.2	0.5	1.9	0.27	25.77
03648	271.0-271.2	1.0	22	5	100	500	0.9	2.4	3.1	170	146	13.0	28	12	2.9	1.0	0.5	1.9	0.32	26.07
03649	278.8-279.0	0.7	15	5	100	500	1.1	3.7	6.6	320	296	17.0	32	16	2.2	0.8	0.5	1.6	0.25	25.18
03650	281.3-281.5	0.3	16	5	100	500	1.9	3.2	5.7	420	190	14.0	28	14	2.3	0.8	0.5	1.6	0.25	27.25
06359	286.4-286.5	0.1	18	5	100	500	2.2	3.9	4.7	370	197	20.0	37	17	3.0	1.1	0.5	1.8	0.25	26.45
06360	294.2-294.4	0.1	14	5	100	500	1.1	3.1	2.9	210	143	14.0	29	13	2.5	0.9	0.5	1.7	0.21	27.62
06361	301.6-301.8	0.4	11	5	100	500	0.6	2.8	3.0	240	110	17.0	29	11	2.2	0.7	0.5	1.2	0.17	30.87
06362	308.7-308.8	0.1	18	5	100	500	1.3	3.6	3.6	220	113	14.0	28	12	2.5	1.0	0.5	1.6	0.24	30.49
06363	312.7-312.8	0.1	16	5	100	500	1.8	3.2	4.3	350	157	15.0	28	12	2.4	0.8	0.5	1.2	0.17	26.65
06364	319.9-320.1	0.1	20	5	100	500	1.3	4.0	4.8	250	177	20.0	39	17	3.1	0.9	0.5	2.0	0.33	28.15
06365	324.1-324.2	1.6	14	5	100	500	1.4	7.1	24.0	230	860	33.0	63	28	5.1	1.5	1.0	4.2	0.70	23.28
06366	330.8-330.9	0.3	22	5	100	500	1.7	4.2	3.3	250	203	22.0	42	19	3.4	0.7	0.5	2.1	0.34	25.28
06367	322.3-322.5	0.1	17	5	100	500	1.4	4.0	5.6	300	165	19.0	39	18	3.1	0.9	0.5	2.0	0.28	24.73
06368	337.5-337.6	0.4	17	5	100	500	1.5	1.6	1.2	520	154	11.0	24	8	2.5	1.0	0.5	2.6	0.38	25.07
06369	338.7-338.8	0.6	25	5	100	500	1.5	2.4	0.7	500	169	15.0	32	16	3.3	1.1	0.5	2.9	0.42	25.76
06371	343.5-343.7	3.8	12	5	100	500	1.6	2.9	11.0	260	349	19.0	32	15	3.0	0.9	0.5	2.5	0.38	27.93
06372	347.9-348.1	0.8	16	5	100	500	1.6	5.3	18.0	400	913	27.0	51	23	4.3	1.5	1.0	3.8	0.52	25.84
06373	355.5-355.6	1.8	17	5	100	500	1.4	6.8	34.0	300	704	33.0	60	27	5.0	1.5	0.8	5.0	0.82	23.94
06374	358.6-358.7	3.7	6.2	5	100	500	1.0	2.5	40.0	270	3310	19.0	26	14	2.6	0.8	0.7	5.2	0.83	27.38
06375	360.1-360.2	1.0	17	5	100	500	0.9	2.8	11.0	130	594	16.0	30	14	3.4	1.1	0.5	3.1	0.47	32.57

GS-15 GEOCHEMISTRY OF THE ALTERED WALLROCKS TO THE COPPER-MAN ZN-CU MASSIVE SULPHIDE TYPE DEPOSIT, SNOW LAKE AREA, MANITOBA (NTS 63J/12)

by M.A.F. Fedikow and E. Kowalyk

Fedikow, M.A.F. and Kowalyk, E., 1992: Geochemistry of the altered wallrocks to the Copper-Man Zn-Cu massive sulphide type deposit, Snow Lake area, Manitoba (NTS 63J/12); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 90-92.

INTRODUCTION

The Copper-Man base metal deposit is situated 27 km southeast of the town of Snow Lake (Fig. GS-15-1) in a sequence of highly altered Amisk Group andesitic to basaltic rocks. The deposit has been known since 1926 and was first examined by Wright (1931). Sinha (1992) describes the deposit as consisting of two zones of Zn-Cu mineralization. The first, or the A Zone, contains 162 360 tonnes averaging 3.1% Cu and 3.1% Zn, whereas the B Zone has 25 092 tonnes averaging 1.88% Cu and 15.2% Zn. The geological setting of the deposit, including unaltered, altered and mineralized surface exposures of massive and fragmental basalts, based on 1:2 000 scale mapping, is discussed by Trembath and Fedikow, (1990). Assay/geochemical results from trenches on the property, as well as a exploration summary are presented by Ferreira and Fedikow (1991).

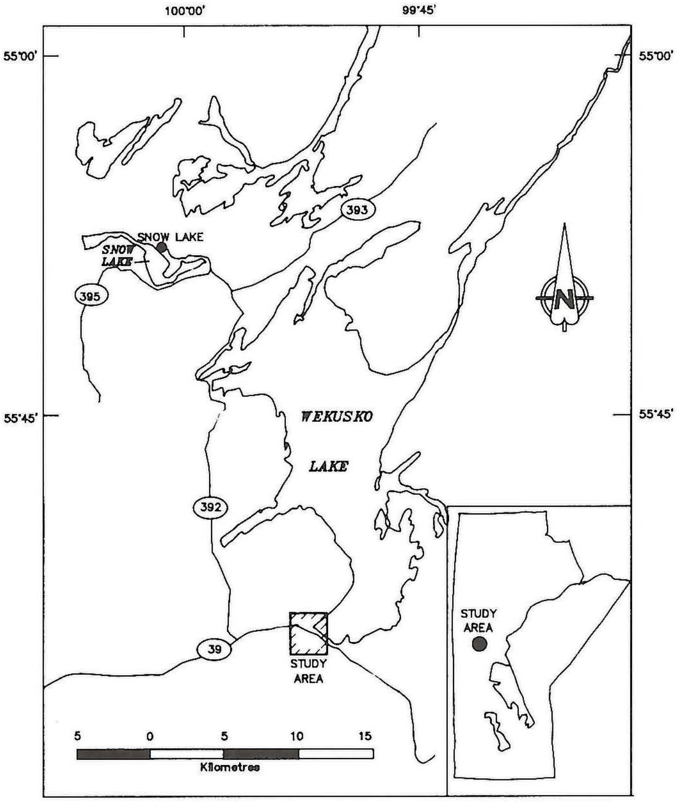


Figure GS-15-1: Sketch map showing the location of the Copper-Man deposit.

Outcrop chip samples were collected from altered and relatively unaltered rocks in the area of the deposit (Fig. GS-15-2, -3). The samples will be analyzed for major and trace elements by using a variety of analytical techniques with the aim of establishing the chemical nature of the host rocks, as well as the subsequent mineralization-related alteration. These data will represent a portion of the integrated geological data base applied to base metal exploration in the Snow Lake area.

REFERENCES

Ferreira, K.J. and Fedikow, M.A.F.
1991: Mineral deposits and occurrences in the Buzz Lake area, NTS G3J/12; Manitoba Energy and Mines, Mineral Deposit Series Report No. 21, 105p.

Sinha, A.K.
1992: Ground very low frequency (VLF) and magnetic survey results at the Copperman site, near Snow Lake, Manitoba; Geological Survey of Canada Open File 2458, 18p.

Trembath, G.D and Fedikow, M.A.F.
1990: Geological setting of the Copper-Man base metal deposit (63J/12); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 84-86.

Wright, J.F.
1931: Geology and mineral deposits of a part of northwest Manitoba; Geological Survey of Canada, Summary Report, 1930, Part C, 124p.

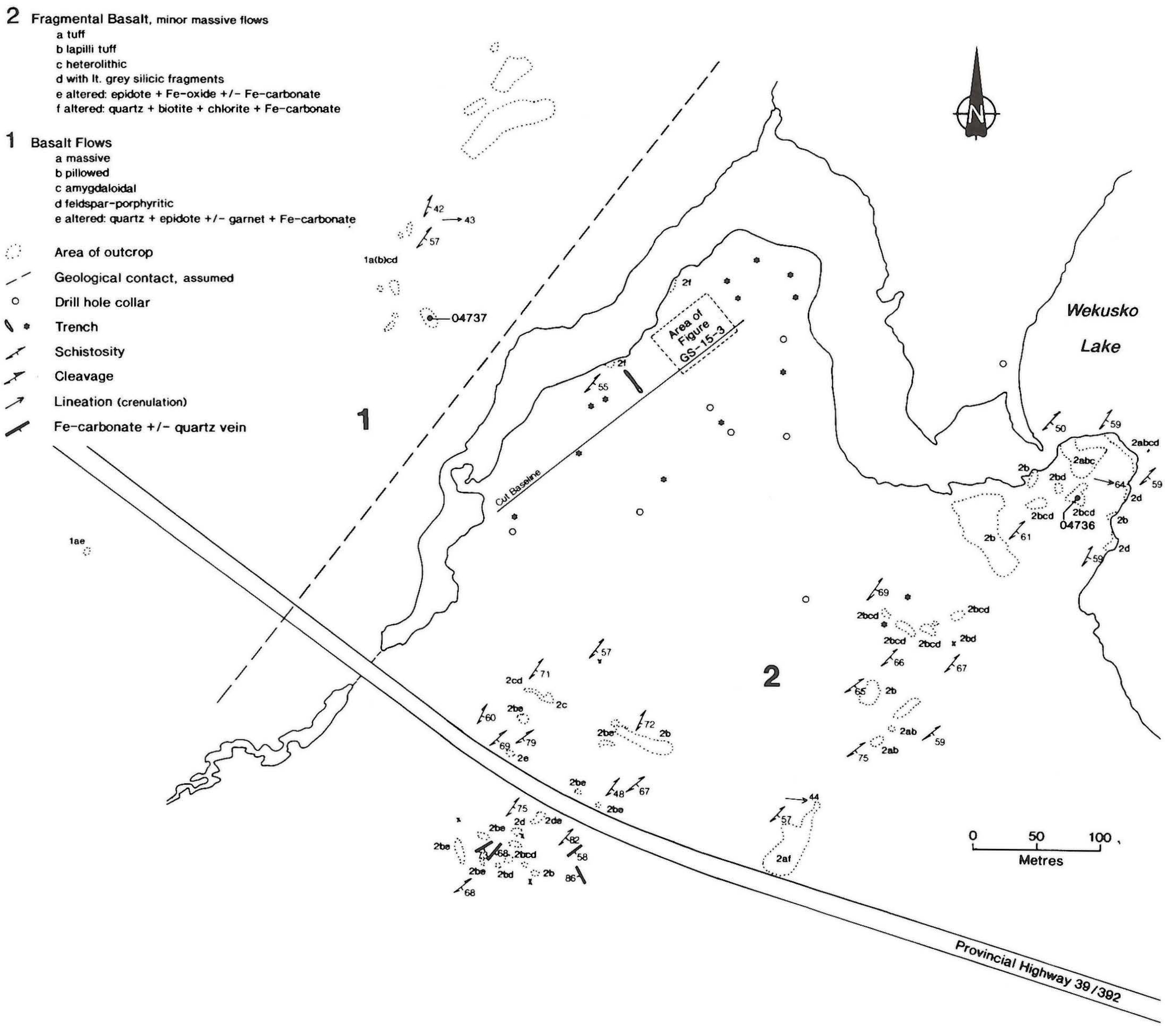


Figure GS-15-2: Local geology and outcrop chip sample location map in the vicinity of the Copper-Man deposit.

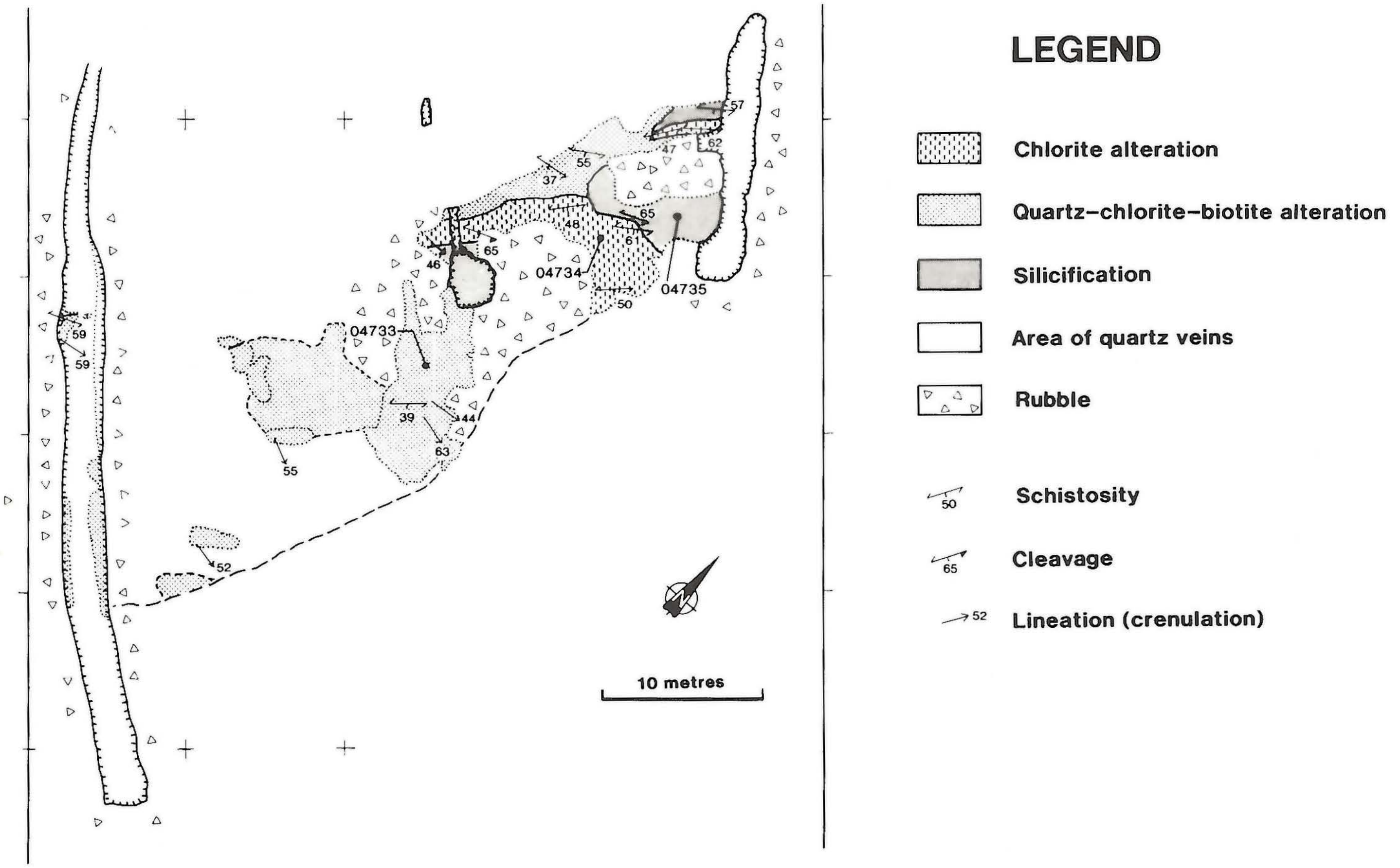


Figure GS-15-3: *Detailed geology map of the main mineralized zone exposed on surface showing geology, trench and outcrop sample locations.*

GS-16 A GEOLOGICAL RECONNAISSANCE OF THE WATCH LAKE AREA, SNOW LAKE, MANITOBA (NTS 63J/12)

by M.A.F. Fedikow and E. Kowalyk

Fedikow, M.A.F. and Kowalyk, E., 1992: A geological reconnaissance of the Watch Lake area, Snow Lake, Manitoba (NTS 63J/12); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 93-94.

INTRODUCTION

The immediate area of Watch Lake is characterized by abundant swamp, low-lying ground and an unmapped northeast-trending area of approximately 24 km^2 (Frarey, 1948; Fig GS-16-1). Bell (1978) presents some geological information in this area at a scale of 1:250 000. As a result of the lack of a geological data base the area was selected for reconnaissance to ascertain whether sufficient outcrop is available to complete geological map coverage and thereby establish the relationships between Missi Group andesitic and basaltic flows mapped by Frarey (1948) to the west of Watch Lake, and Missi basalt mapped by Bailes (1985) to the east in the Saw Lake area. Bell (1978) tentatively interpreted the mafic volcanic rocks west of Watch Lake as Amisk Group.

RESULTS

Two days were spent traversing in the area. A northeast-trending unit of quartzite, siltstone and arkose occurs approximately 1 km northwest of Watch Lake and is interpreted to represent the westward extension of Missi Group siliceous paragneiss, quartzofeldspathic biotite paragneiss and protoquartzite mapped as unit 6a by Bailes (1985) in the adjacent Saw Lake area. Further to the northwest an intrusion comprising diorite and quartz diorite is documented (Fig GS-16-1). Intrusive rocks, mapped by Frarey (1948), may represent the westward equivalents of Bailes' (1985) late- to post-kinematic hornblende leucogranite (unit 19c) and synkinematic hornblende melatonalite and melagranodiorite (unit 13).

An outcrop on the west shore of Watch Lake exposes tightly-folded and interlayered quartzite, amphibolite, and a garnet-biotite rich unit. These rocks may be equivalent to layered garnetiferous amphibolite and siliceous paragneiss (Missi Group, unit 7d) mapped by Bailes (1985) in the Saw Lake area.

MINERAL OCCURRENCES

One kilometre north of western Watch Lake, in an area underlain by felsic intrusive rocks and Missi Groups sedimentary rocks, uranium mineralization occurs within a 550 m long by 60 to 75 m wide pegmatite. Samples collected and analyzed by Oro Mines Ltd. averaged >0.05% U_3O_8 (Ferreira and Fedikow, 1991; *cf.* location 1, Fig. GS-16-1). The Watts River/Daisy 4 gold occurrence is present in the area west of Watch Lake. The area of the occurrence is characterized by Amisk Group (?) mafic to intermediate volcanic rocks flanked to the north and south by felsic intrusive rocks. At the occurrence, disseminated pyrite with minor chalcopyrite and trace sphalerite occurs in two sets of mineralized quartz veins. These veins have a known strike length of approximately 520 m. Visible gold occurs in quartz veins and fine grained mafic wall rock adjacent to the veins. Samples collected from outcrop contained up to 10 200 ppb Au (Ferreira and Fedikow, 1991: *cf.* location 2, Fig. GS-16-1)

In addition to these occurrences, a rounded glacial boulder containing a mixture of clino- and orthopyroxene was discovered on the west shore of Watch Lake. The provenance of this boulder is unknown.

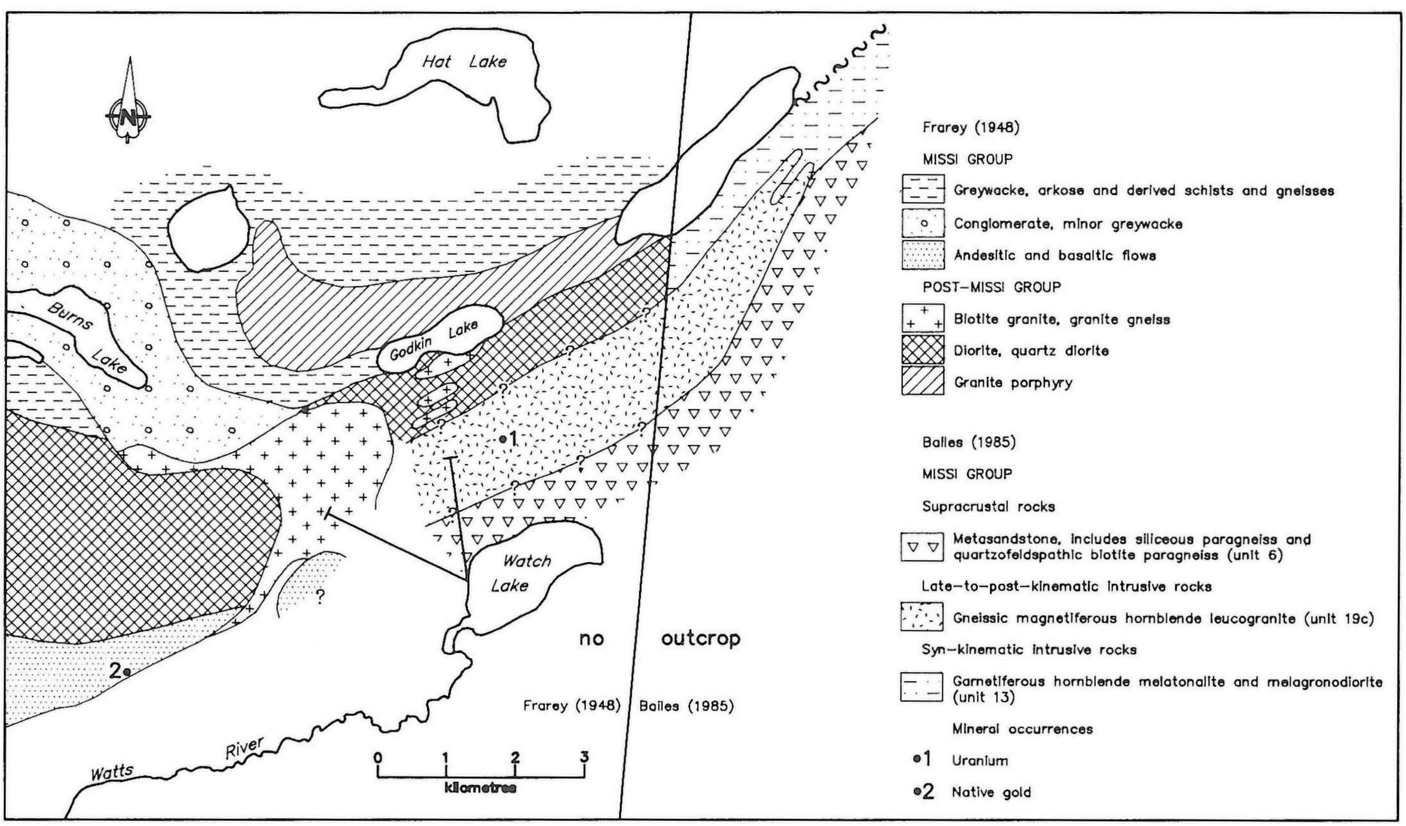


Figure GS-16-1: General geological setting and mineral occurrences in the Watch Lake area (simplified from Frarey, 1948; and Bailes, 1985).

CONCLUSIONS

The Watch Lake area contains the westward extension of Missi Group sedimentary rocks mapped in the Snow Lake area by Bailes (1985). These rocks have been intruded by late- to post-kinematic diorite and quartz diorite. Further west of Watch Lake mafic to intermediate rocks of uncertain age are present. These rocks have been designated as Missi Group (Frarey, 1948; Bailes, 1985), and tentatively as Amisk Group by Bell (1978). A vein type gold occurrence with visible gold and base metals is associated with these mafic rocks (Watch Lake/Daisy 4); a pegmatite type uranium deposit occurs just north of Watch Lake. A geological mapping program of 1:20 000 scale would elucidate geological environments, age of mafic volcanic rocks and provide a framework for metallogenetic studies in the Watch Lake area.

REFERENCES

Bailes, A.H.
1985: Geology of the Snow Lake area; Manitoba Energy and Mines, Geological Report GR83-2, 47p.

Bell, C.K.:
1963: Geology, Wekusko Lake map area, Manitoba; Geological Survey of Canada, Memoir 384, 84p,, includes map 1423A, 1:250 000.

Fedikow, M.A.F. and Malis, C.
1988: Mineral occurrence documentation - Herblet and Pulver gneiss domes and Wekusko Lake area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 84-94.

Ferreira, K.J. and Fedikow, M.A.F.
1991: Mineral deposits and occurrences in the Buzz Lake area, NTS63J/12; Manitoba Energy and Mines, Mineral Deposit Series Report No. 21, 105p.

Frarey, M.J.
1948: Crowduck Bay, Manitoba; Geological Survey of Canada, Map 987A, 1:63 360.

GS-17 GEOLOGICAL SETTING OF THE OSBORNE CU-ZN MASSIVE SULPHIDE TYPE DEPOSIT, SNOW LAKE AREA, MANITOBA (NTS 63J/13)

by M.A.F. Fedikow and E. Kowalyk

Fedikow, M.A.F. and Kowalyk, E., 1992: Geological setting of the Osborne Cu-Zn massive sulphide type deposit, Snow Lake area, Manitoba (NTS 63J/13); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 95-96.

INTRODUCTION

A 1:5 000 scale mapping project was initiated at the Osborne Lake Cu-Zn massive sulphide type deposit. Mapping was undertaken using 1:5 000 scale airphotos and a freshly cut grid covering the deposit. The map will serve as the basis for future geochemical studies and mapping projects designed to extrapolate the host rocks to the deposit northeastward where metamorphic grade, recrystallization and deformation make geological interpretation difficult.

GEOLOGICAL SETTING

The general area of the Osborne deposit is characterized by Amisk Group felsic pyroclastic and volcaniclastic rocks (Fig. GS-17-1; Froese and Moore, 1980). The felsic volcanic rocks are flanked to the northwest by Missi Group lithic arenite and to the southeast by Amisk Group greywacke. The felsic volcanic rocks are intruded by pegmatitic granite and pegmatite. The deposit and the wall rocks have been metamorphosed to the biotite-sillimanite-almandine facies, which represents the highest grade of regional metamorphism in the Snow Lake are (Bristol and Froese, 1990). At the deposit felsic volcanic rocks have been altered to a coarse grained assemblage of cordierite, anthophyllite, staurolite, chlorite and phlogopite. Gahnite is present locally as inclusions in cordierite.

Detailed mapping in the immediate area of the surface expression of the deposit (Fig. GS-17-1) has elucidated a characteristic structural and stratigraphic hanging wall and footwall stratigraphy. On the basis of a southwest-plunging alteration pipe associated with the Osborne deposit the stratigraphic younging direction is interpreted to be to the east. East of the deposit the stratigraphy is characterized by massive, fragmental and quartz phyric rhyolite with thin units of garnet and amphibole porphyroblastic greywacke. The southeast shore of Pine Lake is characterized by exposures of fragmental and quartz phyric rhyolite with anastomozing biotite-chlorite veinlets as well as patchy rusty weathered zones. Rusty weathered and silicified equivalents of these rhyolites are also exposed adjacent to two trenches that expose near solid to solid pyrrhotite, pyrite, sphalerite and chalcopyrite (the surface expression of the Osborne deposit). Further to the east and southeast massive and weakly quartz phyric rhyolite (quartz phe-

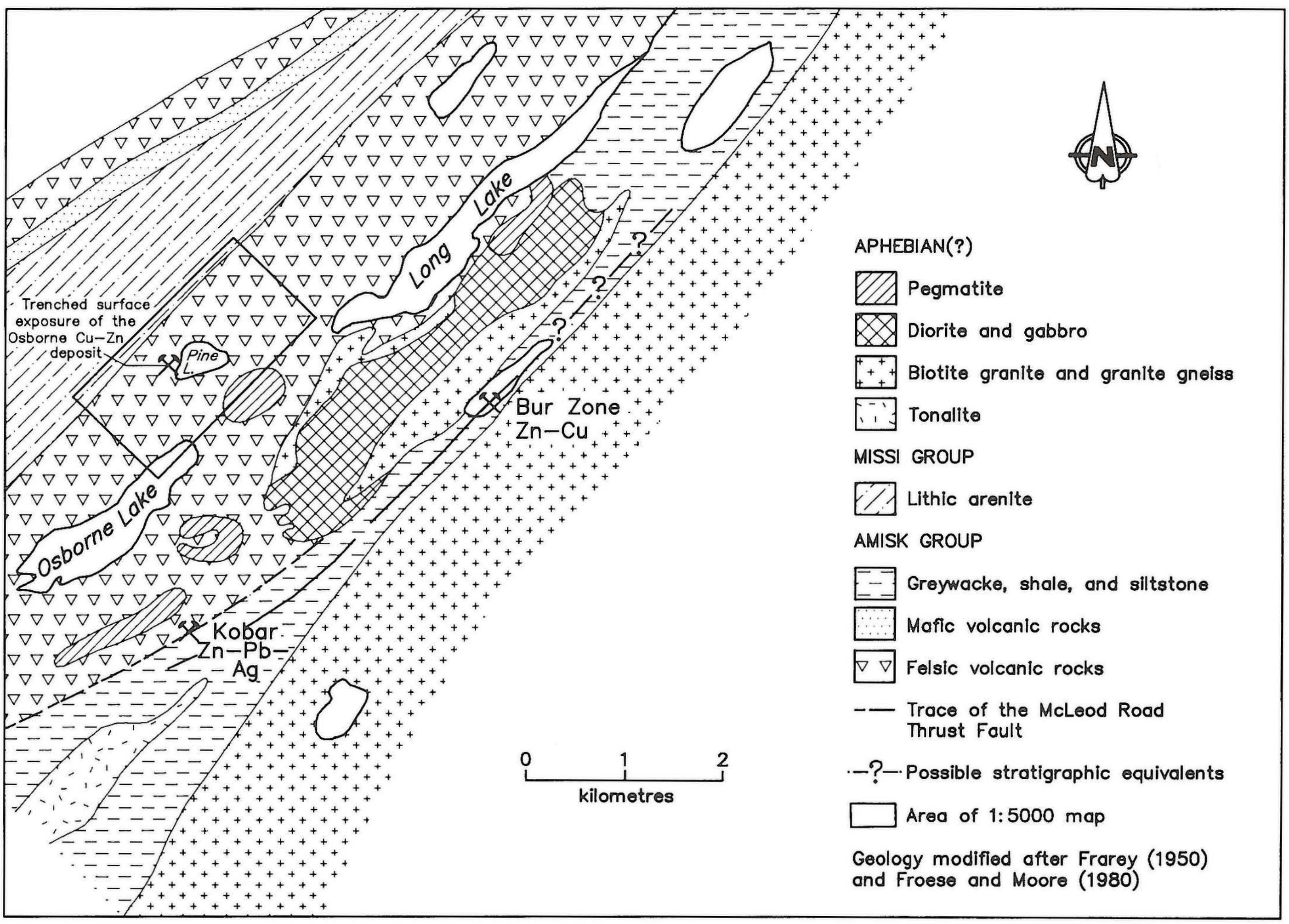


Figure GS-17-1: Regional geological setting of the Bur Zone Zn-Cu, Kobar Zn-Pb-Ag and Osborne Cu-Zn massive sulphide type deposits, Snow Lake area.

nocrysts 1-3 mm) predominate. These rocks have been intruded by white pegmatite.

West and south of the deposit the stratigraphy is characterized by layered felsic volcaniclastic rocks interlayered with basaltic amphibolite and pyroxene-hornblende gneisses. Missi Group sedimentary rocks occur further to the west. The immediate footwall rocks to the deposit are exposed as silicified and weakly garnetiferous aphyric felsic volcaniclastic rocks. Frarey (1948) mapped the extension of a fault, first mapped by Armstrong (1941), that occurs at the contact between Amisk Group mafic to intermediate rocks and greywacke. This fault persists in the immediate area of the Osborne deposit and is exposed in outcrop to the west of the headframes. At this locality the fault crosscuts Amisk Group felsic volcaniclastic rocks and Missi Group sedimentary rocks, and as such represents a departure from its localization at a volcanic-sedimentary contact.

MINERALIZATION

The Osborne deposit is a near solid to solid sulphide lens that strikes 045°, dips 65° northwest and plunges 30° southwest, and is conformable to the host rocks. The deposit is 232 m long, with an average width of 8 m and is composed mainly of pyrrhotite and pyrite with lesser amounts of chalcopyrite and sphalerite. Sangameshwar (1968) describes two types of mineralization in the orebody. The first is an early, fine grained pyrite-arsenopyrite assemblage that is observed to occur as inclusions within a larger coarse grained pyrite-arsenopyrite-pyrrhotite-chalcopyrite-sphalerite ± cobaltite-galena assemblage. The pyrrhotite in the deposit has a coarse texture without preferred orientation; hexagonal and monoclinic pyrrhotite have been described by Bristol (1974).

Two footwall alteration zones are associated with the deposit. The main alteration zone, which varies from 6 to 17 m wide, occurs adjacent to the ore between 305 to 457 m. Below 457 m the alteration bifurcates; the volumetrically greater portion plunges to the northeast away from the deposit and the less extensive alteration accompanies the mineralization to the lowest part of the deposit that have been mined (838 m). A second zone of mineralization, 0.8 m thick and extending from a depth of 150 m to 640 m below surface, occurs in the footwall. This zone contains 1.0% Cu and 1.9% Zn. This mineralization plunges to the northeast; its exact limits are unknown. A second alteration zone, delineated by four diamond drill holes on the 442 m level, is approximately 25 m thick and was intersected between 243 to 275 m from the deposit. Diamond drilling has traced this zone for 243 m away from the deposit.

GEOCHEMICAL DATA

Bamburak (1990) reports the deposit contained 3 380 000 tonnes grading 3.03% Cu and 1.48% Zn. As of December 31, 1984 the deposit was reported to contain ore reserves of 528 054 tonnes grading 2.45% Cu and 1.28% Zn (Esposito, 1986). Between 1968 and 1983, 2 852 007 tonnes grading 3.14% Cu and 1.52% Zn had been produced (Mineral Inventory Card 63J/13 Cu 1).

A sample collected from a trench on the northwest shore of Pine Lake that exposes the surface expression of the Osborne deposit contained 0.51% Cu and 2.20% Zn (C.A.F. 90081).

Bristol and Froese (1990) summarize geochemical data derived from the altered and unaltered wall rocks to the Osborne deposit. The data indicate depletion of Na_2O, CaO and locally, K_2O, and enrichment of FeO, MgO and H_2O. These trends correlate with the depletion of plagioclase and potassium feldspar, and the formation of staurolite, anthophyllite and cordierite in altered wall rocks relative to unaltered counterparts. Sangameshwar (1968) determined the trace element content of pyrrhotite and sphalerite from 36 ore samples collected from the deposit. Pyrrhotite contains 51 to 481 ppm Ni, 698 to 1395 ppm Se, nil to 922 ppm Co and nil to 1669 Mn. Sphalerite contains 3.75 to 15.61 mole percent FeS, 2.20 to 9.18 wt% Fe and nil to 4.90 wt% Mn.

CONCLUSIONS

The Osborne deposit is hosted by variably altered felsic pyroclastic rocks. These rocks can be traced northeastward towards the northwest shore of Long Lake. This highly prospective "horizon" will be the focus of future 1:5000 mapping and geochemical projects.

REFERENCES

Armstrong, J.E.
1941: Wekusko, Manitoba; Geological Survey of Canada, Map 665A.

Cancelled Assessment File, 90081
Manitoba Energy and Mines, Minerals Division

Bamburak, J.D.
1990: Metallic mines and mineral deposits of Manitoba; Manitoba Energy and Mines, Geological Services, Open File Report OF90-2, 103p.

Bristol, C.C.
1974: Sphalerite geobarometry of some metamorphosed orebodies in the Flin Flon and Snow Lake districts, Manitoba; Canadian Mineralogist, 12, p. 308-315.

Bristol, C.C. and Froese, E.
1990: Highly metamorphosed altered rocks associated with the Osborne Lake volcanogenic massive sulphide deposit; Canadian Mineralogist, vol. 27, p. 593-600.

Esposito, B.
1986: Copper and Zinc in Manitoba; Manitoba Energy and Mines, Mineral Education Series.

Froese, E. and Moore, J.M.
1980: Metamorphism in the Snow Lake area, Manitoba; Geological Survey of Canada Paper 78-27, 16p.

Mineral Inventory Card 63J/13 Cu 1
Manitoba Energy and Mines, Minerals Division.

Sangameshwar, S.R.
1968: Trace element and ore mineralogy of the Osborne Lake Mine, Manitoba; University of Saskatchewan, M.Sc. Thesis, 65p.

GS-18 NTS MAPS 63J/3, 63J/4 63K/2, 63K/3, 63K/6, 63K/7 GRADIOMETER SURVEYS

by Regis Dumont[1], Frank Kiss[1]

Dumont, R. and Kiss, F., 1992: NTS Maps 63J/3, 63J/4 63K/2, 63K/3, 63K/6, 63K/7 Gradiometer Surveys; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 97.

The gradiometer survey maps were compiled from data recorded during an aeromagnetic gradiometer survey carried out by Aerodat Limited using an AS350-B helicopter (C-GJIX). Two 0.005nT sensitivity cesium vapour magnetometers were mounted in a bird towed 30 m below the helicopter and were vertically separated by 3 m. The survey operations were carried out from September 1991 to January 1992, at a bird altitude of 150 m mean terrain clearance. The average traverse line spacing was 300 m, flown in a northwest-southeast direction in the Talbot Lake area and in an east-west direction in the Cormorant Lake area. Control lines were flown at an average spacing of 3 km. Flight path was recovered using a Syledis radio positioning system, supplemented by a vertically mounted video camera.

1 Geological Survey of Canada

The vertical gradient values, which approximate closely the first vertical derivative of the earth's total field, were obtained by dividing the difference between the total field readings of the two magnetometers by their vertical separation. The vertical gradient data were then filtered with a digital operator to remove instrument noise and to level the data. The data were then interpolated on a 50 m^2 grid (0.10 cm spacing at published map scale) for contouring.

The maps will be released during the first quarter of 1993. Copies of these maps may be obtained from the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A OE8, 3303-33rd Street, N.W. Calgary, Alberta, T2L 2A7 and Manitoba Energy and Mines, 555-330 Graham Avenue, Winnipeg, Manitoba, R3C 4E3. The survey data used to compile this map are available in digital form from the Geophysical Data Centre, Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ontario, K1A OY3.

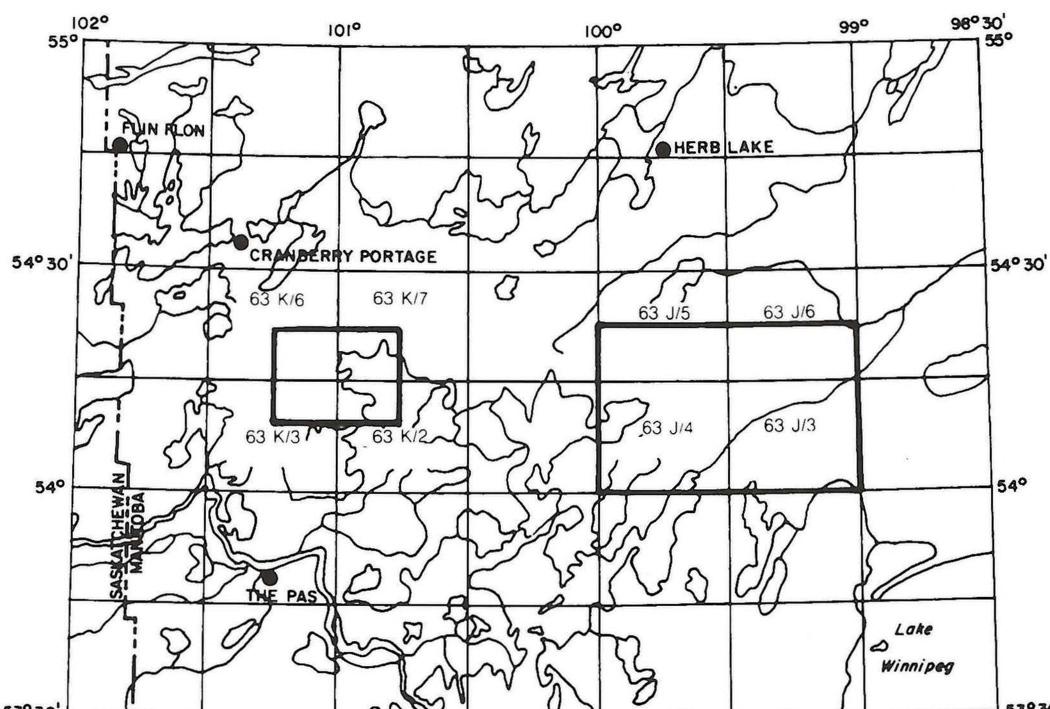


Figure GS-18-1: Gradiometer surveys.

GS-19 REPORT ON MAPPING ALONG THE SOUTHERN MARGIN OF THE KISSEYNEW GNEISS BELT, NORTH OF KISSEYNEW LAKE, CENTRAL MANITOBA

by A.R. Norman[1] and P.F. Williams[1]

Norman, A.R. and Williams, P.F., 1992: Report on mapping along the southern margin of the Kisseynew Gneiss Belt, north of Kisseynew Lake, central Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 98-99.

INTRODUCTION

The northern margin of the Flin Flon volcanic belt is flanked by complexly deformed metasedimentary, volcaniclastic, pyroclastic and volcanic-derived gneisses, which have been previously mapped as part of the Missi Group (Froese and Gall, 1981; Froese, 1984; Schledewitz, 1988; Zwanzig and Schledewitz, in press). South of Kisseynew Lake, these gneisses are in contact with mafic volcanic rocks of the Flin Flon volcanic belt. The purpose of this study has been to examine the structure of gneisses along and to the north of this contact. Rocks exposed on Kisseynew Lake, east of Lobstick Narrows, mainly comprise east-striking quartz-rich polymictic conglomerates, arkosic gneisses, massive pink quartzofeldspathic gneiss and minor altered mafic volcanic gneisses. The polymictic conglomerates typically contain vein-quartz clasts. North of Kisseynew Lake, polymict conglomerates that contain vein-quartz clasts are rare and the rocks are mainly quartz-amphibole-biotite greywackes, amphibole-epidote calcic greywackes, heterolithic fragmental arkoses, pink arkosic gneisses, mafic volcanics and metagabbro, quartzofeldspathic gneisses and graphite-bearing biotite-garnet-sillimanite-staurolite schistose gneiss. The graphite-bearing schistose gneiss has been mapped as part of the Burntwood Suite (Schledewitz, 1988). In contrast to the gneisses exposed on Kisseynew Lake, these gneisses have a complex outcrop pattern because of; (1) probable primary discontinuities, (2) marked facies changes, (3) structural discontinuities, and (4) multiple folding. Three areas were mapped at a scale of 1:3 000 because of the complex nature of the geology. Elsewhere mapping was undertaken using 1:15 000 scale airphotos.

Evidence for three deformation events (D_1-D_3) associated with three episodes of metamorphism (M_1-M_3) has been recognized in these gneisses north of the Flin Flon volcanic belt. At least four fold generations (F_1-F_4) were produced during D_1 and D_2 and resulted in the macroscopic fold pattern. D_1 was accompanied by prograde metamorphism (M_1) up to amphibolite facies conditions. D_2 was accompanied by local retrogression (M_2), development of coarse grained segregations and the intrusion of S-type granitic pegmatite dykes. Narrow shear zones associated with pseudotachylyte developed during D_3 at greenschist facies conditions (M_3).

D_1 STRUCTURES

The earliest recognized tectonometamorphic fabric is defined by leucocratic segregations that are sporadically developed in orthogneiss, which intrudes metasedimentary gneiss of the Burntwood Suite. In the northern part of the mapped area, the Burntwood Suite forms a schlieren migmatite.

Cm- to m-thick compositional layers, which may contain primary or metamorphic grading and cross-stratification, generally define S_0. However, S_0 commonly is impossible to recognize because of flattening and transposition during D_1. At least two fold generations (F_1-F_2) developed locally during D_1. S_0, leucocratic segregations and orthogneiss are folded by F_1 and F_2 folds. Both F_1 and F_2 folds are tight to isoclinal. F_1 folds commonly have sheared-out limbs and are intrafolial. An S_1 foliation, which is subparallel to S_0 is defined by flattened clasts, boudin trails and thin alternations of monomineralic layers. F_2 folds refold F_1 folds and contain a penetrative S_2 foliation, parallel to F_2 axial planes. S_2 is commonly oblique to S_1 and is defined by an alignment of medium grained amphibole in mafic gneisses and biotite, muscovite and flattened sillimanite faserkiesel in more quartz-rich gneisses. Some faserkiesel are also folded by F_2. However, due to the similar fold style of D_1 structures it is generally impossible to distinguish between fold generations without overprinting relationships. It is also probable folding and the development of axial plane foliations was a continuous process during D_1.

The best evidence for extensive deformation prior to F_2 folding is a common macroscopic repetition in stratigraphy. In places, separate thrust sheets can be identified. On the south shore of Kisseynew Lake, west of Lobstick Narrows, a repeated overturned stratigraphy forms the southern limb of a south-verging F_2 antiform. Similarly, a repeated overturned stratigraphy south of the Kississing River shear zone (KRSZ) forms the northern limb of an F_2 synform. This is interpreted as folding of F_1 thrust sheets during F_2. Elsewhere macroscopic F_1 folds are refolded by coaxial F_2 folds.

F_2 fold axes plunge between the northeast and southeast where there is little deformation by D_2 and D_3 structures. The variation in plunge appears to coincide with a well developed stretching lineation. F_2 folds south of the KRSZ plunge east to northeast and have a stretching lineation and mineral elongation (L_2) parallel to F_2 fold axes. A deformed clast within an F_2 closure has an aspect ratio of 1:2.5:17. North of the KRSZ L_2 is less well developed. L_2 is generally best developed on the overturned limb of macroscopic F_2 folds and south of the KRSZ towards the Flin Flon volcanic belt. Parasitic F_2 fold axes generally plunge towards the northeast where L_2 is well developed. Elsewhere F_2 fold axes plunge towards the east and southeast.

At least two fold generations (F_1-F_2) are interpreted to have formed during a major continuous episode of north to south crustal shortening. Euhedral garnets overgrow S_1 and S_2; this implies that peak metamorphism postdated D_1. S_1 and S_2 mineral assemblages also suggest that D_1 was concomitant with prograde metamorphism.

D_2 STRUCTURES

Open to tight F_3 folds that verge to the west refold F_2 folds and S_2. The style and orientation of F_3 folds is extremely variable and irregular. They are generally associated with coarse grained segregations, tourmaline-bearing veins and intrusion of S-type granitic pegmatite. D_2 segregations may also contain F-bearing biotite and scapolite. Northeast of the KRSZ, a major overturned southwest-verging F_3 synform with a wavelength of about 4 km, an axial trace towards 300° to 310° and a macroscopic S-asymmetry refolds F_2 folds. On the southwestern limb of this fold F_1 and F_2 folds plunge towards 060°-070°. On the eastern overturned limb refolded F_1 and F_2 folds are near-coaxial with F_3 folds. An S_3 foliation is defined in the hinge of F_3 folds by an alignment of fine grained biotite and recrystallized quartz parallel to the axial plane. An alignment of coarse grained amphibole and magnetite commonly overprints D_1 structures and is parallel to the axial trace of F_3 folds. Granitic pegmatite dykes also trend parallel to the axial trace of F_3 folds. South of the KRSZ, F_3 folds are open to tight, and their fold axes plunge northeast and are overturned on eastern limbs. These F_3 folds tend to occur in north-northwest-trending sinistral tensional zones that are up to 150 m wide and commonly contain S-type granitic pegmatite. Coarse grained microcline-bearing segregations and tourmaline-bearing segregations are oriented parallel to pegmatite dykes and occur within the necks of boudinaged S_2 foliation, which form F_3 scar folds. These boudin necks also plunge towards the northeast.

F_4 folds vary from open folds that trend and plunge northeast to tight kink folds with a Z-asymmetry. In schistose gneisses, F_3 and F_4 folds form a conjugate set about an approximate east-west direction. Some F_3 folds and segregations are reoriented about a northeast-plunging axis. This may reflect continual folding of D_2 structures during a progressive deformation and may imply a southeast-northwest principal shortening direction.

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The irregular style of folding and the development of segregations and granitic pegmatite in D_2 structures is interpreted to represent a widespread intracontinental east to west compressional deformation associated with a pervasive B-, F- , Cl-bearing fluid flow. Local retrogression also suggests that D_2 occurred at lower temperatures than D_1, but still within the sillimanite stability field.

D_3 STRUCTURES

D_1 and D_2 structures are deformed by thin continuous D_3 shear zones, which are associated with pseudotachylyte and greenschist facies metamorphism (M_3). Displacement during D_3 appears to have been small and unrelated to D_1 and D_2.

THE KISSISSING RIVER SHEAR ZONE

The Kississing River shear zone (Kississing River fault zone of Zwanzig, 1985; Schledewitz, 1988) extends from the Saskatchewan-Manitoba border and appears to terminate north of Kisseynew Lake. It is interpreted to be a D_1 ductile shear zone that was probably active during F_2 folding. This structural discontinuity marks a change in orientation of S_0 and S_1 foliations and in the style of D_2 structures. Ultramylonite that occurs in the footwall is deformed by D_2 kink folds and is cut by D_3 pseudotachylyte. The apparent termination of the KRSZ is probably due to it being folded about a large northwest-trending F_3 synform.

CONCLUSIONS

The complex outcrop pattern of gneisses that flank the northern margin of the Flin Flon volcanic belt is the result of marked depositional facies changes, primary and structural discontinuities, and fold interference associated with two major deformation events. An early leucocratic segregation and migmatite may be related to extension during deposition within an intra-arc or back-arc basin. D_1 produced nappes, thrust sheets and inclined folds during a continuous episode of north to south crustal shortening and thickening, which was concomitant with prograde metamorphism. D_2 produced irregular conjugate folds, kinks and crenulations during a widespread east to west intracontinental compressional deformation. D_2 was associated with the development of segregations and intrusion of granitic pegmatite, which was probably related to a pervasive fluid flow derived from the crust. D_2 occurred after the metamorphic peak at lower temperatures and pressures than D_1. The last recognized deformation (D_3) occurred under greenschist facies conditions within narrow shear zones.

It is suggested that gneisses exposed along the northern margin of the Flin Flon volcanic belt have a distinct structural style that differs from the steeply dipping structure in the Flin Flon volcanic belt and the flat-lying structure of gneisses exposed further to the north in the Kisseynew gneiss belt. The inclined to upright D_1 structures along the northern flank of the Flin Flon volcanic belt were probably responsible for the irregular style of deformation during D_2.

REFERENCES

Froese, E. and Gall, Q.

1981: Geology of the eastern vicinity of Kisseynew Lake, Manitoba; **in** Geological Survey of Canada, Current Research, Part A, Paper 81-1A, p. 311-313.

Frose, E.

1984: Geology of the Weldon Bay-Fay Lake area, Manitoba; **in** Geological Survey of Canada, Current Research, Part B, Paper 84-1B, p. 355-358.

Zwanzig, H.V.

1985: Kisseynew Project; **in** Manitoba Energy and Mines, Geological Services, Mines Branch, Report of Field Activities 1985, p. 51-53.

Schledewitz, D.C.P.

1988: Manitoba Energy and Mines, Preliminary Map Kississing Lake, 1988K-1, 1:20 000.

Zwanzig, H.V. and Schledewitz, D.C.P.

in press: Geology of the Kississing-Batty Lakes area; Manitoba Energy and Mines, Open File Report OF92-2.

GS-20 NATMAP DIAMOND DRILLING PROGRAM

by W. Weber

Weber, W., 1992: NATMAP diamond drilling program; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 100-101.

Ten diamond-drill holes were drilled in NTS 63K (Fig. GS-20-1) to ground-truth new aeromagnetic interpretations of the sub-Paleozoic Precambrian basement that were recently acquired by the GSC. Eight of these holes retrieved a total of 89.40 m of Precambrian core. Results of the drilling are incorporated in the new 1:250 000 scale Preliminary Compilation Map of Cormorant Lake (NTS 63K). Drill logs (measurements in metres) are presented below.

M-15-92
0.00-84.40 Paleozoic
84.40-87.45 weathered granitoid rocks
87.45-91.45 mesocratic, foliated biotite-hornblende tonalite, weakly porphyroblastic, pegmatitic dykes up to 20 cm
91.45-93.95 pink pegmatite
93.95-96.60 medium grained, biotite-hornblende tonalitic gneiss with pink feldspar porphyroblasts, with up to 20 cm thick pegmatitic portions
End of hole

M-17-92
0.00-53.30 Paleozoic
54.30-56.10 weathered granitoid rock
56.10-58.15 mesocratic granitoid biotite gneiss
58.15-66.40 pink pegmatitic granite with diffuse portions of fine- to medium-grained pink granitoid rocks, sphene bearing
66.40-68.75 medium grained pink granitoid rock, in part pegmatitic
End of hole

M-18-92
0 00-35.90 Paleozoic
35.90-36.20 weathered granitoid gneiss
36.20-39.95 leucocratic granitoid gneiss
39.95-41.65 pink pegmatite and medium grained grey tonalite
End of hole

M-19-92
0.00-55.30 Paleozoic
55.30-55.60 weathered granitoid rock
55.60-60.90 pink pegmatite
60.90-61.25 medium grained granite-tonalite
61.25-64.70 mesocratic to melanocratic hornblende-biotite tonalite (to granite?)
64.70-66.20 melanocratic tonalitic gneiss intruded by grey fine grained tonalite and younger pink medium grained granite
End of hole

M-21-92
0.00-61.35 Paleozoic
61.35-63.10 weathered granitoid rock
63.10-65.75 leucocratic pink granite to pegmatite
65.75-69.40 coarse amphibolite with white leucocratic granitoid mobilizate (+sulphide 1-5%)
69.40-71.70 pink pegmatite to granite
71.70-77.40 coarse amphibolite
77.40-77.65 pink pegmatite
End of hole

M-22-92
0.00-5.45 dolomite
5.45-6.00 weathered greenstone/mafic metavolcanic
6.00-9.50 sheared feldspar phyric mafic volcanic with epidote-rich veins
9.50-12.50 feldspar phyric mafic volcanic with brown, hematitic alteration of pyrite (?), and isolated amphibole porphyroblasts
12.50-32.50 mafic volcanic, in part fine grained, sheared (possibly flow top), in part medium- to-coarse grained (flow core), in part with hematitic alterations (as 9.50-12.50);
15.10-16.50 quartz vein
13.30-14.30 felsic (silicified?) portion
27.70-28.60 fine grained amphibolitic schist with pyrite
28.45-31.70 feldspar phyric dyke (?)
End of hole

M-23-92

0.00-14.25	medium sand and boulders of various lithologies (granitoid, ultramafic, mafic volcanic) hole abandoned

M-24-92

0.00-7.00	coarse sand and pegmatitic granite boulders
7.00-8.75	grey pegmatitic granite

End of hole

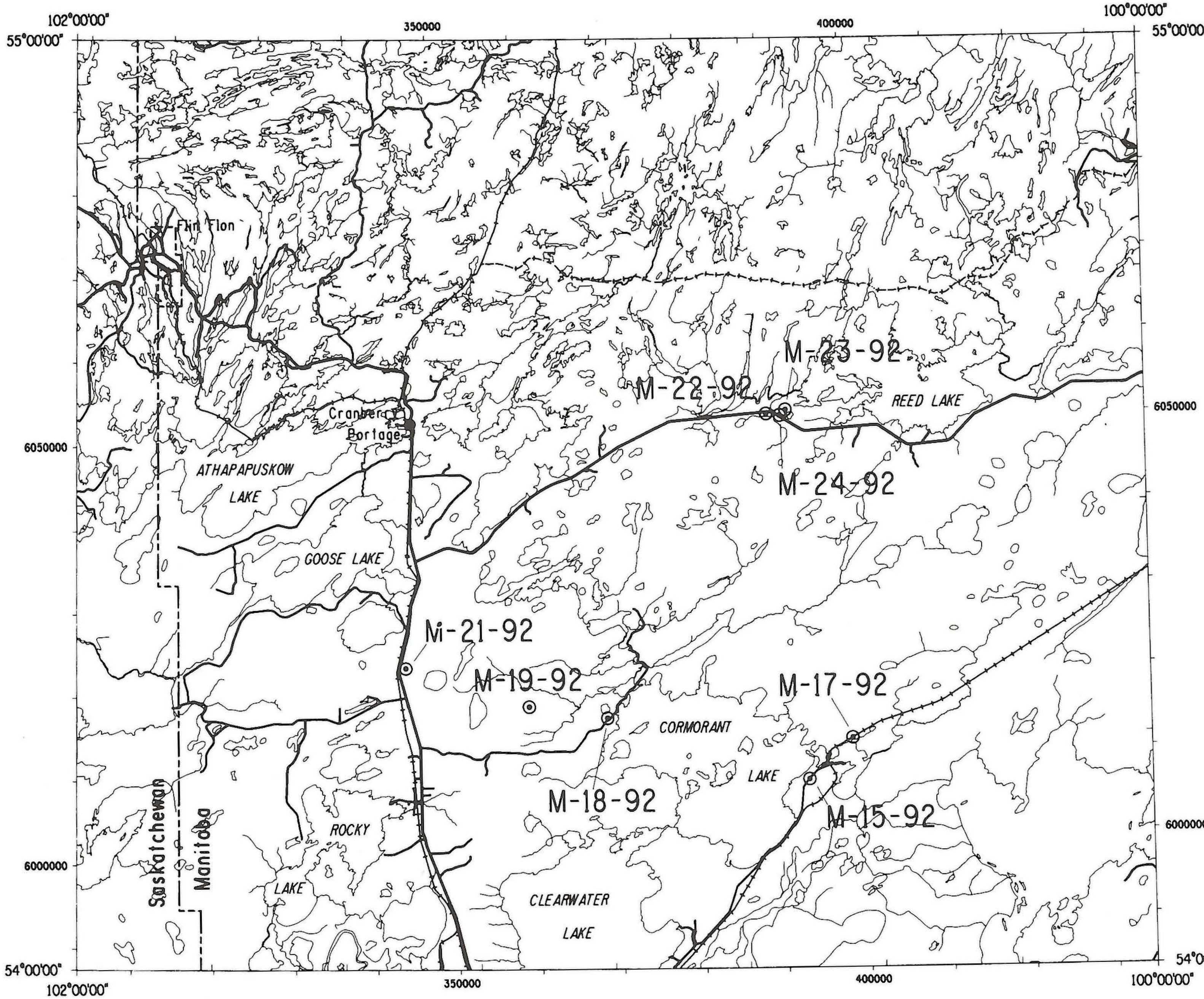

Figure GS-20-1: Location of drillholes of the 1992 NATMAP drilling program.

GS-21 NATMAP SHIELD MARGIN PROJECT: NEW RESULTS FROM MULTIDISCIPLINARY STUDIES IN THE FLIN FLON-SNOW LAKE BELT AND ITS SUB-PALEOZOIC CONTINUATION

by S.B. Lucas[1]

Lucas, S.B., 1992: NATMAP Shield Margin Project: New results from multidisciplinary studies in the Flin Flon-Snow Lake Belt and its sub-Paleozoic continuation; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 103-105.

OVERVIEW

The Shield Margin Project of the Geological Survey of Canada's (GSC) National Mapping Program (NATMAP) was initiated in March 1991 with the successful development of a joint GSC-Manitoba Geological Services Branch (MGSB)-Saskatchewan Geological Survey (SGS) proposal. The project is focused on the Cu-Zn-Ni-Au-rich Flin Flon-Snow Lake-Hanson Lake Belt and its sub-Paleozoic continuation in the area bounded by 99° and 103° west longitude and 54° and 55°15' north latitude. The Shield Margin Project is developing two fundamentally new geoscientific "map products" for this area: (a) a comprehensive digital geoscience database and map inventory, and (b) an interpretive map of the sub-Paleozoic continuation of the Flin Flon-Snow Lake-Hanson Lake Belt. A project team has been assembled and involves over 50 participants from the GSC, MGSB, SGS, the Saskatchewan Research Council (SRC) and the Universities of New Brunswick (UNB), Québec (à Montréal), Manitoba, Regina, Saskatchewan and Calgary. The Shield Margin Project has integrated with the PAMD (1991-96) programs in Manitoba and Saskatchewan, the Trans-Hudson Orogen Transect (THOT) of the Lithoprobe program, the international Metamorphic Map program, and has proceeded with the involvement of the local mineral exploration industry.

This report summarizes the principal achievements of the Shield Margin Project in its first operational year (to June 1992), and highlights new approaches, developed through the cooperative, multidisciplinary research program to the study of the Flin Flon-Snow Lake-Hanson Lake Belt and its sub-Paleozoic continuation. The success of the NATMAP project to date is a testament to the importance of integrated multidisciplinary research in generating new perspectives on geologically complex and economically important areas such as the Flin Flon-Snow Lake-Hanson Lake Belt.

This report summarizes the work of many individuals; much of this work is either unpublished or in preparation for publication. A listing of NATMAP Shield Margin Project working group members is found at the end of the report.

MAP PRODUCTS: 1991-92

The first four geological maps generated through NATMAP interagency cooperation were displayed at the November 1991 Manitoba and Saskatchewan Mineral Activity Forums and the January 1992 GSC Forum. These maps included the Elbow Lake (Manitoba), Kississing Lake (Manitoba), Batty Lake (Manitoba) and east Amisk Lake (Saskatchewan) areas. These preliminary maps were digitally produced from new and existing field data through the collaboration of the GSC, MGSB, SGS and UNB. Portable microcomputers were used in the field to store both map and numerical information in digital form. Several software packages were employed for field data acquisition, with each package customized to meet the particular needs and preferences of the user (GEODATA, FieldLog, FieldStation). This information was used to quickly generate preliminary digital geological maps in the field and was later transferred to central project databases at the GSC and UNB using standard data interchange formats. The preliminary colour maps were generated on UNIX-based workstations using ArcInfo and CARIS (GIS) software and were printed at the GSC using large-format colour plotters.

DIGITAL DATABASE

Significant progress has been made on the design and implementation of the central project digital database, which now houses topographic, geological, geophysical, radar, LandSat and geochronological datasets for parts of the project area. During the life of the project, all geoscience data for the project will reside in a central database. This will facilitate distribution, GIS analysis and the generation of digital map products. However, at the conclusion of the project, the digital database and the digital map products will reside (physically or through high-speed network access) at all participating institutions. Digital data for the project area currently resides in a number of government and university databases (principally SGS, MGS and UNB) that are both geographically dispersed and widely varied in format. Standard data interchange formats are being refined to enable rapid transmission of data, using high-speed computer networks between participants, where possible, and ultimately to clients interested in some or all of the project database. The data from the various sources is being rationalized at the GSC using Oracle database management software while ArcInfo is being employed to analyze and display the data, and generate high-quality hardcopy products. Important recent achievements include the final development and implementation of the symbol library and database structure agreed upon at the NATMAP Spring Workshop (see below).

ISOTOPIC RESULTS

An important component of the NATMAP Shield Margin Project is the provision of new isotopic and geochronological data in order to improve our understanding of the tectonostratigraphic evolution of the Flin Flon-Snow Lake-Hanson Lake Belt. The focus of the study to date has been the measurement of Nd/Sm isotopic compositions in volcanic and plutonic rocks of the Flin Flon and Snow Lake areas. A first-order conclusion from the Nd-isotopic study of approximately 100 samples is that the volcanic arcs were influenced at a relatively early stage in their development by older crust, probably Archean in age (Stern *et al.*, 1992). In addition, the economically important massive sulphide deposit-bearing volcanic sequences near Flin Flon and Snow Lake have distinctive Nd-isotopic profiles that provide a new and powerful tool for stratigraphic correlations. U/Pb geochronological studies on rocks from the project area are being undertaken at present by 4 laboratories: GSC, U. Saskatchewan, Royal Ontario Museum (through SGS) and GEOTOP (U. Québec à Montréal). Investigation of the geochronology and Nd-isotopic composition of drill core samples has been initiated in support of the sub-Paleozoic interpretation component of the Shield Margin Project.

BEDROCK GEOLOGY COMPILATION PROGRAM

Three major bedrock geological compilation projects, each spanning the Manitoba-Saskatchewan border, were initiated in 1992: (1) NTS 63K at 1:250 000; (2) a 1:50 000 compilation centered on Flin Flon-Creighton and including all recent mapping in both provinces between Amisk Lake and Athapapuskow Lake; and (3) a 1:50 000 compilation of the south margin of the Kisseynew Belt. Compilation of each map is being undertaken as a joint MGSB-SGS-GSC project, with digital cartographic support provided by each organization and by UNB. As each compilation map is finalized in digital form, it will be transferred into the central GIS for the project and integrated with other datasets (*e.g.*, LandSat and radar imagery, geochronological and isotopic results, gravity, magnetics) for analysis and further study. NTS 63K is being readied for display in November 1992; it will contain an interpretive map of the sub-Paleozoic geology. The compilation program's goal is to come up with 1:100 000 compilation maps for the entire project area (both shield and sub-Paleozoic geology) by the end of the project (spring 1996).

1 Geological Survey of Canada

INTERPRETATION OF SUB-PALEOZOIC GEOLOGY

A fundamental component of the NATMAP Shield Margin Project is the development of an interpretive geological map for the sub-Paleozoic continuation of the Flin Flon-Snow Lake-Hanson Lake Belt in Manitoba and Saskatchewan. High resolution aeromagnetic data (total field and vertical gradient) was collected in NTS 63 J, K, L to complete the high resolution coverage south of the Shield Margin area to 54° north latitude, and between 99° and 103° west longitude. In addition, a program designed to enhance the density of gravity stations on top of the Paleozoic cover in the project area was initiated this year, to provide critical data required for the interpretation of the aeromagnetic surveys. Detailed analysis of the high resolution aeromagnetic data on a flight line by flight line basis, integrated with the gravity data, led to the development of a preliminary pseudo geology map for the sub-Paleozoic portion of NTS 63K. "Ground truth" constraints for this interpretation are being provided through a regional study of Precambrian drill core, in Manitoba and Saskatchewan, recovered by industry in the course of mineral exploration south of the Shield Margin. The drill core study is being undertaken by A. Leclair (GSC).

Field activities this summer in support of this project included: (i) systematic documentation and assessment of sub-Paleozoic drill core at government and industry core facilities; (ii) relogging of core using a regionally relevant legend; (iii) measurement of density and magnetic susceptibility of the core; (iv) selection of samples for metamorphic, geochemical, tracer isotope and geochronological studies; and (v) examination of the exposed Precambrian geology in the Shield Margin area to correlate both rock types and magnetic susceptibility-density units between outcrops and drill core. The drill core mapping, coupled with preliminary results from the isotopic, rock property and metamorphic studies of the drill core, has enabled regional correlation of major tectonostratigraphic units to be made between the exposed part of the Flin Flon Belt and the buried Precambrian rocks.

QUATERNARY GEOSCIENCE SURVEYS

Quaternary and environmental geoscience studies are being undertaken by the GSC, MGSB and SRC (on contract to the GSC). Emphasis to date has been on regional mapping and airphoto/satellite image interpretation, compilation, and till geochemistry and provenance studies.

NATMAP Shield Margin Project: 1st Annual Spring Workshop

The first annual NATMAP Shield Margin Project workshop was held on May 5-7 (1992) in Winnipeg and was an unqualified success. The workshop was attended by 26 scientists from the GSC, MGSB, SGS, Saskatchewan Research Council and the Universities of New Brunswick and Saskatchewan. At the start of the day-long general session participants were offered an overview of progress and plans in all project areas. The remainder of the meeting was spent addressing more detailed aspects of the project in four thematic working groups. The working groups addressed: (a) digital database design and standards, (b) Quaternary and environmental geology; (c) a 1:50 000 "trans-border" geological compilation in the Flin Flon area; and (d) a 1:50 000 "trans-border" geological compilation of southern Kisseynew Belt geology. Each of the working groups made substantial progress towards achieving new results and setting goals and work schedules for the next 6 months. The principal results of the working group sessions are summarized in the next 2 paragraphs.

The Quaternary working group discussed and planned the mapping and sampling program for the field season, including agreements on the sedimentological and geochemical analysis of samples, Quaternary geological legend, Quaternary field-based digital systems, and procedures for the digital compilation of maps. In addition, the group also had a brief field excursion into the Bissett area (NE of Winnipeg).

The digital database group made extensive progress towards the design of the overall database structure, topographic base standards, file transfer formats, and together with the geologists, agreed on a set of symbols for geological maps. Geologists working in the Flin Flon-Creighton area developed a legend for the 1:50 000 compilation map that will unite the interpretation of Manitoba-Saskatchewan border geology. Similarly, detailed discussions were held by the group undertaking the trans-border compilation of geology north of the "Kisseynew Lineament" that lead to an agreement on a legend for the compilation area and recompilation of geology in the Duval Lake area (adjacent to the Manitoba-Saskatchewan border).

Additional results of the meeting included the further development of geochronological and isotope research programs (R. Stern, K. Ansdell); sub-Paleozoic drilling, drill core study and "ground-truthing" in the exposed shield (A. Leclair); and discussion of plans for detailed gravity surveys in the Flin Flon-Snow Lake Belt and the Kisseynew Domain (M. Thomas). Field trips were planned for several areas in Manitoba and Saskatchewan (Snow Lake, June 3-4; Flin Flon-East Amisk, June 5-7; West Amisk, June 8-9). Annual or semi-annual workshops are planned for the duration of the entire NATMAP Project.

REFERENCES

Stern, R.A., Syme, E.C., Bailes, A.H., Galley, A.G., Thomas, D.J. and Lucas, S.B

1992: Nd-isotopic stratigraphy of Early Proterozoic Amisk Group metavolcanic rocks from the Flin Flon Belt; **in** Radiogenic Age and Isotopic Studies: Report 5, Geological Survey of Canada, in press.

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GS-22 SHIELD MARGIN PROJECT PROGRESS REPORT

by P.G. Lenton

Lenton, P.G., 1992: Shield Margin Project progress report; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 106.

In the spring of 1991 Manitoba Geological Services, the Saskatchewan Geological Survey and the Geological Survey of Canada initiated the Shield Margin Project (SMP) in the Hanson Lake - Flin Flon - Snow Lake area as the first Precambrian project of the new federally sponsored National Mapping Program (NATMAP). Central to NATMAP is a totally new thrust in geological mapping technology; the use of computerized Geographic Information System (GIS) technology to house all available information for each project area and to develop geological maps by computerized graphic technology utilizing the comprehensive databases.

The Shield Margin Project will produce two principal types of products; (1) 1:100 000 compilation maps of exposed geology and 1:250 000 compilation of extrapolated sub-Paleozoic geology, and (2) a comprehensive digital database for the entire project area. The first year of the project focussed on development of technology and methodology with a number of "technology demonstration" outputs produced between November 1991 and February 1992. These included 1:20 000 geological maps for Elbow Lake in Manitoba and East Amisk Lake (Table Lake) in Saskatchewan, and 1:50 000 geological maps for Batty Lake and Kississing Lake in Manitoba. The 1:20 000 maps were produced from current year mapping projects with an elapsed time of approximately 3 months from the completion of mapping to the release of full colour preliminary maps for each project. The 1:50 000 maps were produced at the University of New Brunswick from existing preliminary maps of older programs to demonstrate the feasibility of scanning and vectorizing archival maps. The Geological Survey of Canada produced geophysical and thematic maps for selected areas to show the integration of numeric and spatial analysis technology into the NATMAP program. All of these products were displayed at the annual Open House presentations for each organization in November 1991 and January 1992.

The first year of the SMP culminated in a three day workshop held in Winnipeg on May 5-7, 1992. The workshop was attended by 26 geoscientists from the GSC, Manitoba Geological Services, Saskatchewan Geological Survey, Saskatchewan Research Council and the Universities of Saskatchewan and New Brunswick. The workshop was used to establish lines of communication between agencies, start compilation projects and set out the work plan for the coming year. Attendants represented all agencies and geoscience disciplines, including provincial, federal and university geologists, Quaternary geologists, geophysicists, isotope geochemists and GIS specialists. Highlights of the workshop include:

- completion of a preliminary 1:100 000 compilation map for the exposed area of the Shield Margin Project to be used for Lithoprobe interpretation;
- completion of a working legend for Manitoba-Saskatchewan cross-border compilation in the Flin Flon greenstone belt;
- completion of a working legend for Manitoba-Saskatchewan cross-border compilation in the Kisseynew gneiss belt;
- preliminary list of map symbols designed for use on all NATMAP products;
- preliminary design of database schema for the NATMAP digital database; and
- development of a common working base for Quaternary geology studies including analysis techniques, Quaternary geology legend and digital database design and systems.

NATMAP related field programs undertaken in Manitoba in 1992 included provincial, federal and university projects. The field season opened with a field trip led by E.C. Syme (MGS) and D. Thomas (SGS) that covered the stratigraphy and setting of the Flin Flon - Creighton area and the Mystic Lake (Saskatchewan) and Athapapuskow Lake areas. The field trip was attended by representatives of the Geological Survey of Canada, Manitoba Geological Services, Saskatchewan Geological Survey and University of New Brunswick.

The following field projects were undertaken:

Manitoba Geological Services:

- E. Syme (MGS) completed 1:20 000 mapping of the Elbow Lake map sheet;
- A. Bailes (MGS) and A. Galley (GSC) completed 1:5000 and 1:20 000 mapping in the Snow Lake area;
- P. Gilbert (MGS) started 1:20 000 mapping in the south Wekusko Lake area;
- D. Schledewitz (MGS) continued 1:20 000 mapping in the Fay - Webb lakes area of the south Kisseynew;
- H. Zwanzig (MGS) expanded mapping at 1:20 000 in the Batty Lake area;
- G. Gale, L. Norquay, T. Heine and D. Prouse (MGS) continued detailed 1:5 000 mapping in the North Star Lake area; and
- E. Nielsen (MGS) completed the till sampling program for the Elbow Lake map sheet with approximately one till and humus sample per km^2. The samples are currently being analyzed for a broad spectrum of base and trace elements.

Universities:

- T. Norman (University of New Brunswick) undertook 1:3 000 and detailed structural studies in the Kisseynew Lake area;1
- C. Dyck (UNB) completed detailed structural mapping at Puffy Lake;[1]
- J. Kraus (UNB) started detailed structural studies at Snow Lake; and
- J. David (Université du Québec à Montréal) sampled for U/Pb zircon studies of sedimentary and plutonic rocks in the Flin Flon area.[1]

Geological Survey of Canada:

- J. Whalen completed mapping of plutonic rocks in the Elbow Lake sheet and started on the major batholithic bodies to the east;
- R. Stern did sampling for Nd isotope and U/Pb zircon studies in the Flin Flon belt;
- K. Ansdell started U/Pb zircon studies on the Missi Group rocks at Flin Flon;
- A. Leclair continued detailed re-examination of Precambrian core from beneath the Paleozoic cover and started correlation studies along the edge of the exposed shield;
- I. McMartin started a program of Quaternary mapping and till sampling in the south east segment of the NATMAP area;
- M. Thomas undertook detailed potential field studies in the Kisseynew belt; and
- L. Tanczyk sampled in the NATMAP project area for physical property studies of rock in support of the potential field study program.

Several products were completed for the fall of 1992. The 1:20 000 Elbow Lake map released in colour preliminary form in November of 1991 will be re-issued including the results of the 1992 field season. Detailed 1:5 000 maps in the Snow Lake area will be issued in colour preliminary form. A preliminary colour compilation at 1:250 000 for the Cormorant Lake sheet (NTS 63K), including interpreted sub-Paleozoic bedrock geology, is targeted for completion by November, 1992.

The digital database design project is well advanced with a preliminary demonstration of detailed databases linked with maps in the GIS (using the Elbow Lake project) targeted for November.

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1 These projects are funded by LithoProbe primarily as part of geological contributions to the Trans-Hudson Orogen Transect but also contribute to NATMAP.

GS-23 MINERAL DEPOSIT INVESTIGATIONS ON ELK ISLAND AND JOWSEY ISLAND IN THE GODS LAKE AREA (NTS 53L/9)

by P. Theyer

Theyer, P., 1992: Mineral deposit investigations on Elk Island and Jowsey Island in the Gods Lake area (NTS 53L/9); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 107-109.

INTRODUCTION

Selected mineral deposits and occurrences on Elk Island and Jowsey Island in the Gods Lake area (NTS 53L/9) were mapped and sampled as part of geological investigations initiated in 1991 (Theyer, 1991a and b). Geological mapping of selected areas was conducted at a 1:5 000 scale in 1992.

Figure GS-23-1 shows the historically most important gold occurrences on Jowsey and Elk islands, and the location and extent of detailed 1992 geological work.

Gold mineralization occurs:

a) on, and in the vicinity of, Jowsey Island;
b) on the northern shore of Elk Island, west of Margaret Lake;
c) in the host rock between #1 and #2 shafts at Gods Lake Gold Mine; and
d) near the shore of southeastern Elk Island

Jowsey Island area

Figure GS-23-2 shows the geology underlying the former Jowsey Island Gold Mine. The mineralization is associated with a 10 m wide, northwest-striking shear zone. Intense shearing, coupled with siliceous and carbonate alteration has obliterated much of the original lithologies that consist mainly of massive and pillowed mafic flow rocks intruded by quartz-feldspar porphyry. The mafic rocks within the shear zone are also altered to siliceous, partially carbonatized schists, whereas the quartz-feldspar porphyries show only evidence of minor deformation and no evidence of alteration. A lense of beige-weathering, aphanitic felsic rock that outcrops on the shore of the island west of the shaft is interpreted to be an altered part of the mafic extrusive suite.

Trace to 5% pyrite and trace chalcopyrite are ubiquitous in the sheared mafic rocks. Subtle differences in the concentration of sulphides are manifest in the weathered colour of the outcrops.

Three rock samples were cut across the Jowsey Island shear zone (cuts A, B and C, Fig. GS-23-1 and -2) and analyzed for gold. Gold concentrations in rocks from cut A vary widely and abruptly from 10 to 61 ppb (background) in the first 3.5 m (from N to S) to 0.3 to 5 g/tonne in the following 2.5 m. Rocks from cuts B and C, contain background gold concentrations. A grab sample from a carbonatized shear zone on an island approximately 400 m east of the Jowsey mine shaft contained 13 g/t gold (Sample 91-357 on Fig. GS-23-1).

These results suggest that in the vicinity of the Jowsey Island shaft, gold occurs within discrete sulphide-rich portions of shear zones. A geophysical survey with a method especially sensitive to disseminated sulphides, such as IP, would be useful to delineate mineralization in this area.

North shore of Elk Island

A shear zone that is from 1 to 5 m wide and strikes 290° (Fig. GS-23-1) crosscuts a gabbroic to hornblenditic dyke, and contains up to 20% pyrite and traces of chalcopyrite and pyrrhotite (Theyer, 1991b). This part of the shear zone had been previously investigated with four, now largely rubble-filled, trenches. Gold concentrations in grab samples from the trenches, range from 25 ppb to 4 g/t.

Gods Lake Gold Mine

Detailed mapping in the area between the two shafts at the Gods Lake Gold Mine (Fig. GS-23-3) indicates that the ore-bearing rocks of the former mine are part of a north-facing sequence of sedimentary and volcanic rocks in fault contact with a gabbroic to hornblenditic dyke to the south.

The sulphide-bearing layer consists of a 1.5 to 2 m thick, beige to buff weathering, very fine grained to aphanitic felsic rock. Parts of this layer contain grey to slightly translucent white, 1 to 2 cm thick and up to 5 cm long cherty fragments. Stratigraphically underlying the felsic rocks is an approximately 3 m thick sequence of black slate and wacke that is in a fault contact with a gabbroic- hornblenditic dyke. Stratigraphically overlying the felsic layer there is an approximately 50 cm thick unit of wacke, that is overlain by approximately 25 m of pillowed

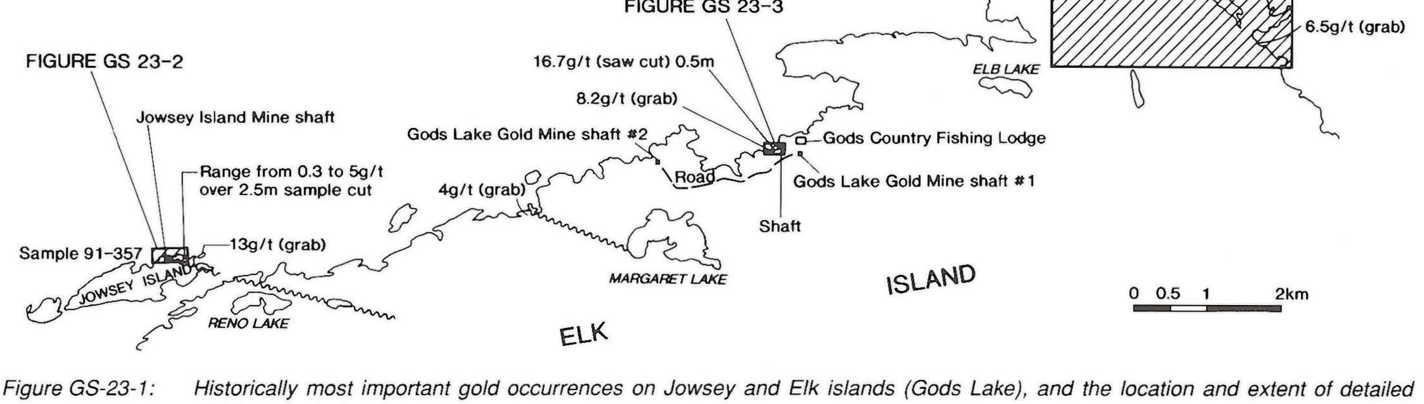

Figure GS-23-1: Historically most important gold occurrences on Jowsey and Elk islands (Gods Lake), and the location and extent of detailed 1992 geological work.

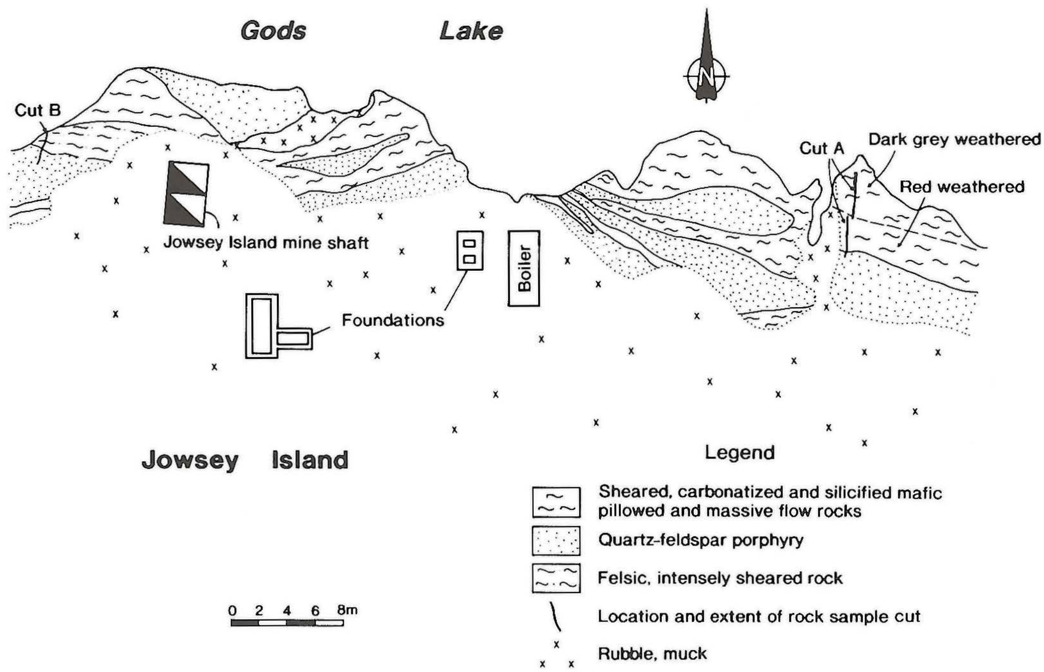

Figure GS-23-2: Detailed geological map of the Jowsey Island Gold Mine area.

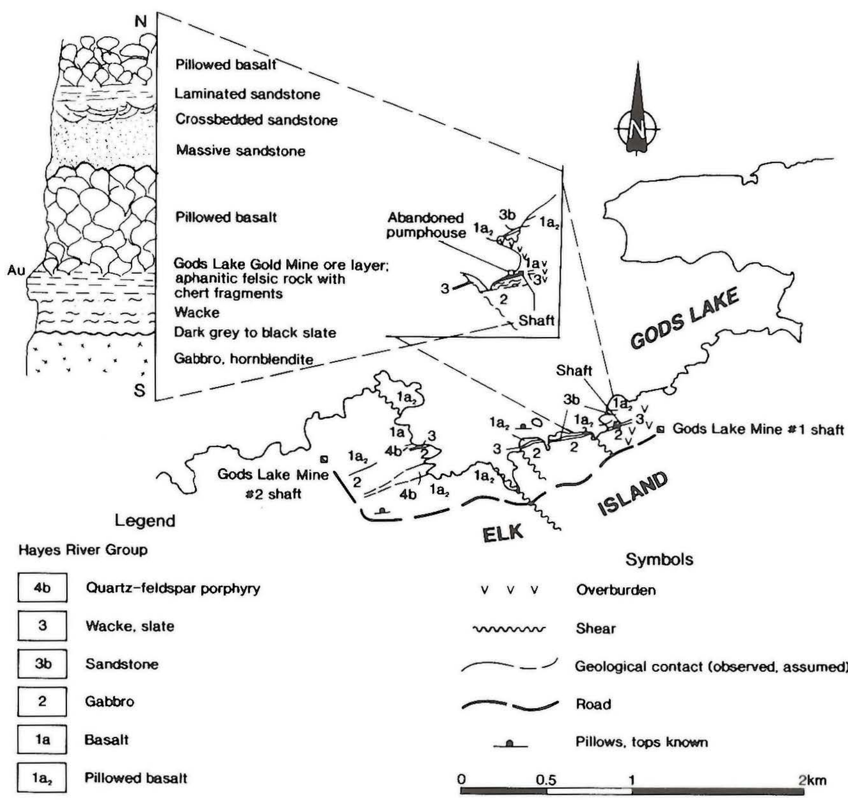

Figure GS-23-3: Geology and stratigraphic position of the gold-bearing rocks in the Gods Lake Gold Mine.

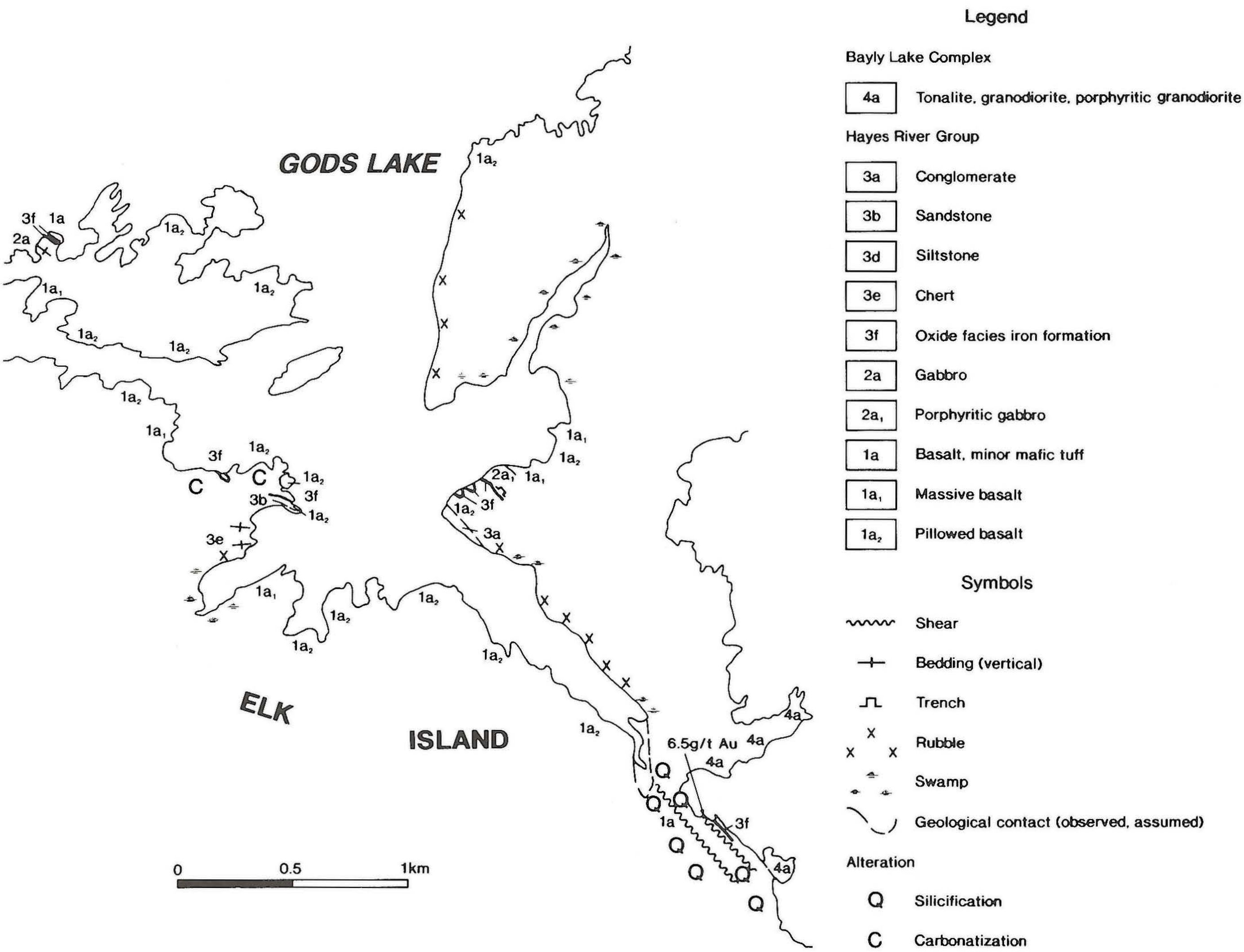

Figure GS-23-4: Geology of a part of eastern Elk Island.

basalt. The pillowed basaltic unit is stratigraphically overlain by a 1 m thick layer of sandstone that is in turn overlain by a 1 m thick unit of crossbedded sandstone and a several metre thick pillowed mafic flow.

Sulphide mineralization is restricted almost exclusively to the silicified layer. At least three, discrete, sequential mineralization events can be distinguished on the basis of sulphide crystal textures and crosscutting relationships.

Southeastern Elk Island

A close relationship between silicate facies iron formation, sandstone, wacke, cherty slates, pillowed mafic flows, feldspar phyric and glomeroporphyritic gabbro is evident from Figure GS-23-4. On a peninsula on the western shore of the bay (Fig. GS-23-4) a sequence of sandstone and wacke is overlain by silicate facies iron formation that is intruded and disrupted by pillowed mafic flows.

Sheared and bleached, massive and pillowed flows are associated with an up to 500 m wide zone of intense silicification that parallels a major shear zone and has a strike of 315° and transects eastern Elk Island (Fig. GS-23-1). A number of parallel shears are mineralized with up to several cm thick pyrite layers. A grab sample of a pyrite-bearing shear zone, contained 6.5 g/t gold.

Summary

In the Elk Island and Jowsey Island area of Gods Lake, gold occurs within discrete sulphide-rich parts of shear zones (Jowsey Island, northwest shore of Elk Island west of Margaret Lake, and on the south shore of Elk Island), or stratabound to an interval of fine grained sedimentary rocks in a sequence of mafic extrusive rocks. Further investigations of these targets should be undertaken using geophysical methods because rock geochemistry and geology are impeded by dense coverage with vegetation.

REFERENCES

Theyer, P.

1991a: Mineral deposit investigations in the Gods Lake area (NTS 53L/9, 53L/10, 53L/16); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, p. 58-60.

1991b: Elk Island and Jowsey Island (NTS Part of 53L/9); Manitoba Energy and Mines, Minerals Division, Preliminary Map 1991G-1, 1:20 000.

GS-24 RELOGGED DRILL CORE FROM THE SUB-PHANEROZOIC SW EXTENSION OF THE THOMPSON NICKEL BELT (NTS 63J, NTS 63G)

by C. R. McGregor and J. J. Macek

McGregor, C.R. and Macek, J.J., 1992: Relogged drill core from the Sub-Phanerozoic SW extension of the Thompson Nickel Belt (NTS 63J, NTS 63G); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 110.

INTRODUCTION

Core from 47 drillholes into sub-Phanerozoic Precambrian rocks (Fig. GS-24-1) were relogged in 1992 (McGregor and Macek, 1992) in order to identify major lithologies within a projected southern extension of the Thompson Nickel Belt under the Phanerozoic cover. Only the nonconfidential complete core stored in the provincial core library in Thompson was examined.

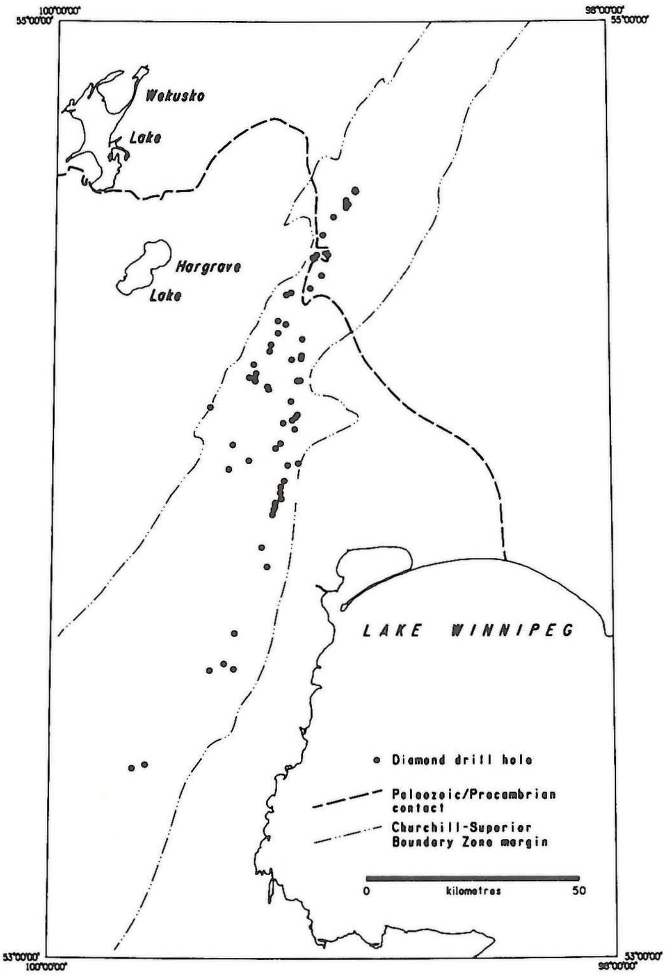

Figure GS-24-1: Location of sub-Phanerozoic drillholes within the Churchill-Superior Boundary Zone in NTS 63J and NTS 63G (after McGregor and Macek, 1992).

Thirty-four of the holes were drilled by Amax and the other thirteen by Cominco. An additional 15 holes (10 Cominco and 5 Amax) were previously relogged by Macek and Nagerl (in press). All the holes were drilled between 1967 and 1975 by Amax and Cominco as part of their regional drilling programs in which a total of approximately 350 holes (175 holes each) were drilled within the interpreted Churchill-Superior Boundary Zone in NTS 63J and NTS 63G. The rest of the Cominco core is no longer available and that of Amax was condensed.

The results of the relogged core were plotted on a 1:250 000 map (NTS 63J and NTS 63G) that records the location of the drillholes and intersected host and target lithologies (McGregor and Macek, 1992). In addition, a catalog containing a summative log, a cross section and a colour photograph documentation for each drill hole, is available to the public for viewing. It is also available for reproduction at cost.

Preliminary work has revealed that several holes contained Ospwagan Group supracrustal rocks. In addition, ultramafic rocks and iron formation (both oxide and sulphide facies) were intersected in some holes.

REFERENCES

Macek, J.J. and Nagerl, P.
in press: Sub-Paleozoic Precambrian geology of the Churchill-Superior Boundary Zone between Hargrave and Minago Rivers (NTS 63J); Manitoba Energy and Mines, Open File Report.

McGregor, C.R. and Macek, J.J.
1992: Location map of relogged nonconfidential core from the SW extension of the Thompson Nickel Belt.

GS-25 GEOLOGY OF CHROMITITE LAYERS ON THE PAGE PROPERTY, BIRD RIVER SILL, SOUTHEASTERN MANITOBA

by J. Young[1]

Young, J., 1992: Geology of chromitite layers on the Page Property, Bird River Sill, southeastern Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 111-113.

INTRODUCTION

The Bird River Sill is a south-facing, ultramafic to mafic layered intrusion emplaced into metavolcanic rocks of the Bird River greenstone belt in southeastern Manitoba. The sill hosts the most significant known concentration of chromite in Canada. Previous mapping of the chromitites has been largely restricted to the Chrome property (Scoates, 1983; Scoates *et al.*, 1988).

A short mapping program on the scale of 1:2 000 was undertaken in 1992 to; (a) produce a detailed map of the chromitite seams in the area of the Page property, and (b) to compare the stratigraphy of chromitites in the Page property with that of the Chrome property.

GENERAL GEOLOGY

The Page property is located on a 2.5 km long section of the Bird River Sill, 2.3 km northeast of the Chrome property (Figure GS-25-1). In the map area the Ultramafic Series (Scoates *et al.*, 1988) consists of the Massive Peridotite Zone overlain by the Chromitiferous Zone; the Chromitiferous Zone has a maximum thickness of 70 m and is in sharp contact with the overlying Mafic Series, except locally where the Transition Series appears to be present. Mapping was restricted to the Chromitiferous Zone, but in areas where the chromitite stratigraphy was absent, examination extended over 200 m north of the contact between the Ultramafic Series and the Mafic Series.

The ultramafic rocks comprise; (a) olivine-chromite cumulates that are commonly smooth weathered and less commonly knobby weathered, and (b) numerous chromitite seams. Chromitite seams comprising 60 to 90% chromite are defined as dense, and those containing 15 to 60% as diffuse (Scoates, 1983).

SUMMARY OF THE CHROMITITE STRATIGRAPHY ON THE PAGE PROPERTY

The stratigraphy of the chromitites at the Page property is similar to that defined at the Chrome property (Scoates, 1983). From north to south, the six suites of chromitite seams are: (a) lower chromitites; (b) disrupted layer series; (c) lower main suite; (d) banded layer - diffuse layer suite; (e) upper main chromitites; and (f) upper chromitites. Detailed descriptions of these chromitite suites are given by Scoates (1983). Chromitite layers dip between 53° and 82°S.

1 University of Manitoba

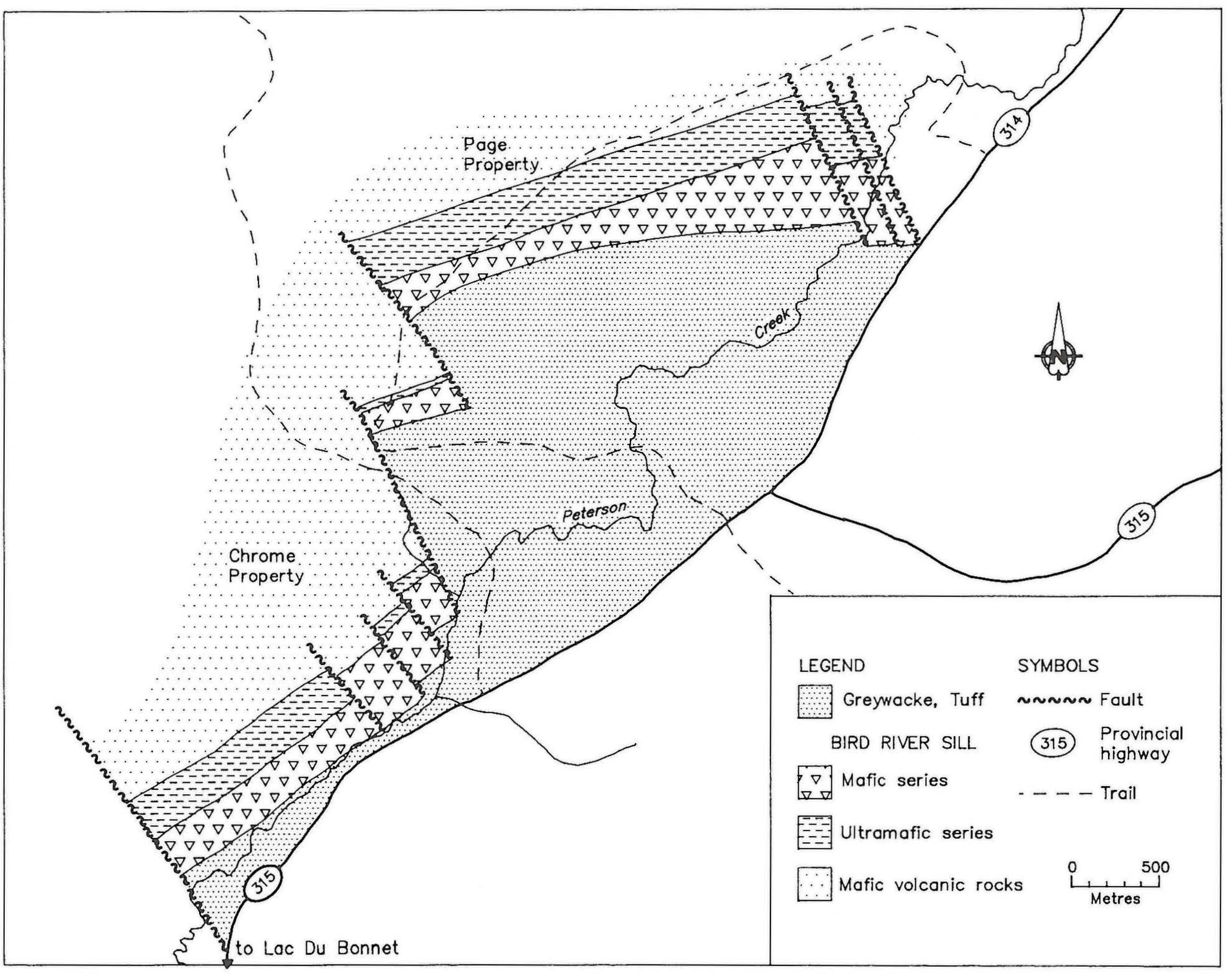

Figure GS-25-1: General geology of the Bird River Sill (modified from Trueman and Macek, 1971).

Besides the similarity between chromitite stratigraphy on the Chrome and Page properties the most important results of the mapping are:

1. The chromitite stratigraphy is discontinuous along strike. Chromitite suites were only observed in the eastern part of the property over a strike length of about 850 m (Preliminary Map 1991R-1). Over this strike length, the lower and upper chromitites were only observed locally, but the other suites of chromitite seams occur throughout. West of the mappable chromitite stratigraphy, the disrupted layer suite was observed on two widely separated outcrops (Preliminary Map 1991R-1). Other chromitite suites that are not part of the chromitite stratigraphy defined by Scoates (1983) and that have limited lateral extent are plotted on Preliminary Map 1991R-1. The best occurrences are described in Table GS-25-1.
2. Outcrops with well exposed chromitite stratigraphy indicate that the area was intensely faulted; both right lateral and left lateral offset were mapped. Displacements of the stratigraphy range from 0.5 cm to 90 m and are largest along right lateral faults. The thickness of the chromitite units change slightly across faults suggesting some rotation during fault movement.
3. A new sequence of chromitite layers, the Page chromitite suite, has been defined on the Page property. These chromitites occur between the disrupted layer suite and the lower main suite.

PAGE CHROMITITE SUITE

The Page chromitite suite occurs locally at the east end of the Page property. It is a 3 to 7.5 m thick sequence of chromitite layers that occurs 4 to 15 m above the disrupted layer series.

The Page chromitite suite comprises a 5 to 10 cm thick dense chromitite layer overlain by diffuse, layered chromitites and local olivine-chromite cumulates. The dense chromitite is locally absent. In one outcrop the Page chromitite suite forms a slump structure; the dense chromitite is discontinuous and occurs as irregular or blocky, angular pieces.

The diffuse layered chromitites are straight or wavy; wavy chromitites are commonly discontinuous. Diffuse chromitites are two millimetres to several centimetres thick. Angular to rounded patches of olivine-chromite cumulates occur throughout the areas of diffuse layered chromitites and appear to penetrate into the top of the dense chromitite layer.

MISCELLANEOUS CHROMITITE LAYERS

Distributed throughout the Chromitiferous Zone are numerous chromitite layers and laminae that are not part of the chromitite stratigraphy. These layers are discontinuous and vary from dense to diffuse and range in thickness form 1 mm to several centimetres. The main occurrences are described in Table GS-25-1.

Table GS-25-1

Miscellaneous chromitite occurrences. (Locations plotted on Preliminary Map 1992R-1)

Location	Thickness	Description
1	Up to 10 cm	These chromitites occur about 14 m below the Mafic series. There is one discontinuous dense chromitite that is disrupted by pegmatitic peridotite. Average thickness is about 5 cm.
2	3.2 m	These chromitites occur about 6 m above the lower chromitites. There are three discontinuous dense chromitite layers that range from 2 to 30 cm in thickness. The chromitites are separated by olivine-chromite cumulates that compose 2.75 m of the section.
3	47.7 cm	These chromitites occur about 25 m below the Mafic series. There are 4 diffuse chromitite laminae that have a total thickness of 1.2 cm separated by 2.5 to 36 cm thick olivine-chromite cumulates layers.
4	15.5 cm	These chromitites occur about 35 m below the Mafic series. There are 2 diffuse layers that have a total thickness of 0.9 cm, and 1 dense layer that is 1.1 cm thick. The chromitites are separated by olivine-chromite cumulates that range in thickness from 1.0 to 12.5 cm.
5	40 cm	These chromitites occur about 10 m above the lower chromitites. There are discontinuous dense chromitites that con tain silicate inclusions in the lower 25 cm. These chromitites are overlain by olivine-chromite cumulates that contain dense chromitite balls. The chromitite balls are randomly distributed or occur in trains up to 12 cm across. In the upper 20 cm of the suite there are also diffuse chromitite balls. Chromitites compose about 15% of the section.
6	8.5 cm	These chromitites occur about 31 m below the Mafic series. There are 3 dense chromitite layers that have a total thickness of 3.1 cm; the dense chromitite layers are separated by olivine-chromite cumulates that are 1.2 to 2.2 cm thick.
7	Up to 5.5 m	These chromitites occur about 88 m below the Mafic series. There is a 20 cm thick section of 5 olivine-chromite cumulate layers that are 2 to 4 cm thick; in the upper 1 cm of each layer chromite increase upwards to a maximum of 20%. In the upper 2 cm of this section there are also 3 chromitite laminae. These chromitites are overlain by 22 cm of olivine-chromite cumulate that contain 2 diffuse chromitite laminae. The olivine-chromite cumulate is overlain by 3 diffuse chromitite laminae that are interlayered with olivine-chromite cumulate. These chromitites are overlain by 1.4 m of olivine-chromite cumulate that are in turn overlain by 3 m of diffuse chromitite . The top of the occurrence is a 57 cm thick section comprising 7 diffuse chromitite laminae that are 2 to 7 mm thick; these chromitite laminae are sepa rated by olivine-chromite cumulates that are 2 to 9.5 cm thick.
8	20 to 30 cm	This chromitite occurs about 13 m below the Mafic series. There is one dense chromitite layer that contain local lami nae of olivine-chromite; olivine composes up to 10% of the laminae.
9	Up to 50 cm	These chromitites occur about 4 m below the Mafic series. The lower half of the occurrence is a 14.5 cm thick section of diffuse chromitites that grade into an overlying dense chromitite that is 4 cm thick. The dense chromitite is overlain by 3.5 cm of olivine-chromite cumulates that are, in turn, overlain by 3 dense chromitite layers that are gradational with interlayered olivine-chromite cumulates; the chromitites have a total thickness of 3 cm. In the upper half of the occurrence there are 6 dense chromitite layers and laminae that range in thickness from 1 mm to 2.7 cm (Figure GS-25-2); the total thickness of the chromitites is 5.4 cm. The chromitites are separated by olivine-chromite cumulates that are 8 mm to 5 cm thick.
10	30 cm	This chromitite occurs about 22 m below the Mafic series. There is one dense chromitite layer that also contains 20% silicate inclusions.

Figure GS-25-2: Dense chromitite layers and laminae in the upper part of miscellaneous chromitite occurrence 9.

In addition rounded, equant to elongate chromitite balls up to 22 cm long and 9 cm across are randomly distributed in the Chromitiferous Zone.

OTHER OCCURRENCES OF THE ULTRAMAFIC SERIES

Trueman and Macek (1971) mapped a 50 m thick section of the Ultramafic series between the Page and Chrome properties (Figure GS-25-1). Reconnaissance examination of this part of the Bird River Sill determined only two poorly exposed outcrops of serpentinized peridotites and pyroxenites; some of the ultramafic rocks are talc bearing. No chromitites were observed.

REFERENCES

Scoates, R.F.J.

1983: A preliminary stratigraphic examination of the ultramafic zone of the Bird River Sill; **in** Manitoba Energy and Mines, Mineral Resources Division, Report of Field Activities, 1983, p. 70-83.

Scoates, R.F.J., Williamson, B.L., Eckstrand, O.R. and Duke, J.M.

1989: Stratigraphy of the Bird River Sill and its chromitiferous zone, and preliminary geochemistry of the chromitite layers and PGE-bearing units, Chrome Property, Manitoba; **in** Investigations by the Geological Survey of Canada in Manitoba and Saskatchewan during the 1984-1989 Mineral Development Agreements, Geological Survey of Canada, Open File 2133, p. 69-82.

Trueman, D.L. and Macek, J.J.

1971: Geology of the Bird River Sill; Manitoba Mines Branch, Preliminary Map 1971A-1.

GS-26 VEGETATION GEOCHEMICAL SURVEYS IN THE AREA OF THE TANCO PEGMATITE - A REGIONAL ASSESSMENT OF GEOCHEMICAL HALOES (NTS 52L/6)

by M.A.F. Fedikow and C.E. Dunn[1]

Fedikow, M.A.F. and Dunn, C.E, 1992: in Vegetation geochemical surveys in the area of the Tanco Pegmatite - a regional assessment of geochemical haloes (NTS 52L/6); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 114.

INTRODUCTION

The vegetation geochemical survey undertaken in 1990 in the area of the Tanco Ta-Li-Cs deposit at Bernic Lake (Fedikow *et al.*, 1990), and continued in 1991 (Fedikow and Dunn, 1991), was completed this summer with a sampling program designed to evaluate the areal extent of geochemical haloes previously described. Samples of black spruce *(Picea mariana)* outer bark, twigs and needles and jack pine *(Pinus banksiana)* outer bark were collected at 0.5 km intervals from short traverses along the Bernic Lake access road. A total of 40 samples were collected from 18 sites (Fig. GS-26-1).

RESULTS

Currently, samples are being ashed in the Geological Survey of Canada laboratories (Ottawa). Analyses are unavailable at the time of writing. Information will be released as it becomes available.

1 Exploration Geochemistry Subdivision, Mineral Resources Division, Geological Survey of Canada, Ottawa

ACKNOWLEDGEMENTS

The Tantalum Corporation of Canada Limited, specifically Peter Vanstone and Dave Alderman, are acknowledged for their continued support and access to Tanco properties and maps.

REFERENCES

Fedikow, M.A.F., Dunn, C.E. and Hall, G.E.M.
1990: Anomalous trace element concentrations in vegetation from the area of the Tanco pegmatite, Bernic Lake, Manitoba (NTS 52L/6); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1990, p. 105.

Fedikow, M.A.F., and Dunn, C.E.
1991: A vegetation geochemical survey in the vicinity of the Tanco pegmatite, Bernic Lake area, Southeastern Manitoba (NTS 52L/6); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 105.

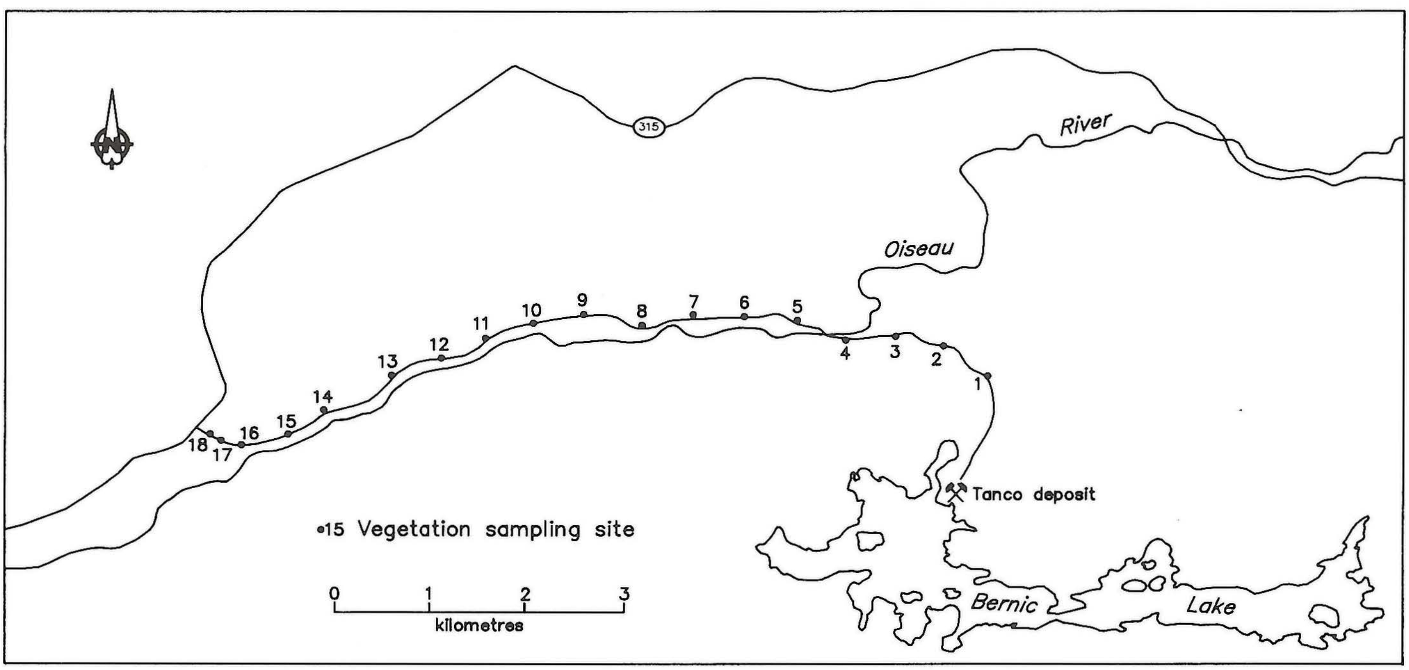

Figure GS-26-1: Location map for vegetation geochemical samples, Tanco study.

GS-27 SUB-QUATERNARY PRECAMBRIAN BASEMENT IN SE MANITOBA (NTS 52E AND NTS 62H EASTERN PORTION)

by C.R. McGregor

McGregor, C.R., 1992: Sub-Quaternary Precambrian basement in SE Manitoba (NTS 52E and NTS 62H Eastern Portion); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 115-117.

INTRODUCTION

Twenty-three holes were drilled in southeastern Manitoba (eastern half of NTS 62H and the Manitoba portion of NTS 52E) in early 1992 (Matile *et al.*, GS-32, this volume) as part of a federal/provincial NATMAP program to collect intact core of Quaternary sediments and underlying bedrock (either Paleozoic or Precambrian) for geochemical and lithological studies. The core (8.5 cm diameter) was drilled using the rotasonic drilling method.

The project objective is to trace indicator minerals and geochemistry of the till overlying interpreted metavolcanic/metasedimentary subcrop with potential base metal mineralization. The holes were drilled in areas where no data on the Precambrian is presently available.

Out of the 23 cores drilled, 15 intersected the Precambrian basement, which is overlain by 26 to 76 m of Quaternary sediments (or overburden). The Precambrian core ranges in length from 0.6 to 12.5 m (average 2 m).

Five of the 15 cores intersected metavolcanic/metasedimentary rocks and the other 10 granitoid rocks. Figure GS-27-1 illustrates an updated version of the sub-Quaternary Precambrian geology (McGregor, 1986) in NTS 52E and eastern portion of NTS 62H based on these drillholes. It indicates that the metavolcanic/metasedimentary suites are not as widespread as originally interpreted.

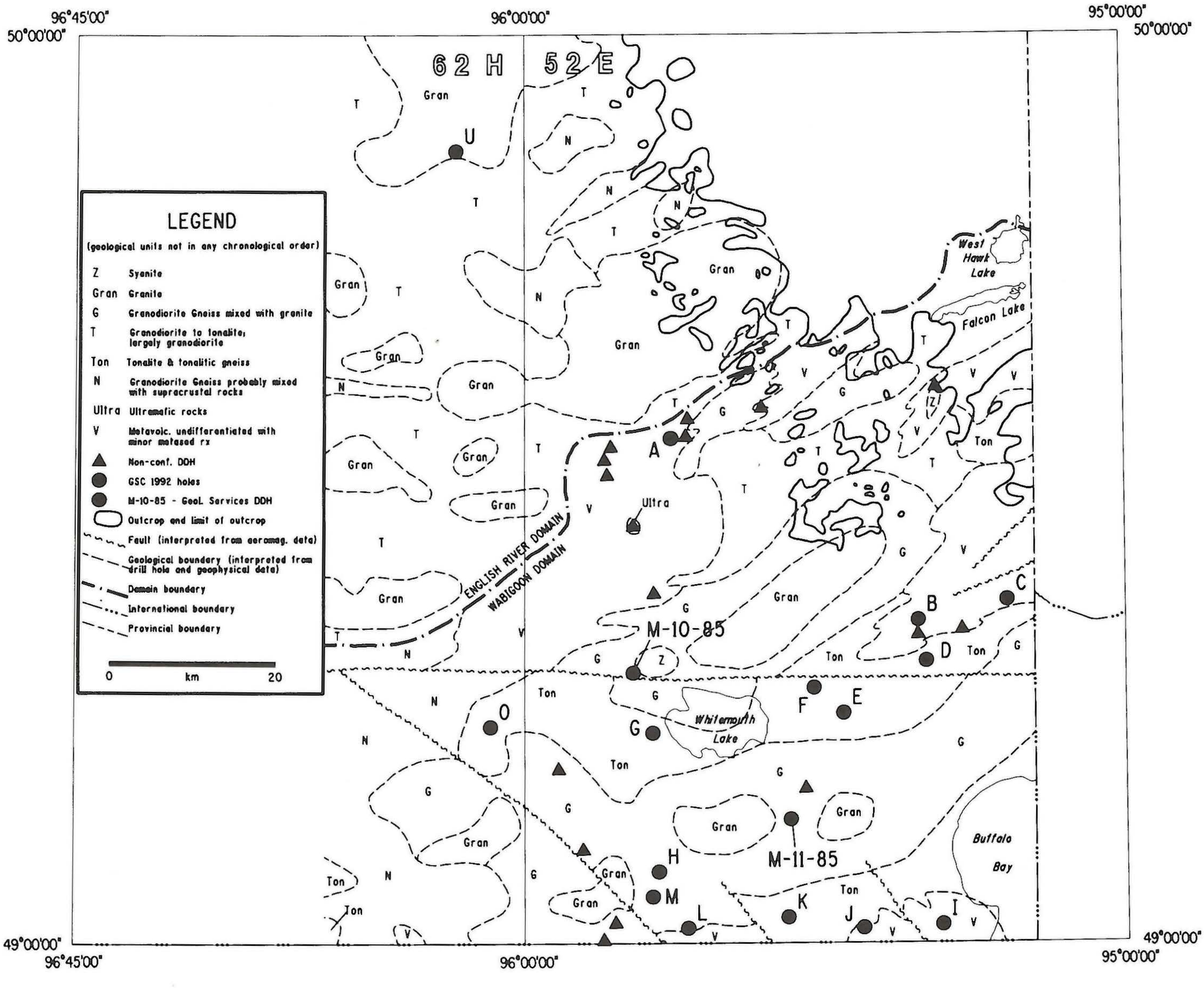

Figure GS-27-1: Sub-Quaternary Precambrian geology of southeastern Manitoba.

Summary of Log

(see Figure GS-27-1 for location and lithology)

HOLE #A

NTS: 52E/12	LSD: SW09-09-07-13E	ELEVATION: +327.7m

EASTING/NORTHING: 300950/5492750

0.0-26.2m	Overburden
26.2-29.0m	META-SILTSTONE, fine grained, light greenish grey, laminated. Fine grained disseminated pyrite is dispersed throughout the rock.

HOLE #B

NTS: 52E/06	LSD: 14-34-04-16E	ELEVATION: +358.1m

EASTING/NORTHING: 329900/5469350

0.0-42.5m	Overburden
42.5-44.2m	META-ARKOSE, fine grained, white to grey with minor carbonate veins and abundant disseminated pyrite.

HOLE #C

NTS: 52E/06	LSD: NW05-07-05-17E	ELEVATION: +335.3m

EASTING/NORTHING: 340250/5471450

0.0-32.7m	Overburden
32.7-32.9m	Weathered Precambrian basement, fine grained, dark green to bluish green
32.9-35.4m	METAGREYWACKE, fine grained, grey, layered. Some of the melanocratic layers contain abundant disseminated pyrite.

HOLE #D

NTS: 52E/06	LSD: NW13-14-04-16E	ELEVATION: +357.5m

EASTING/NORTHING: 330300/5464100

0.0-57.7m	Overburden
57.7-59.7m	Weathered Precambrian basement, grusified granite, very light coloured clay with abundant angular quartz and feldspar*
59.7-59.8m	Clay, abundant pebbles, mafic>>feldspar (granules only), weathered
59.8-61.0m	TONALITE, very weathered, green to light green, coarse grained, massive.

HOLE #E

NTS: 52E/06	LSD: SW04-35-03-15E	ELEVATION: +358.1m

EASTING/NORTHING: 320600/5458250

0.0- 61.1m	Overburden
61.1-62.2m	Lost core
62.2-65.8m	PEGMATITIC HORNBLENDE GRANITE, light pink to dark grey, coarse grained, massive, strongly magnetic, melanocratic.

HOLE #F

NTS: 52E/05	LSD: NE16-05-04-15E	ELEVATION: +349.9m

EASTING/NORTHING: 316950/5461500

0.0-43.6m	Overburden
43.6-44.5m	Possible weathered Precambrian basement, unconsolidated, grusified granite, coarse grained.

HOLE #G

NTS: 52E/04	LSD: SW12-21-03-13	ELEVATION: +349.9m

EASTING/NORTHING: 297100/5456700

0.0-47.2m	Overburden
47.2-47.5m	Weathered Precambrian basement, grusified, green, fine grained, crystalline with reddish brown clay (shale?)
47.5-49.2m	GRANODIORITE GNEISS, pale pink to light grey, fine- to coarse-grained, with layering produced by biotite-rich and biotite-poor sections.

HOLE #H

NTS: 52E/04	LSD: 04-33-01-13E	ELEVATION: +351.1m

EASTING/NORTHING: 297150/5439850

0.0-69.6m	Overburden
69.6-70.7m	GRANITE PEGMATITE, weathered, light grey, very coarse grained, massive, with some pyrite blobs.

HOLE #I

NTS: 52E/03	LSD: SW04-07-01-17E	ELEVATION: +326.1m

EASTING/NORTHING: 331300/5431900

0.0-28.5m	Overburden
28.5-38.1m	Weathered Precambrian basement, green, very fine grained, unconsolidated
38.1-41.0m	FELDSPAR PORPHYRY, dark green, very fine grained, very weathered, with white feldspar phenocryts.

HOLE #J

NTS: 52E/03 LSD: NW13-06-01-16E ELEVATION: +332.2m
EASTING/NORTHING: 321900/5431900

0.0-39.0m	Overburden
39.0-40.2m	Lost core
40.2-43.0m	DIRTY QUARTZITE, greenish grey, very fine grained.

HOLE #K

NTS: 52E/04 LSD: 15-07-01-15E ELEVATION: +331.3m
EASTING/NORTHING: 312400/5433550

0.0-38.4m	Overburden
38.4-41.5m	TONALITE, whitish grey, medium grained, massive.

HOLE #L

NTS: 52E/04 LSD: NW13-01-01-13E ELEVATION: +334.7m
EASTING/NORTHING: 300500/5432600

0.0-57.6m	Overburden
57.6-59.4m	GRANODIORITE GNEISS, light to dark grey, fine- to medium-grained and medium grained massive granite.

HOLE #M

NTS: 52E/04 LSD: 06-21-01-13E ELEVATION: +352.0m
EASTING/NORTHING: 296250/5436600

0.0-68.6m	Overburden
68.6-71.5m	GRANODIORITE GNEISS, light to dark grey, fine- to medium-grained and medium grained massive granite.

HOLE #O

NTS: 62H/01 LSD: SW02-29-03-11E ELEVATION: +350.5m
EASTING/NORTHING: 714200/5457750

0.0-76.2m	Overburden
76.2-76.8m	GRANODIORITE, orange to green, medium- to coarse-grained, slightly foliated, strongly magnetic.

HOLE #U

NTS: 62H/16 LSD: 07-35-10-10E ELEVATION: +299.9m
EASTING/NORTHING: 707400/5528700

0.0-61.0m	Overburden
61.0-62.3m	GRANITE, slightly rusty orange to grey, fine- to medium-grained, massive, strongly magnetic.

REFERENCE

McGregor, C.R.
1986: Subsurface Precambrian geology of southeastern Manitoba south of 49° 30'; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1986, p.139-140.

GS-28 LITHOPROBE ACTIVITIES IN MANITOBA, 1992

by W. Weber

Weber, W., 1992: Lithoprobe activities in Manitoba, 1992: in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 118.

Field work undertaken in 1992 along the Trans-Hudson Orogen Transect (THOT) of LITHOPROBE (Phase III) comprised contributions from the federal and provincial geological surveys and universities. Extensive refraction seismic surveys were originally planned for 1992, but due to funding reductions they had to be postponed to 1993.

The 1992 government surveys and studies that contribute towards LITHOPROBE were undertaken largely as part of the Canada-Manitoba-Saskatchewan Shield margin NATMAP project. The largest of these projects was an extensive gravity survey, conducted in spring 1992 in selected parts of NTS 63K, and undertaken by the Geological Survey of Canada. Sub-Paleozoic Precambrian core investigations in NTS 63K and NTS 63 J by A. Leclair (GSC), and McGregor and Macek (GS-24, this volume) are also a significant contribution.

Activities funded specifically by LITHOPROBE along the Manitoba portion of the Trans-Hudson Orogen Transect comprised four geological field projects from 3 universities; all started in 1991. They are as follows:

1. Structural studies and 1:3 000 scale mapping in the Kisseynew Lake area, south margin of the Kisseynew gneiss belt by A. R. Norman (Post Doctoral fellow), University of New Brunswick;
2. Structural studies and 1:5000 scale mapping in the Puffy Lake area by Cynthia L. Dyck (MSc student), University of New Brunswick;
3. U-Pb geochronology studies of supracrustal and plutonic rocks in the the Flin Flon-Snow Lake area by J. David (Post Doctoral fellow) and N. Machado, Université du Québec à Montréal; and
4. Paleomagnetism of Molson dykes in the northwestern Superior Province margin by Y. Zhai (Post Doctoral fellow) and H. C. Halls, University of Toronto.

A Transect meeting/workshop was held in Saskatoon on March 9 and 10, 1992, in which 5 MGS geologists participated. Results of the 1990/91 year were presented, specifically those of the VIBROSEIS survey, and research projects. In addition future plans and projects were discussed.

An informal workshop was held in Winnipeg on May 28, 1992, organized by the GAC Winnipeg Section, the CIM Winnipeg Branch and Geological Services Branch. This workshop, chaired by Z. Hajnal, addressed topics of interest to the exploration industry.

Another workshop took place in Winnipeg, September 15 and 16, involving MGS staff. This workshop discussed results of the processed 1991 seismic survey data and attempted the first geological interpretations of this survey, in view of preparation for publication the main results of the first phase investigations along the transect.

GS-29 MINERAL DEPOSIT SERIES: AN UPDATE

by K.J. Ferreira

Ferreira, K.J., 1992: Mineral deposit series: an update; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p.119.

The Mineral Deposit Series (MDS) is designed to provide a summary of current data and accurate locations for known mineralization. The MDS was initiated under the Canada-Manitoba Mineral Development Agreement (1984-1989). The initial goal was to provide MDS coverage for the Flin Flon - Snow Lake, Lynn Lake and Rice Lake greenstone belts, *i.e.*, the areas that have traditionally held great interest for mineral exploration in Manitoba, have infrastructure and have abundant exploration data available. Immediate goals are to complete this initial coverage, prior to extending coverage to the northern Superior Province, the sub-Paleozoic south of the Flin Flon - Snow Lake greenstone belt, and eventually to the entire Province.

Production of the MDS involves field visits to many of the known mineral occurrences and deposits, as well as compilation from cancelled assessment files, published articles, the Manitoba Energy and Mines' Mineral Inventory Card file, and other sources, such as unpublished company data and personal communications. For all known occurrences of mineralization, however large or small, the MDS reports systematically present known data: a summary of exploration work, descriptions of the geological setting and mineralization, geochemical data, a list of references, name(s), UTM coordinates, means of access, airphoto number, and a classification of mineral deposit types. The accompanying maps consist of a simplified geological base map, on which are plotted electromagnetic conductors, locations of mineralization, and symbols that reflect the type and amount of mineralization and host lithology. The reports and maps are organized by NTS area. The maps are published at 1:50 000, but 1:20 000 was initially used for part of the Flin Flon area where exploration data are particularly abundant.

Figure GS-29-1 shows progress on the series to date. Table GS-29-1 lists MDS reports that have been published; these may be obtained from Publications Sales, Manitoba Energy and Mines, 555-330 Graham Avenue, Winnipeg, MB R3C 4E3. The data files summarized in these reports are resident with the individual authors of the MDS reports, and interested individuals or companies are invited to contact the author(s) for further assistance.

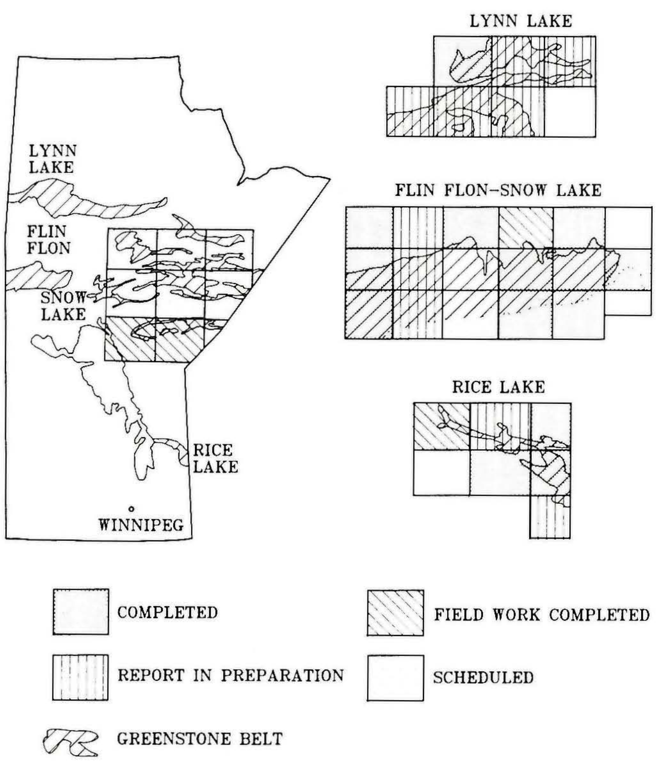

Figure GS-29-1: Summary of progress on Mineral Deposit Series Reports.

Table GS-29-1
Areas for which MDS reports have been published and are currently available

NTS Area	NTS Name
Rice Lake Greenstone Belt	
52L/13	Manigotagan Lake
52L/14	Garner Lake
52M/3	Aikens Lake
Flin Flon - Snow Lake Greenstone Belt	
63J/12	Buzz Lake
63J/14	Saw Lake
63K/13SE	Mikanagan Lake
63K/13SW	Flin Flon
63K/13N	Flin Flon: Weasel Bay, Defender Lake
63K/16	File Lake
63K/9	Tramping Lake
63N/2	Batty Lake
63N/4	Duval Lake
63O/4	Wimapedi Lake
Lynn Lake Greenstone Belt	
64C/14	Lynn Lake

GS-30 BEDROCK GEOLOGY COMPILATION MAP SERIES ATLAS

by D. Lindal

Lindal, D., 1992: Bedrock geology compilation map series atlas; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 120.

The 1:250 000 compilation maps of this atlas series are well advanced (Fig. GS-30-1). Map sheet NTS 53M, Knee Lake is scheduled for release in November, 1992. Map NTS 63K, Cormorant, is currently in the production process as a preliminary edition in cooperation with the Geological Survey of Canada under the auspices of the NATMAP Shield Margin Project and is planned for release in the first quarter of 1993. NTS 63J, 62I, 63I and 63P are the next ones scheduled. By 1994 most of the exposed Precambrian Shield of Manitoba will be covered by this series and by recently released 1:250 000 maps north of latitude 58° except the Berens River block of largely granitoid rocks and some portions along the northeastern provincial boundary.

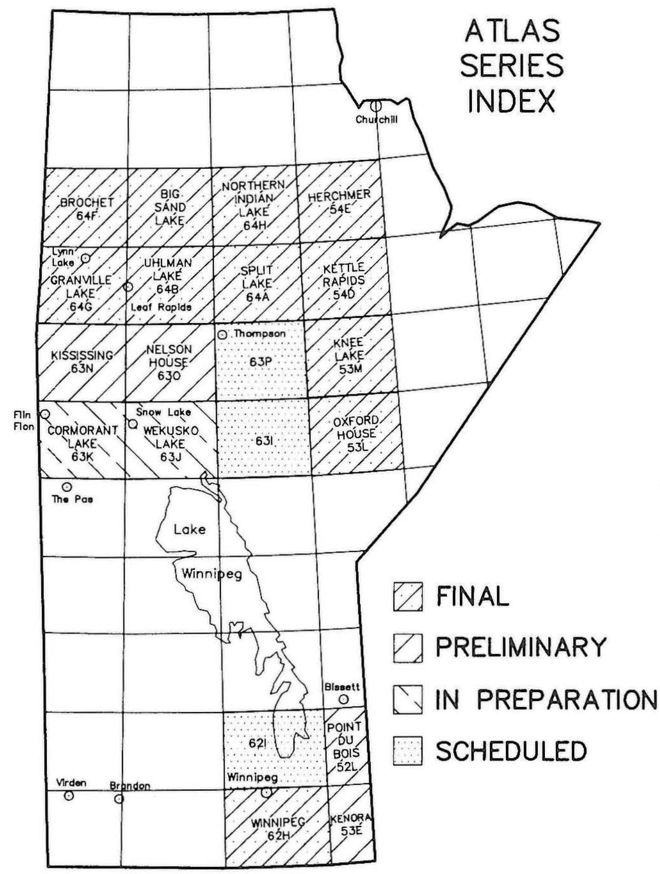

Figure GS-30-1: Status of Bedrock Geology Compilation Map series.

GS-31 AEROMAGNETIC SURVEY OF SOUTHERN MANITOBA

by D. Teskey[1] and I. Hosain

Teskey, D., and Hosain, I., 1992: Aeromagnetic survey of southern Manitoba; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 121.

The Geological Survey of Canada and Manitoba Energy and Mines have initiated a three year program to complete aeromagnetic coverage of southern Manitoba. The areas to be covered and the years in which corresponding surveys will be conducted are illustrated in Figure GS-31-1. Survey specifications are .01 nT sensitivity and better than 25 m positioning accuracy using GPS. Flight altitude is 150 m at 800 m line spacing. The data will be valuable for mineral and hydrocarbon exploration. Industry participation is welcomed in this program. Participants in any given survey year will obtain exclusive use of the geophysical results obtained in that year, prior to release to the public. For further information on participation in this project please contact:

Dennis Teskey (613) 992-9763
Ifti Hosain (204) 945-6540

1 Geological Survey of Canada

Phase 2 1992/93 DAUPHIN AREA, MANITOBA

altitude =	150 metres MTC
line spacing =	800 metres
control line spacing =	5 kilometres
line direction =	east-west
control line direction =	north-south
kilometreage = traverse lines =	13 050 kilometres
control lines =	2 210 kilometres
Total =	15 260 kilometres

Two industry participants require one winter exclusivity rights. We anticipate the release of the data May/June 1993.

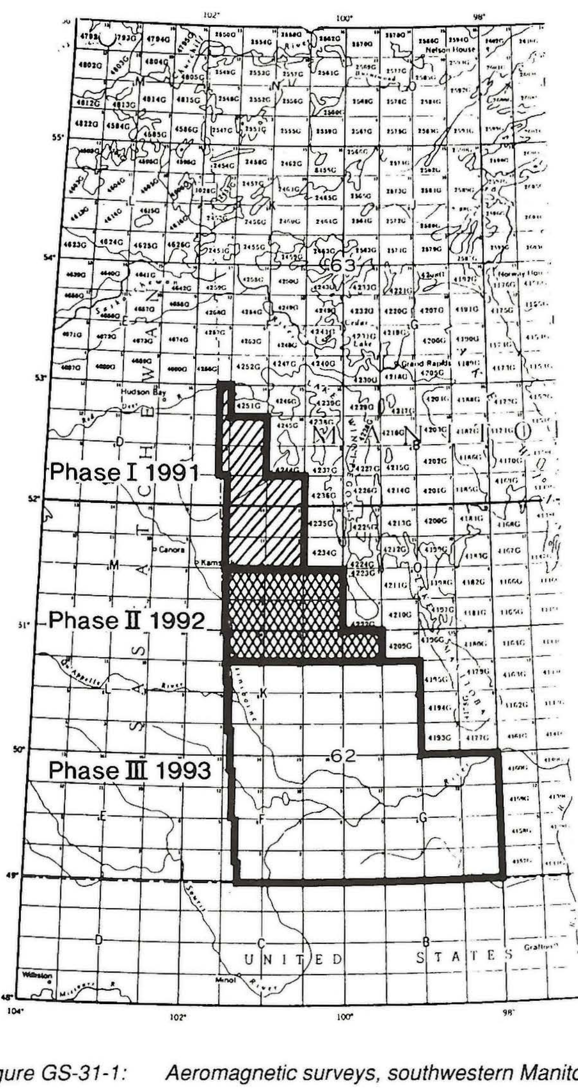

Figure GS-31-1: Aeromagnetic surveys, southwestern Manitoba.

GS-32 QUATERNARY GEOLOGICAL STUDIES IN SOUTHERN MANITOBA

by G.L.D. Matile, H. Groom and H. Thorleifson[1]

Matile, G.L.D., Groom, H. and Thorleifson, H., 1992: Quaternary geological studies in southern Manitoba; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 122.

INTRODUCTION

During 1992, field and laboratory activity by Manitoba Geological Services Branch (GSB) staff continued in support of surficial geological mapping, drift sampling, and stratigraphic studies initiated in 1991. Much of the activity was carried out under jointly funded federal/provincial programs, including the National Mapping Program (NATMAP) and the Canada-Manitoba Partnership Agreement on Mineral Development (MDA).

In the prairie region, two areas have been selected for GIS-oriented Quaternary geological mapping programs: an area in southeastern Manitoba and adjacent Ontario that spans the prairie/shield contact and the provincial boundary, and an area in southwestern Manitoba that extends into adjacent Saskatchewan.

An MDA project in the shield area of southeastern Manitoba is being carried out in coordination with the NATMAP project in this area. The emphasis of the work is on indicator mineral tracing and geochemistry in a drift covered area that has potential for base metals and other commodities.

A regional indicator mineral and soil geochemistry sampling program, conducted by the Geological Survey of Canada (GSC) in Alberta and Saskatchewan, has been extended across southern Manitoba as a result of an agreement between Manitoba Energy and Mines and the GSC.

SOUTHEASTERN MANITOBA

The Southeastern Manitoba study area includes the eastern half of NTS 62H and the western half of 52E. Mineral development research is concentrated in the latter area. Mapping was extended west to Winnipeg as part of NATMAP activity. Emphasis in the portion of the area underlain by Phanerozoic rocks has been on engineering, environmental, and groundwater geology. Work in the area has been carried out in cooperation with H. Thorleifson of the GSC since 1991.

Compilation of colour 1:100 000 GIS-oriented surficial geology maps is being coordinated by Matile and will include synthesis of mapping carried out by the former Aggregate Resources Section of the Mines Branch.

Continuous rotasonic core of Quaternary sediments and underlying bedrock was collected at 23 sites during a drilling program carried out in early 1992. All core has been analyzed in detail and resultant drift samples are being processed for indicator minerals and geochemistry. Precambrian and Phanerozoic bedrock core was analyzed by C. McGregor and R. Bezys of GSB. Downhole geophysics (conductivity, gamma and magnetic susceptibility) was done on most holes. Hydrogeological research was included in the program as a result of cooperation with the Manitoba Water Resources Branch.

A total of 492, 15 kg, sand and till samples were taken from the core for mineral exploration purposes. Surface till samples were also collected at 142 sites across the area, as well as at several sections on the Roseau River.

Engineering seismic, ground penetrating radar, and sonar subbottom profiling surveys were completed in cooperation with the GSC the drill sites and in other areas.

SOUTHWESTERN MANITOBA

The Virden area (NTS 62F) has also been chosen as a NATMAP area. Studies by federal, Manitoba and Saskatchewan agencies will produce GIS-oriented surficial geology maps, and in addition provide a compilation that will emphasize subsurface data relevant to hydrogeology.

Mapping of the aggregate resources in the area is being continued by Groom. S. Sun of the University of Manitoba carried out additional surficial mapping in the northeastern portion of the area under the direction of R. Fulton of the GSC.

Four rotasonic drillholes were cored at sites between Brandon and the Saskatchewan border. This drilling, coordinated by Thorleifson of GSC and Matile of GSB, was meant to be a selective follow-up of drilling previously carried out by R. Klassen of GSC. This work will be coordinated with work in the Saskatchewan portion of the Virden area (NTS 62F) in order to produce a standardized stratigraphy for the area.

LOW DENSITY PRAIRIE TILL/SOIL SAMPLING PROGRAM

In 1991, R. Garrett and H. Thorleifson of the GSC initiated a low density soil and till sampling program across southern Saskatchewan. This work is intended to enhance knowledge of regional glacial geology, background trends for kimberlite, lamproite and other indicator minerals, as well as exploration and environmental geochemistry. This work has, during 1992, been extended across southern Alberta. An agreement between GSB and GSC has allowed the survey to be extended to include the entire prairie region. Sampling in Manitoba by Matile, Groom and Nielsen at 240 sites included the collection of a 30 kg till sample, as well as A horizon and upper C horizon samples. Analytical work is being coordinated by the GSC, with the Saskatchewan Research Council as principal contractor for preliminary processing of the samples.

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1 Geological Survey of Canada

GS-33 STRATIGRAPHIC MAPPING AND CORE HOLE PROGRAM 1992

by R.K.Bezys

Bezys, R.K., 1992: Stratigraphic mapping and core hole program 1992; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 123-131.

INTRODUCTION

Stratigraphic activities were carried out on three separate projects in 1992. They include: 1) continued drilling of the Winnipegosis Formation reef in the Bluff area; 2) implementation of the Ordovician Red River Formation study; and 3) compilation for the Western Canada Sedimentary Basin atlas project.

A total of 1460.05 m in 40 core holes were drilled. Results of all drilling are shown in Figure GS-33-1 and Table GS-33-1.

The Bluff Area (in collaboration with D. Kent, University of Regina)

Drilling continued in the Bluff area (Dawson Bay, Lake Winnipegosis) (core holes M-6-92, M-27-92, and M-28-92) to delineate the extent of the Devonian Winnipegosis Formation reef complex.

Drilling in 1992 targeted a Winnipegosis reef dome on Highway 10, 27 km north of Mafeking. Figure GS-33-2 demonstrates the several depositional settings in the lithologies of the core holes. These settings can be applied to other Winnipegosis Formation reef localities in the Dawson Bay area. The rocks making up the "algal rim" are similar to those found in outcrop at the Steeprock Bay reef, 15 km to the south. The rocks at the base of that exposure are similar to those identified in Figure GS-33-2 as "reef flat".

No algal rim or reef flat rocks are recognizable in the outcrops at the Bluff, 4 km northeast of the Highway 10 dome. However, some of the boulders on the surface at the south end are clearly similar to the algal rim rocks and can be interpreted as having been eroded from the top of the climax reef at the north end and transported by glacial ice advance to the south end, probably during the Pleistocene.

The climax reef, at the Highway 10 dome, appears to have two facies; a coral-stromatoporoid, and a chaetitid. A clearly recognizable chaetitid facies has not been identified at the Bluff. However, chaetitids have been found at the extreme south end of the climax reef near core hole M-4-88 and it may be that the chaetitid facies occur in the covered area between core hole M-2-91 and the line of core holes from M-4-88 to M-6-88 (see Figure GS-34-2 in Kent *et al.* GS-34, this volume). If the interpretation of the Highway 10 dome reef is valid, it may be that the chaetitid facies extends over the back reef dipping flank beds at the Bluff, as shown in Figure GS-33-2.

These interpretations are tentative and need to be further supported by more detailed core examination and thin section analysis. See Kent *et al.* (GS-34, this volume) for further information on the Bluff Winnipegosis reef.

Red River Formation Study

Manitoba Energy and Mines has initiated a major basin analysis program designed to examine Paleozoic formations in the Williston Basin. Hydrocarbons from deeper Paleozoic formations have been found in Saskatchewan, North Dakota, and Montana, whereas in Manitoba these targets remain relatively unexplored. The Red River Formation study has been implemented to present stratigraphic and sedimentologic information on the formation by means of cross sections, structure contour and isopach maps, and detailed lithologic descriptions.

The study area encompasses about 195,000 km^2 and is situated between the Manitoba/Saskatchewan border and the edge of the outcrop belt of the Williston Basin, and from the International boundary to approximately latitude 55°N.

The Red River Formation in southwestern Manitoba lies wholly in the subsurface; to the north (north-central Manitoba) and east, the unit is eroded and constitutes an outcrop belt that fringes the Precambrian Shield and/or Winnipeg Formation rocks. Type outcrop sections occur along the outcrop belt. In total, the Red River Formation has been penetrated by approximately 150 oil and gas wells and approximately 200 stratigraphic, mineral exploration and water resources wells.

To date, the 150 oil and gas wells and corresponding wire-line logs have been rechecked by the Geological Services Branch for Lower Paleozoic picks and entered into the Manitoba Oil and Gas Well Information System (MOGWIS). Core hole log descriptions of eleven wells have also been entered. The oil and gas well database is supplemented by approximately 200 stratigraphic, mineral exploration and water resources wells. Presently, this electronic database is being synthesized to produce 1:250 000 and 1:1 000 000 scale isopach and structure contour maps of the Red River Formation in Manitoba. As well, regional cross sections of the Lower Paleozoic sequence for the entire province have been produced.

The present work has permitted a more detailed subdivision of the Red River Formation, Fort Garry Member. Saskatchewan terminology and subdivisions of the member are identifiable in Manitoba and have been adopted here as units. They include the Lake Alma, Lake Alma Anhydrite, Coronach and Redvers units, in ascending stratigraphic sequence. The Hartaven Member (Stony Mountain Formation), previously not picked in Manitoba, is recognized in the southwest corner of the province and north along the Saskatchewan/Manitoba border. It is now included in the Manitoba database.

More core holes are to be logged this fall, as well as detailed thin section analyses of the core. Compilation of data continues with a report and accompanying maps due in 1993.

Western Canada Sedimentary Basin Atlas Project

This project is a tectono-stratigraphic synthesis and basin analysis that encompasses the three Prairie provinces. It is being coordinated by the Alberta Research Council, with contributions by federal and provincial agencies, academia, and the private sector. In 1989-91, a systematic check of all atlas well picks from Manitoba was carried out, with some of this data being incorporated into basin-wide cross sections for the Tippecanoe sequence (Lower Paleozoic). Much of this work has been included into the Red River Formation Study as outlined above. Additional work for the atlas included: a Hudson Bay Basin cross section; a nomenclature chart incorporating Manitoba outcrop terminology and present subsurface usage; and a subsurface map of evaporite distribution. In 1992, final edits on the atlas chapter's were carried out with a scheduled release date in 1993.

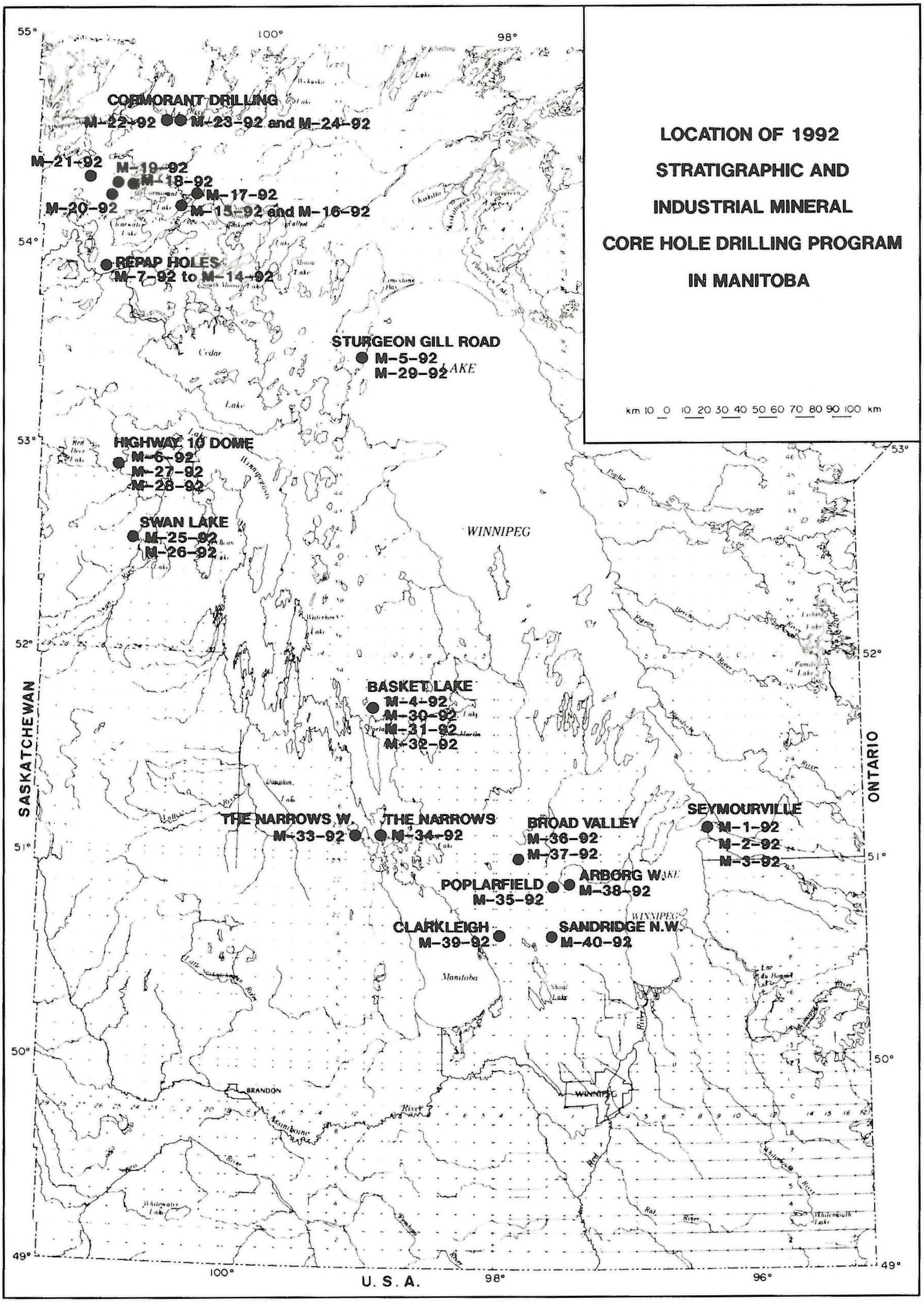

Figure GS-33-1: Location of 1992 stratigraphic and industrial mineral coreholes in Manitoba. See Table GS-33-1 for coordinates and elevations.

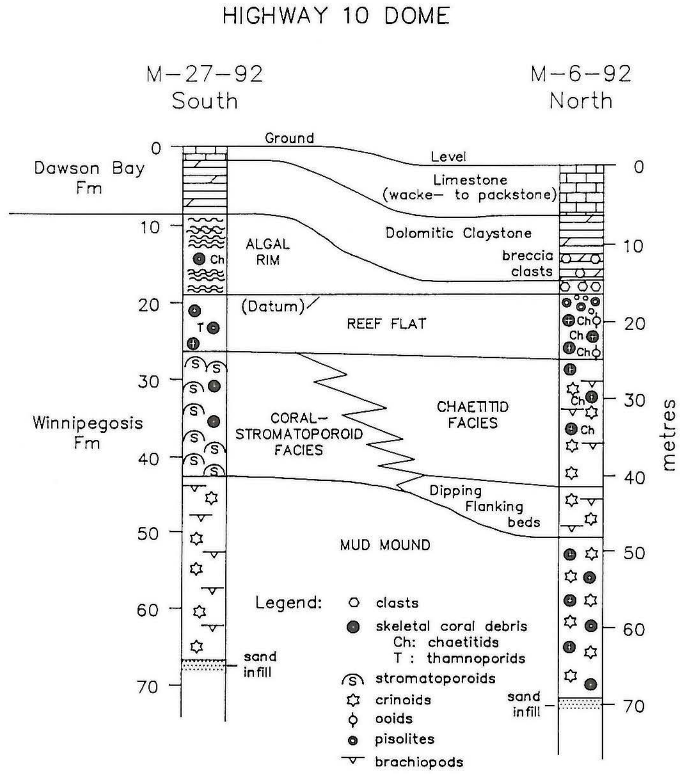

Figure GS-33-2: Stratigraphic cross section of coreholes M-6-92 and M-27-92 at the Highway 10 dome.

Table GS-33-1
SUMMARY OF CORE HOLE DATA 1992

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-1-92 Seymourville	5673300N 287000E +240.0	ORDOVICIAN-Winnipeg(?)	0.0-6.6	Unconsolidated sand: fine grained quartz sand; minor kaolin at base; possibly some weathered Precambrian at base.
M-2-91 Seymourville	5673500N 286995E +237.0	ORDOVICIAN-Winnipeg and PRECAMBRIAN	0.0-4.9	Unconsolidated sand and clay: 0.5 m of sandstone at top; altered Precambrian at base.
M-3-92 Seymourville	5673500N 286825E +240.0	OVERBURDEN	0.0-4.6	Clay, sand and pebbles.
		ORDOVICIAN-Winnipeg	4.6-5.5	Unconsolidated sand and kaolinitic clay.
		PRECAMBRIAN-Weathered	5.5-6.9	Altered chloritic shale, unconsolidated.
M-4-92 Basket Lake	13-17-32-11 +257.6	DEVONIAN-Winnipegosis	0.0-1.8	Limestone: brown; mottled; massive; dense.
		Ashern	1.8-5.1	Mudstone: calcitic dolomite; red to yellow; massive.
M-5-92 Sturgeon Gill Road (Precambrian redrilled as M-29-92)	11-11-52-12W +228.6	ORDOVICIAN-Stony Mountain	0.0-15.6	Wackestone to packstone: dolomitic, pale yellow to brown; dense; slightly mottled.
		(Transition Zone)	15.6-17.0	Wackestone: grey to brown; 5-12% porosity; minor burrowing; dolomitic.
		Red River (Fort Garry)	17.0-33.9	Laminated to massive mudstone: dolomitic; greys to brown; scattered breccia beds.
		Lower Red River	33.9-75.5	Wackestone: brown to orange; dolomitic; mottled; fossiliferous; scattered chert nodules.
		Winnipeg	75.5-82.0	Sandstone: white to grey; burrowed; massive to unconsolidated.
		PRECAMBRIAN-Weathered	82.0-86.7	Brecciated ultramafic flow: sheared lower contact.
		PRECAMBRIAN-Unweathered	86.7-89.3	Hematized ultramafic peridotite, intruded by a Molson dyke.

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-6-92 Highway 10 Dome (North)	2-28-45-25W +261.0	DEVONIAN-Dawson Bay	0.0-7.5	Limestone: yellow grey; microcrystalline; three wackestone to wackepackstone fining upward cycles.
			7.5-14.8	Claystone: red brown to green grey; dolomitic; some fissility.
			14.8-16.6	Claystone: red brown to green; limestone clasts in upper interval; dolomitic claystone clasts at base.
		Winnipegosis	16.6-18.3	Dolomite: mixed interval of yellow brown to grey lime mudstone clasts, laminar crusts and posolites (=Algal rim).
			18.3-25.2	Dolomite: yellow grey; microcrystalline; wackepackstone to grainstone; abundant chaetitid, brachiopod, and crinoid debris) = Reef flat).
			25.2-41.5	Dolomite: yellow grey; microcrystalline; wackepackstone; rare chaetitid, brachiopod and crinoidal debris (= Chaetitid facies).
			41.5-48.3	Dolomite: yellow grey to brown; microcrystalline; wackepackstone to grainstone; brachiopod and crinoid fragments; hardgrounds with dips of 20° (=Dipping flank beds).
			48.3-69.1	Dolomite: yellow grey; microcrystalline; lime mudstone to wackepackstone; coral and crinoid fragments; fractured at base (=Mud mound). Hole abandoned in sand infill.
M-7-92 Repap Site (HH)	~7-27-56-26W +267.8	OVERBURDEN	0.0-6.4	Till.
		SILURIAN-East Arm	6.4-16.7	Mudstone to wackestone.
		(U2-marker)	16.7-17.6	Mudstone: green grey; argillaceous.
		Atikameg	17.6-21.0	Grainstone to boundstone; reefal.
		Moose Lake	21.0-29.2	Packstone to grainstone; stromatolitic.
		(U1-marker)	29.2-29.9	Mudstone: green grey, argillaceous.
		Fisher Branch	29.9-38.8	Mudstone to some grainstone: lithographic in places; *Virgiana decussata* at base; sand infill at 32.7-35.2.
		Stonewall	38.8-42.8	Mudstone to packstone/grainstone.
		(T-marker)	42.8-44.0	Mudstone: red and green, argillaceous to arenaceous.
		ORDOVICIAN-Stonewall	44.0-44.9	Wackestone.
M-8-92 Repap Site (PP)	~7-27-56-26W +267.8	OVERBURDEN	0.0-7.8	Till.
		SILURIAN-East Arm	7.8-16.8	Mudstone to wackestone/packstone.
		(U2-marker)	16.8-17.7	Mudstone: green, argillaceous.
		Atikameg	17.7-22.2	Grainstone; reefal.
		Moose Lake	22.2-29.0	Packstone to grainstone: sublithographic and stromatolitic.
		(U1-marker)	29.0-29.4	Mudstone: green, argillaceous.
		Fisher Branch	29.4-35.5	Wackestone to packstone.
M-9-92 Repap Site (QQ)	~7-27-6-26W +267.8	OVERBURDEN	0.0-7.1	Till.
		SILURIAN-East Arm	7.1-12.6	Mudstone to wackestone/packstone.
		(U2 -marker)	12.6-13.4	Mudstone: green-grey, argillaceous.
		Atikameg	13.4-18.5	Grainstone: reefal.
		Moose Lake	18.5-24.9	Packstone to grainstone: stromatolitic; sublithographic.
		(U1-marker)	24.9-25.9	Mudstone: green-grey, argillaceous.
		Fisher Branch	25.9-29.6	Mudstone to wackestone.
M-10-92 Repap Site (NN)	~7-27-56-26W +267.8	OVERBURDEN	0.0-4.3	Till.
		SILURIAN-East Arm	4.3-17.3	Mudstone to wackestone/packstone.
		(U2-marker)	17.3-18.3	Mudstone: green grey, argillaceous.
		Atikameg	18.3-22.4	Grainstone to boundstone: reefal; porous; distinct oil staining between 17.3-20.4.
		Moose Lake	22.4-29.5	Wackestone to packstone: stromatolitic; slightly fossiliferous.
		(U1-marker)	29.5-30.5	Mudstone: grey, argillaceous; laminated.
		Fisher Branch	30.5-35.6	Mudstone to wackepackstone.
M-11-92 Repap Site (BB)	~7-27-56-26W +267.8	OVERBURDEN	0.0-4.8	Till.
		SILURIAN-East Arm	4.8-14.3	Packstone to grainstone.
		(U2-marker)	14.3-15.4	Mudstone: green grey, argillaceous; laminated.
		Atikameg	15.4-20.7	Grainstone to boundstone: reefal.
		Moose Lake	20.7-26.7	Wackestone to packstone.
		(U1-marker)	26.7-27.4	Mudstone: grey, argillaceous; laminated.
		Fisher Branch	27.4-36.5	Wackestone to packstone: *Virgiana decussata* at base.
		Stonewall (marker)	36.5-37.1	Mudstone: argillaceous to arenaceous; dark grey.

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-12-92	~7-27-56-26W	OVERBURDEN	0.0-12.0	Till.
Repap Site	+267.8	SILURIAN-East Arm	12.0-14.3	Packstone to grainstone.
(CC)		(U2-marker)	14.3-15.1	Mudstone: green grey, argillaceous; laminated.
		Atikameg	15.1-15.8	Packstone to grainstone: reefal.
M-13-92	~7-27-56-26W	OVERBURDEN	0.0-5.0	Till.
Repap Site	+267.8	SILURIAN-East Arm	5.0-11.2	Wackestone to grainstone.
(TT)		East Arm/(U2-marker)/ Atikameg	11.2-22.8	Difficult to pick contacts; very broken and rubbly core.
		Moose Lake	22.8-29.5	Mudstone to packstone: sublithographic.
		(U1-marker)	29.5-30.1	Mudstone: green, argillaceous.
		Fisher Branch	30.1-35.6	Mudstone to wackestone.
M-14-92	~7-27-56-26W	OVERBURDEN	0.0-7.4	Till.
Repap Site	+267.8	SILURIAN-East Arm	7.4-12.7	Packstone.
(RR)		(U2-marker)	12.7-13.9	Mudstone: green grey; argillaceous; laminated.
		Atikameg	13.9-18.6	Grainstone: reefal.
		Moose Lake	18.6-25.4	Mudstone to packstone: sublithographic.
		(U1-marker)	25.4-26.3	Mudstone: green grey, argillaceous.
		Fisher Branch	26.3-32.6	Mudstone to wackestone: sand infill at 26.5-27.5.
M-15-92 Cormorant Hill-1	8-23-60-22W +289.0	SILURIAN-Fisher Branch(?)	0.0-1.4	Packstone: light yellow; broken and rubbly core; *Paleofavosites* and brachiopod (*Virgiana*(?)) fragments; dolomitic.
		Stonewall	1.4-5.2	Mudstone to grainstone: dolomitic with minor calcareous intervals in weathered zones; yellow to grey; conglomerate breccia at 3.3-4.0.
		(T-marker)	5.2-6.5	Mudstone: red; dolomitic; argillaceous; rubbly.
		ORDOVICIAN-Stonewall	6.5-9.9	Mudstone to wackestone: yellow orange; minor mottling; fine crystalline; dolomitic.
		(Williams Member)	9.9-14.6	Mudstone with minor floatstone to grainstone: grey, dolomitic; argillaceous in places; mottled.
		Stony Mountain	14.6-41.5	Mudstone to wackestone: pink to grey; dolomitic; nodular bedding; fine crystalline.
		Red River (Fort Garry)	41.5-55.1	Mudstone: dolomitic; argillaceous in appearance; interbedded; grey to brown; some mottling; very fine to fine crystalline.
		Lower Red River	55.1-83.2	Mudstone to wackestone to minor floatstone: grey orange to pink; dolomitic (slightly calcareous); burrow mottled; fine to medium crystalline.
		Winnipeg	83.2-84.4	Sandstone: dolomitic; buff to brown; fine to medium grained quartz sand; massive; much missing core.
		PRECAMBRIAN-Weathered	84.4-87.5	Weathered granitoid rocks.
		Unweathered	87.5-91.5	Biotite-hornblende tonalite.
			91.5-94.0	Pink granite.
			94.0-96.6	Biotite-hornblende tonalitic gneiss.
M-16-92	8-23-60-22W	SILURIAN-Fisher Branch	0.0-1.5	Broken and rubbly dolomite: probably Fisher Branch.
Cormorant	+289.0		1.5-3.7	Wackestone: dolomitic; light brown; massive; no *Virgiana* present.
Hill-2		Stonewall	3.7-5.1	Mudstone to wackestone: dolomitic; conglomeratic.
		(T-marker)	5.1-5.9	Mudstone: red; laminated; rubbly.
		ORDOVICIAN-Stonewall	5.9-14.2	Wackestone to packstone: light brown to grey; dolomitic.
		(Williams Member)	14.2-19.1	Mudstone: red; argillaceous; dolomitic; massive.
		Stony Mountain	19.1-40.2	Wackestone: mottled to nodular; dolomitic.
M-17-92	15-4-61-21W	OVERBURDEN	0.0-5.5	Rubbly pebble till.
Cormorant	+261.0	ORDOVICIAN-Red River	5.5-23.1	Mudstone: massive; brown; dolomitic; brecciated interbeds.
North		(Fort Garry)		
		Lower Red River	23.1-54.0	Wackestone: dolomitic; brown; sandy at base.
		Winnipeg	54.0-54.3	Sandstone: silty; grey brown; dolomitic; very broken up.
		PRECAMBRIAN-Weathered	54.3-56.1	Granitoid rock.
		Unweathered	56.1-58.2	Granitoid biotite gneiss.
			58.2-66.4	Pegmatitic granite with granitoid rocks.
			66.4-68.8	Granitoid rock.
M-18-92	16-8-61-24W	ORDOVICIAN-Red River	0.0-3.4	Mudstone: yellow brown; cherty; very porous; dolomitic.
Cormorant	+260.0	(Cat Head Member?)		
		(Dog Head Member?)	3.4-32.2	Wackestone: grey to brown; massive; dolomitic.
		Winnipeg	32.2-35.9	Sandstone: light brown; massive; dolomitic; sharp lower contact.

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
		PRECAMBRIAN-Weathered	35.9-36.2	Granitoid gneiss.
		Unweathered	36.2-40.0	Leucocratic granitoid gneiss.
			40.0-41.7	Pink pegmatite and grey tonalite.
M-19-92 Mitchell Lake Road N	8-20-61-25W +289.0	Overburden	0.0-20.5	Till: grey with large Red River Formation clasts (dolomitic).
		ORDOVICIAN-Red River (Dog Head?)	20.5-52.8	Wackestone: massive; dolomitic; dense; cherty at top; sandy at base.
		Winnipeg	52.8-55.3	Sandstone: grey to brown; massive; fine to medium grained; silty in places; sharp lower contact; dolomitic.
		PRECAMBRIAN-Weathered	55.3-55.6	Granitoid rock.
		Unweathered	55.6-60.9	Pink pegmatite.
			60.9-61.3	Granite-tonalite.
			61.3-64.7	Hornblende-biotite tonalite (to granite).
			64.7-66.2	Tonalitic gneiss intruded by fine grained tonalite and granite.
M-20-92 Mitchell Lake Road S	11-36-60-26W +312.0	Overburden	0.0-29.0	Infill material of minor Precambrian and dolomite clasts-some sand and clay; may be Mesozoic? Hole abandoned.
M-21-92 Off Namew Lake Road	15-35-61-27W +302.0	Overburden	0.0-20.2	Till: large boulders of Precambrian clasts and dolomite.
		ORDOVICIAN-Red River	20.2-60.5	Mudstone to wackestone: brown; dolomitic; broken and rubbly; sandy at base.
		Winnipeg	60.5-61.4	Sandstone: silty; brown; dolomitic; fine to medium grained; sharp lower contact (much lost core).
		PRECAMBRIAN-Weathered	61.4-63.1	Granitoid rock.
		Unweathered	63.1-65.8	Pink granite to pegmatite.
			65.8-69.4	Amphibolite with granitoid.
			69.4-71.7	Pink granitoid to granite.
			71.7-77.4	Coarse amphibolite.
			77.4-77.7	Pink pegmatite.
M-22-92 Highway 39	6051100N 389900E +292.9	ORDOVICIAN-Red River	0.0-5.4	Wackestone: red to brown; dolomitic; sandy at base.
		PRECAMBRIAN-Weathered	5.4-6.0	Weathered greenstone/mafic metavolcanic.
		Unweathered	6.0-9.5	Sheared mafic volcanic.
			9.5-12.5	Mafic volcanic.
			12.5-32.5	Mafic volcanic: in places sheared; hematitic; amphibolitic schist at base.
M-23-92 Reed Lake N	6051000N 391750E +290.5	Overburden	0.0-14.3	Unconsolidated sand with pebbles of Precambrian-type lithologies. Hole abandoned.
M-24-92 Reed Lake S	6050750N 391400E +290.8	Overburden	0.0-7.1	Unconsolidated sand and pegmatitic boulders.
		PRECAMBRIAN-Weathered	7.1-8.8	Grey pegmatitic granite.
			converted:	
M-25-92 Swan Lake (45° angle)	2-21-41-24W +259.0	Overburden	0.0-3.3	Rubbly till.
		DEVONIAN-Dawson Bay	3.3-5.5	Floatstone to boundstone: massive; light grey; calcitic dolomite.
			5.5-5.7	Sand infill.
			5.7-35.7	Limestone (mudstone to floatstone): fractured throughout; stylolitic; some clay infill; minor brecciation; fossiliferous.
		(Transitional Beds)-Winnipegosis	35.7-44.3	Limestone: wackestone to mudstone; red to green; intensely brecciated; red to green.
			converted:	
M-26-92 Swan Lake (45° angle)	2-21-41-24W +259.0	Overburden	0.0-0.4	Overburden.
		DEVONIAN-Dawson Bay	0.4-37.5	Mudstone to wackestone: light brown; fractured and brecciated; limestone; minor stylolites; green clay infill throughout; fossiliferous in places.
		(Second Red Beds)	37.5-38.9	Mudstone: red; dolomitic; brecciated in places.
		(Transitional Zone)	38.9-46.0	Mudstone: dolomitic at top; calcitic in places; red to green; limestone.
		Winnipegosis	46.0-50.7	Floatstone to mudstone: some mudstone; porous; stromatoporoids; brown to grey; calcitic; some stylolites.

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-27-92 Highway 10 Dome (Center)	2-28-45-25W +263.0	DEVONIAN-Dawson Bay	0.0-1.8	Limestone: yellow grey; microcrystalline; lime mudstone.
			1.8-8.8	Claystone: red brown to grey; dolomitic in upper 6 m.
		Winnipegosis	8.8-19.4	Dolomite: grey yellow to brown; microcrystalline; algal crusts; some encrusting chaetitid fragments; interlayered with wackestone with chaetitids (=Algal rim).
			19.4-26.3	Dolomite: yellow grey; microcrystalline wackepackstone; some coral and skeletal remains (=Reef flat).
			26.3-42.4	Dolomite: yellow grey; microcrystalline; wackepackstone composed of stromatoporoid and thamnoporoid debris (=Coral-Stromatoporoid facies).
			42.4-66.0	Dolomite: pale grey; microcrystalline; lime mudstone to wackestone; some brachiopod and crinoidal fragments (=Mud mound). Hole abandoned due to sand infill.
M-28-92 Highway 10 Dome (South)	2-28-45-25W +261.0	Overburden	0.0-5.5	Rubbly limestone fragments (pebbles).
			5.5-12.0	Sand infill (as in M-6-92, M-27-92). Hole abandoned.
M-29-92 Sturgeon Gill Road	11-11-52-12W +228.6	(See M-5-92 for description)		
M-30-92 Basket Lake	13-19-32-11W +257.6	DEVONIAN-Elm Point	0.0-5.0	Limestone: medium buff; fine crystalline; faintly mottled; minor secondary calcite; abundant stylolites.
			5.0-8.1	Dolomitized limestone and limestone breccia: yellow saccharloidal dolomite with abundant veinlets, lenses and vugs of secondary calcite interbedded with mudstone conglomerate and brecciated dolomitic limestone; lower contact gradational over 0.5 m.
		Ashern	8.1-9.0	Limestone: white chalk, (weathered zone?); abundant secondary calcite.
			9.0-11.2	Limestone and dolomite breccia: red; angular clasts, 1-2 cm; numerous open vugs and mud seams.
M-31-92 Basket Lake S.	12-7-32-11W +257.6	DEVONIAN-Elm Point	0.0-10.1	Limestone: medium grey; fine crystalline; abundant yellow-orange dolomitized mottles; local fossil molds and brachiopods; several mud zones near base of hole, but no change in lithology across breaks; mottles gradually become lighter toward top of hole.
M-32-92 Basket Lake S.	13-7-32-11W +257.6	DEVONIAN-Elm Point	0.0-9.6	Limestone: light buff to grey; fine crystalline; minor light yellow mottles between 2.1 and 2.9 m; locally fossiliferous, fossil molds lined with secondary calcite.
		Ashern	9.6-11.2	Limestone: conglomeratic; greenish grey; reddish at basal 10 cm; 5 cm thick mud seam at top of interval may represent weathered zone.
M-33-92 The Narrows West	3-33-24-12W +248.1	DEVONIAN-Dawson Bay (Lower Member)	0.0-5.2	Limestone: fine crystalline to sublithographic; light buff brown with red colouration around fossil molds and along fractures; minor secondary calcite.
		(Second Red Beds)	5.2-21.9	Calcareous mudstone: fine crystalline to sublithographic; rare open fossil molds; local pyrite coated fractures; bottom contact sharp.
			21.9-25.8	Mudstone breccia: subrounded limestone and dolomite clasts that decrease from 3 cm to 1 cm, downward; several clasts are fine grained reddish mudstone, possibly Second Red Beds; several open space fillings of fine to very fine grained pyrite.
		Winnipegosis	25.8-69.2	Dolomite: medium brown; medium crystalline; very vuggy with 5 mm to 1 cm vugs (50% of core) which are generally open and dry, but calcite and pyrite occur locally toward top; locally laminated over 10-20 cm of section; "ghost" shapes resemble dolomitized brachiopods.
M-34-92	6-36-24-11W +246.0	DEVONIAN-Dawson Bay	0.0-20.0	Limestone and dolomitized limestone: fine crystalline to sublithographic; light buff with red stain on fossil mods and fractures; abundant secondary calcite as veinlets, lenses and coatings on fossil molds; dolomitized zone from 13.9-14.3 m, medium yellow to orange, saccharoidal texture with abundant secondary calcite, few fossils.
		(Second Red Beds)	20.0-20.3	Mudstone: brick red.

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-35-92 Poplarfield	5-4-22-1W +272.8	SILURIAN-Moose Lake	0.0-5.0	Dolomite: buff; fossiliferous (coral); pin-point porosity; hint of stromatolitic laminations.
		(U1-marker)	5.0-5.2	Argillaceous dolomite: purple with spheroid imprints.
		Fisher Branch	5.2-18.3	Dolomite: buff; porcelaneous near top becoming porous and fossiliferous downward below 15.2 m; *Virgiana decussata* at 17.9 m.
		(Upper Stonewall marker)	18.3-19.6	Argillaceous dolomite: red with spheroid imprints smaller than U_1 marker spheroids; small fractures "reduced" to buff colour; red clay partings.
		Stonewall	19.6-20.4	Dolomite: buff; porcelaneous, similar to that of Fisher Branch.
M-36-92 Broad Valley	1-26-23-3W +281.0	SILURIAN-Cedar Lake	0.0-5.9	Dolomite: buff; porous, vuggy and fossiliferous; mottled, slightly orange.
		East Arm	5.9-20.3	Dolomite: buff; very fine crystalline; mottled orange; becoming laminated (stromatolitic?) downward, then argillaceous dolomite with spheroid imprints and stromatolitic laminations near base; some red clay partings.
M-37-92 Broad Valley	15-25-23-3W +283.0	SILURIAN-Cedar Lake?	0.0-3.8	Dolomite: buff; porous, slightly vuggy near top and pin-point porosity near base with stromatolitic?
			3.8-5.3	Calcareous sandstone: fine to medium grained becoming finer grained upward; orange near top becoming reddish downward and resembles weathered Silurian beds just below Ashern.
		East Arm	5.3-18.7	Dolomite: buff; porcelaneous near top becoming mottled and brecciated near base and then banded and porous at base; 5 mm spheroid imprints at several intervals; abundant red clay partings: (0.03-0.13 m thick) within porcelaneous beds.
		(V-marker)	18.7-20.0	Argillaceous dolomite: red and blue banded; red clay parting.
		Moose Lake	20.0-20.3	Dolomite: buff to brown; mottled; hint of stromatolitic laminations.
M-38-92 Arborg West	15-6-22-1E +262.1	ORDOVICIAN-Lower Stonewall	0.0-1.7	Dolomite: buff to cream; laminated.
			1.7-3.6	Lost core and cave infill (possible Lower T-marker).
			3.6-5.9	Dolomite: cream to brown; distinctly mottled.
		(Williams Member)	5.9-9.5	Argillaceous dolomite: pink-grey-buff; laminated; becoming more reddish in center before returning to buff at base; lower contact placed above mottles.
		Stony Mountain (Gunton)	9.5-19.9	Dolomite: buff to cream; mottled and vuggy interbedded with argillaceous dolomite: blue and red; speckled and laminated in part; blue clay partings.
		(Penitentiary)	19.9-41.6	Argillaceous dolomite: blue and red; mottled; variable stained hematite?
		Red River (Fort Garry)	41.6-75.1	Dolomite: interbedded laminated mudstone, argillaceous mudstone-minor floatstone; very pale orange with occasional pink red mottling; minor chert; green and red argillaceous zones at 53.6-54.02 m and 56.46-56.48 m.
		Lower Red River	75.1-99.7	Slightly calcareous dolomite at 75.1-75.91 m and limestone at 75.91; wackestone to floatstone in places; crinoids and corals; sugary, burrow mottled, cherty, common from 75.1-83.25 m (up to 30%), also vuggy in places; "good" Tyndall-stone below 93.28 m.
M-39-92 Clarkleigh	3-20-19-4W +256.0	SILURIAN-Cedar Lake	0.0-4.7	Dolomite: broken core; red-brown with brecciated argillaceous intervals.
			4.7-33.9	Dolomite: grey-buff mottled beds interlayered with aphanitic buff beds becoming "cleaner" downward with stromatolitic bands and pin-point porosity.
		East Arm	33.9-54.7	Dolomite: light to medium buff with red bands; massive to slightly stromatolitic; porcelaneous intervals dominant near base.
		(V-marker)	54.7-56.2	Dolomite: argillaceous to slightly silty; red to green-grey; spheroid imprints.
		Moose Lake	56.2-58.1	Argillaceous dolomite: grey to slightly pink in places; vuggy and finely mottled becoming more white and micritic downward.
			58.1-58.2	Argillaceous dolomite: grey with distinct spheroid imprints (U_2-marker?).
			58.2-60.0	Dolomite: fine crystalline, slightly nodular, stromatolitic.

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-40-92 Sandridge Northwest	4-21-19-1W +274.3	SILURIAN-Moose Lake	0.0-3.3	Dolomite: buff to brown; porous and rubbly; mottled near middle; becoming argillaceous near base with spheroid imprints.
		(U1-marker)	3.3-3.5	Argillaceous dolomite: grey-buff; spheroid imprints.
			3.5-3.6	Sand: unconsolidated; buff (infill?)
		Fisher Branch	3.6-4.7	Argillaceous dolomite: orange-buff; laminated.
			4.7-5.2	Arenaeous dolomite: buff-brown; speckled.
			5.2-8.2	Dolomite: buff; fossiliferous brachiopod? at 7.1 m; vuggy in part.
			8.2-8.7	Dolomite: cream mottled; similar to above but more massive.
			8.7-9.2	Dolomite: orange at top, more porous downward, coral present at top.
			9.2-12.3	Dolomite: brown-buff mottled; fossiliferous; pinpoint porosity; darker (grey-buff) near top.
			12.3-12.8	Dolomite: argillaceous and arenaceous rubbly interval (karst?).
			12.8-17.4	Dolomite: grey cream; mottled and vuggy; possible brachipod at base (*Virgiana?*).
		Stonewall	17.4-18.0	Argillaceous dolomite: grey-buff; laminated; spheroid imprints increasing downward.
		(Upper Stonewall marker)	18.0-19.3	Argillaceous dolomite: grey; laminated with red bands increasing downward; white spheroid imprints; red clay at 18.55 m.
			19.3-20.3	Dolomite: white; porcelaneous (ground core).

GS-34 CONTROLS ON INITIAL GROWTH, SHAPE AND DISTRIBUTION OF DEVONIAN WINNIPEGOSIS REEFS, ELK POINT BASIN, MANITOBA

by D.M. Kent[1], J.W. Minto[1] and D. Sparks[1]

Kent, D.M., Minto, J.W. and Sparks, D., 1992: Controls on initial growth, shape and distribution of Devonian Winnipegosis Reefs, Elk Point Basin, Manitoba; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 132-137.

INTRODUCTION

Preamble

This study has developed from the senior author's continuing interest in the Winnipegosis Formation reefs of the Manitoba outcrop belt; an interest that has been nurtured through twenty five years of guiding both formal and informal field trips for university, petroleum and potash industry personnel to the outcropping reefs. Recent discoveries of oil in the Winnipegosis reefs in the subsurface of southeastern Saskatchewan has given impetus to detailed studies of the outcropping reefs in anticipation that they are analogues of the subsurface reefs. This study is composed of two components: 1) an analysis of an outcropping Winnipegosis reef including detailed examination of the outcrops and cores obtained from a drilling program, to determine reef morphology and lithofacies distribution; and 2) a subsurface study, throughout the Elk Point Basin in Saskatchewan, directed at determining the factors controlling reef distribution.

The outcrop study

A corehole drilling program in the outcrop belt, initiated by Manitoba Energy and Mines in 1976, demonstrated that the configuration of Winnipegosis reefs and their lithofacies distribution is considerably more complex than can be determined from their surface exposures. However, few of the reefs were penetrated by more than one corehole and reef shape was mainly interpreted from the surface expression of the reefs, as demonstrated by the drape pattern of the overlying Dawson Bay Formation.

One of the most visited outcrop locations is the Bluff reef on the western shore of Dawson Bay on Lake Winnipegosis. The Bluff is considered to be important because it presents a three-dimensional view of the upper 8 to 9 m of a Winnipegosis reef. The Bluff is an elongated island connected to the mainland by a tombola (Fig. GS-34-1). The trend of its long axis is approximately due north.

METHOD OF STUDY

In 1988, the senior author with financial assistance from a consortium of five oil companies and corehole drilling support from Manitoba Energy and Mines, initiated a detailed study of the Bluff reef. The inaugural five coreholes were drilled at the north end of the Bluff that was considered, at the time, to be the entire area underlain by the reef. An additional four cores, three of which were drilled south of the inaugural study area, showed that the entire island was underlain by a Winnipegosis buildup. Five of the 9 coreholes penetrated into the upper part of the Ashern Formation at a depth of approximately 87 m. The other 4 had to be terminated at various depths between 40 and 70 m below the surface, due to drilling difficulties after encountering sand infill.

The subsurface project

The study of the surface exposures and coreholes at the Bluff was designed to develop an understanding of the configuration and lithofacies distribution of a Winnipegosis reef. However, both oil explo-

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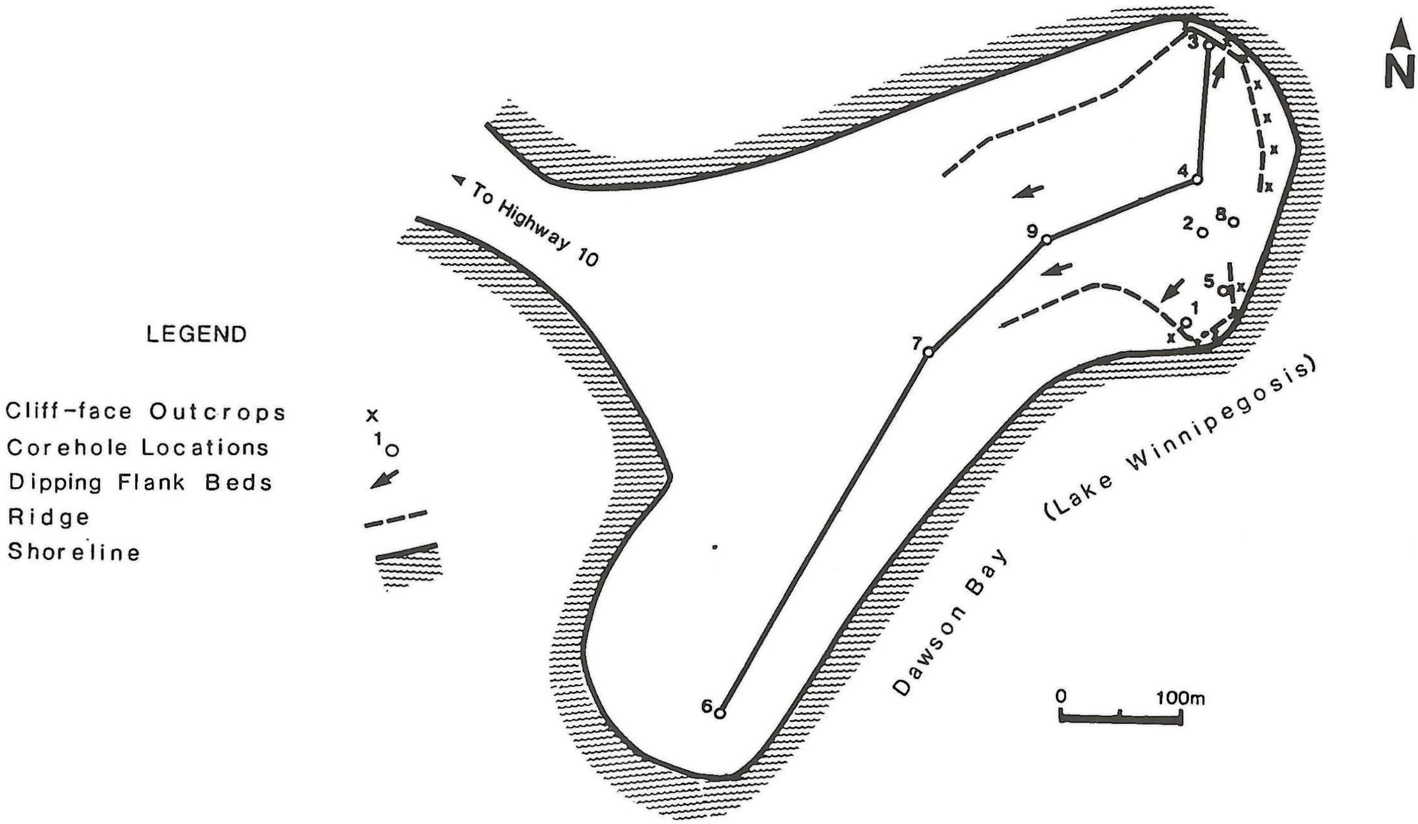


Figure GS-34-1: Bluff site map showing distribution of coreholes and the line of the cross section shown in Figure GS-34-2. Corehole locations are: 1- M-4-88; 2- M-5-88; 3- M-6-88; 4- M-7-88; 5- M-8-88; 6- M-8-90; 7- M-9-90; 8- M-1-91; 9- M-2-91.

ration companies and potash producers are also interested in the distribution of the reefs. A second project was initiated to attempt to identify the controls on reef distribution in the subsurface of Saskatchewan.

Paleobathymetrically positive features on the seafloor are the most common sites for the initiation of reef growth. The origin of these features may be attributed to a number of causes, including:

1. regional structural elements;
2. paleokarst;
3. current or wave built sedimentary bodies; and
4. stratigraphic stacking of carbonate buildups.

REGIONAL STRUCTURAL ELEMENTS

Fault blocks and linear fault trends are favoured as prime sites for the initiation of reef growth. The linearity of the Upper Devonian Rimbey-Meadowbrook reef trend in central Alberta is attributed to growth on the upthrown side of a linear fault trend, despite the lack of recognizable structural displacement. Smith (1982) also identified upthrown edges of block faults as the sites of accumulation of Waulsortian-type mounds.

With regard to Winnipegosis reefs, Penner *et al.* (1987) demonstrated that the Tableland Reef in southeastern Saskatchewan lies along a northwesterly-trending linear feature. Consequently, structure should be considered as a major control for the initiation of Winnipegosis reef growth.

PALEOKARST

Submerged karst topography developed in the Pleistocene rocks along the coastlines of the Caribbean is considered to be a major control of Holocene reef growth. The existence of paleokarst features at the Interlake Group/Ashern Formation contact has been documented in the geological literature, and although it is expected that much of the paleokarst relief would have been smoothed by the immediately overlying strata, differential compaction over relatively high-relief, paleokarst features may have produced subtle paleobathymetrically positive elements on the top of the platform carbonates of the lower Winnipegosis. Consequently, the possibility that the paleokarst surface may act as a control for the initiation of Winnipegosis reef growth should be investigated.

CURRENT OR WAVE BUILT SEDIMENTARY BODIES

This mechanism identifies carbonate sand shoals as the sites of initial reef growth. Although their presence has not been recognized in cores of the lower Winnipegosis Formation some consideration should be given to their possible existence.

STRATIGRAPHIC STACKING OF CARBONATE BUILDUPS

This control depends on draping by differential compaction of younger strata over pre-existing carbonate buildups and the initiation of a new buildup on the relief formed by the drape structure. Sereda and Kent (1987) identified this mechanism for the initiation of Waulsortian-type mound growth in the Mississippian of southeastern Saskatchewan.

Stratigraphic stacking can readily be recognized as the control on Pennsylvanian phylloid algal mound in the outcrops of the Sacramento Mountains of New Mexico. However, there is no evidence of former reef growth in the Interlake Group immediately beneath the Ashern Formation. Consequently, this is a control that can be disregarded.

METHOD OF STUDY

A search of the Saskatchewan subsurface well data files indicates that some 800 wells penetrate the Winnipegosis Formation. The initial phase of this study consisted of: 1) searching the well files using a CD ROM file system to access the Winnipegosis data in the 800 wells; 2) retrieving the pertinent information from each well file; and 3) storing it in a customized computer spreadsheet using Lotus 1-2-3.

All stratigraphic picks for the Winnipegosis are undergoing revision in an attempt to standardize them and minimize anomalies resulting from improperly determined picks. Some 700 wells penetrate to the top of the lower Winnipegosis or deeper and these make up the stratigraphic database for the maps that will be developed. Two hundred of those wells have cores that penetrate to the base of the reef or deeper and they will make up the lithologic database for the study. Detailed core logging will concentrate on the upper Winnipegosis/lower Winnipegosis contact, the nature of the platform lithologies immediately subjacent to the contact and the nature of the Ashern Formation and underlying rocks of the Silurian Interlake Group. Recent exploration for oil-bearing reefs in southeast Saskatchewan has markedly increased the Winnipegosis well density in that area, improving the potential for the recognition of structurally controlled reef trends. It was for this reason that the southeast area was chosen as a pilot project to the larger regional study. The pilot project includes computer-generated structure and paleostructure maps for the area lying south of township 17 and between the Manitoba border and range 10 west of the second meridian.

RESULTS AND INTERPRETATION

Growth patterns of the Blue Reef

The reef outcrops are on the north and northeast margin of the Bluff, but recent corehole drilling at the south end indicates that the shape of the island closely imitates the outline of the Winnipegosis reef. However, the southern half is overlain by 26 to 38 m of Dawson Bay

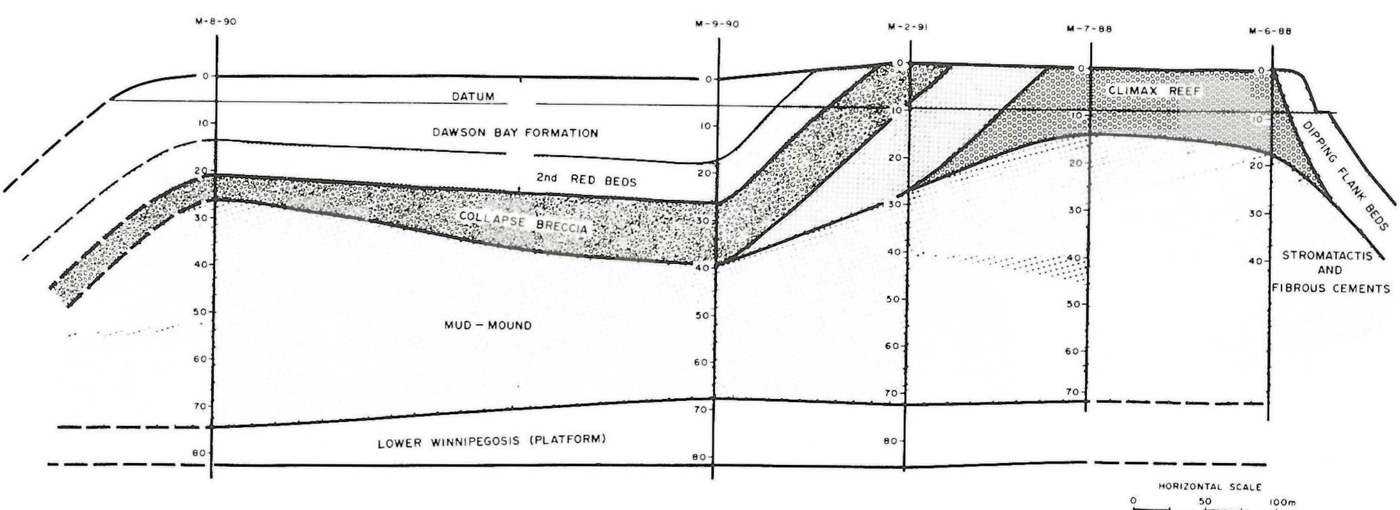


Figure GS-34-2: North-south cross section through the Bluff reef.

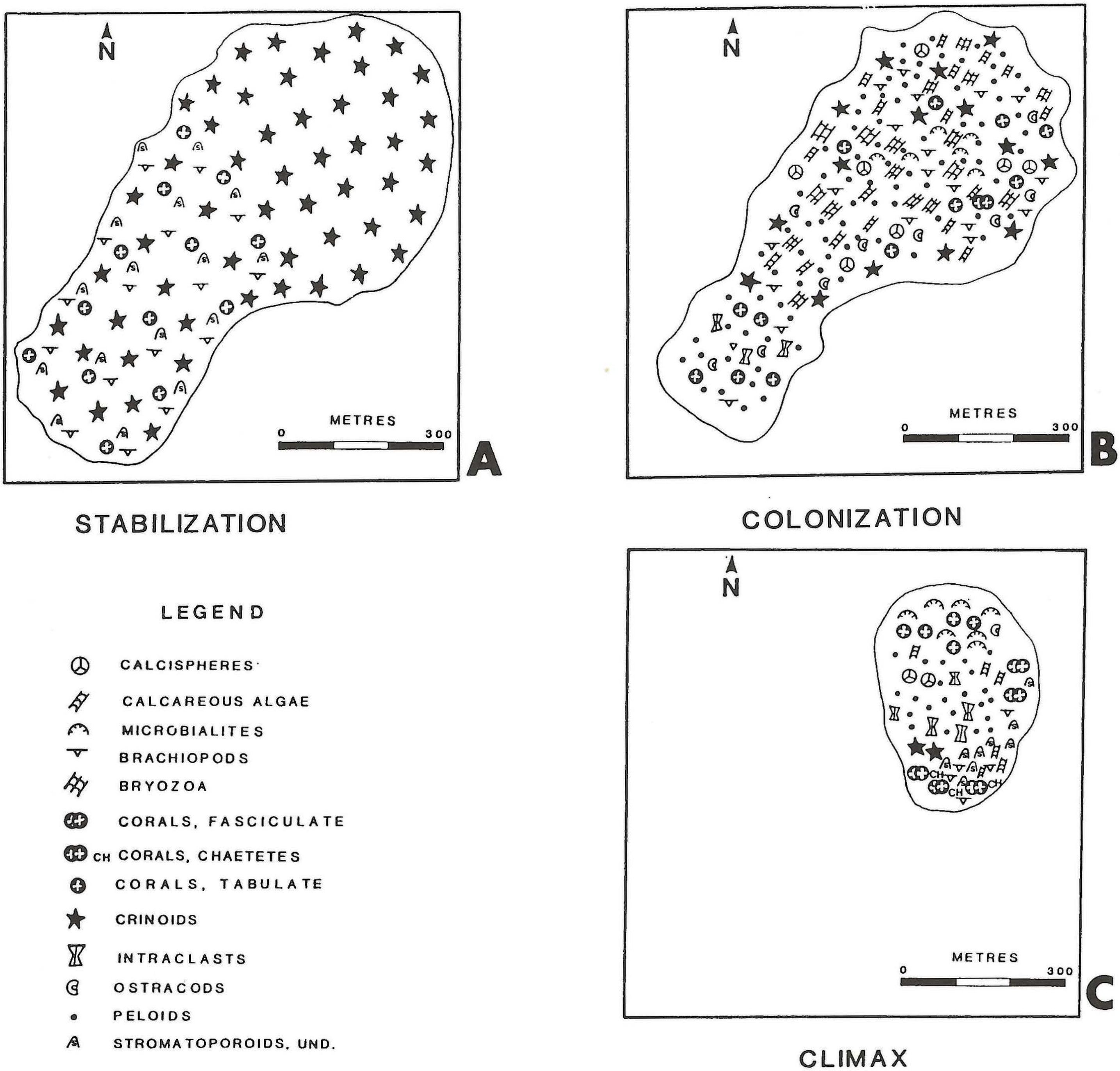


Figure GS-34-3: *a) Map based on Figure GS-34-4 showing the distribution of biota making up the stabilization growth phase of the Bluff reef; b) map based on Figure GS-34-4 showing distribution of biota making up the colonization growth phase of the Bluff reef; and c) map based on Figure GS-34-4 showing distribution of biota making up the climax growth phase of the Bluff reef.*

Formation, Second Red Beds and a collapse breccia (Fig. GS-34-2). Thus, at the north end the reef is about 70 m thick, and in the south half it varies from 43 to 51 m. The buildup has a northeast axial trend and a surface length of about 700 m along that axis.

The coreholes that penetrate to the Ashern Formation show that the Bluff reef rests conformably on the same carbonate rock unit that underlies all Winnipegosis reefs and is commonly called the platform (Fig. GS-34-2). The platform consists of mottled to nodular dolomitized lime mudstone with scattered crinoid columnals and fragmented brachiopod valves. The platform, at the Bluff, has a variable thickness ranging from about 8 to 12 m at the ends of the Bluff to 14 m beneath the central portion. This variation in thickness of the platform may have produced a paleobathymetric positive feature on the Middle Devonian sea floor that acted as a nucleus for the pioneer growth phase of the reef. At the south end of the reef, growth was initiated by a community dominated by small hemispherical stromatoporoids and thamnoporid corals (Fig. GS-34-3a). They occur in a dolomitized micritic rock with a high proportion of dispersed organic material. At the northern end of the reef, the pioneer community appears to have been dominated by crinoids (Fig. GS-34-3a). The second stage of reef growth is commonly

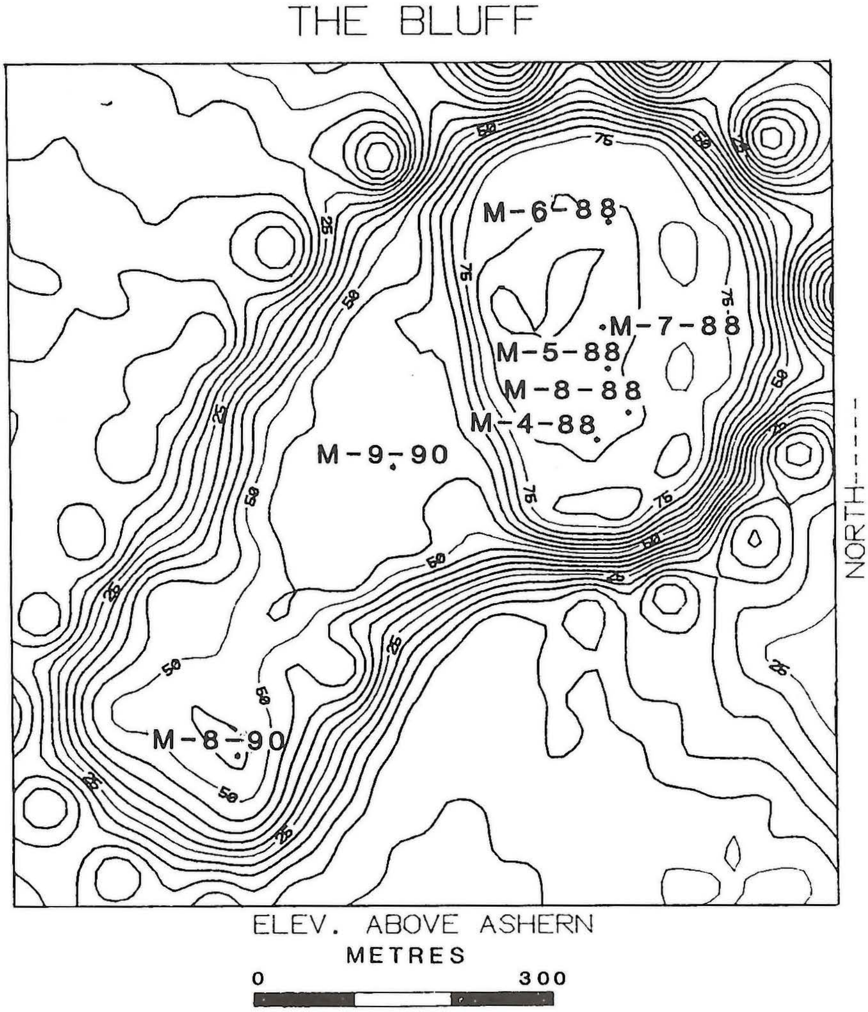


Figure GS-34-4: *Computer generated contour map of the Bluff reef. The contours represent the distance above the Ashern Formation.*

described as the colonization phase and with the exception of a second coral-stromatoporoid community a few metres above the founding one, this next phase of growth in the Bluff buildup is dominated by dolomitized micrite containing the skeletal remains of crinoids, tabulate corals and articulated, branching, calcareous algal, as well as peloids (Fig. GS-34-3b). None of the biota of this growth phase is noted as a reef- building organism, but they could act as sediment bafflers and when a sufficiently larger number occupy a particular location on the sea floor, they can trap lime mud causing it to vertically accrete. Since there is an abundance of dispersed organic material in the sediments of this type of buildup, there are also abundant burrowers, hence the presences of peloids.

The buildups gave some rigidity through subaqueous cementation and these cements are recognizable as features in the rock identified as stromatactis. Similar accumulations of lime mud, nonreef building biota and stromatactis have been recognized in Late Paleozoic rocks, some of which are called Waulsortian-type mounds (Smith, 1982). There are also modern forms found in the Straits of Florida, known as lithoherms (Neumann *et al.*, 1977).

The outcrops and the cluster of 6 coreholes at the north end show that the upper 15 to 30 m at that location consists of a climax community of tabular, hemispherical and bulbous stromatoporoids, tabulate, fasciculate and chaetitid corals, stringocephalid brachiopods, codiacean algae and Girvanella-like microbialites (Fig. GS-34-3c). The climax phase is a typical ecologic reef (Dunham, 1970). By contrast, Waulsortian-type mounds and the colonization phase of the Bluff reef are, what has been referred to, as stratigraphic reefs (Dunham, 1970).

Coreholes M-8-90 and M-9-90 show that growth in the southern part of the buildup terminated during the colonization phase. Continued growth in that region was probably interrupted by the establishment of the climax community at the north end of the reef. Climax biota commonly develop in a high energy, shallow water environment. The fauna that makes up the community generally proliferates in this type of environment because of highly oxygenated waters and an abundance of nutrients. This suggests that the northeast end of the Bluff reef faced into the prevailing wind, which in Middle Devonian time was probably from the east (Kent and Minto, in press). Thus the configuration of the reef may be the result of conformation to bottom currents created by those winds (Fig. GS-34-4 and 5). The shapes of the lithoherms in the Straits of Florida are also attributed to current flow direction.

Literature descriptions (Martindale *et al.*, 1991; Martindale and McDonald, 1990; Eherts and Kissling, 1987) of Winnipegosis reefs in the subsurface of the Elk Point Basin generally identify growth phases similar to those of the Bluff reef, that is each is a combination of a

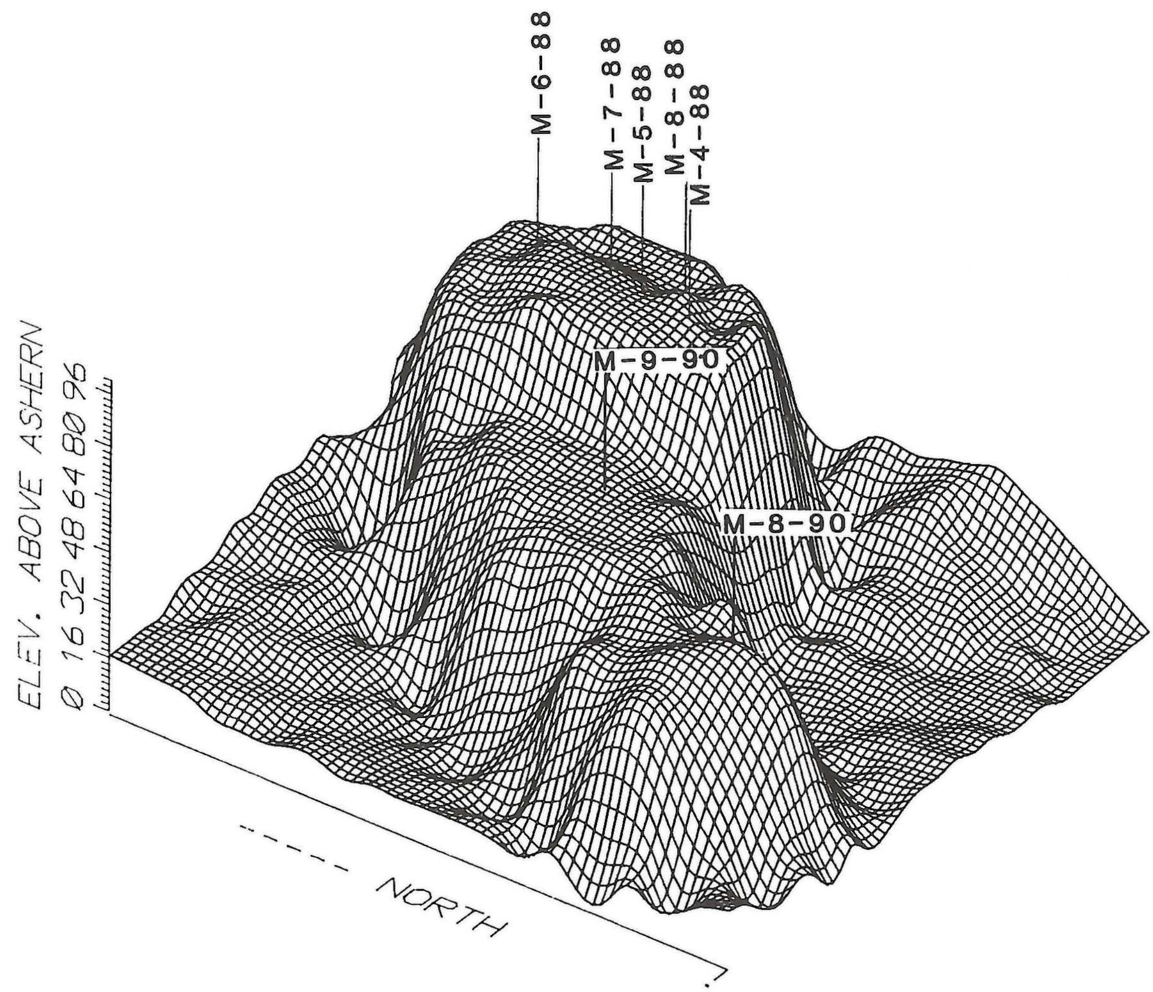


Figure GS-34-5: Computer generated three dimensional model of the Bluff reef.

stratigraphic and ecologic reef. Some of the better defined reefs in the subsurface, particularly those of the Tableland-Macoun-Hitchcock area of southeastern Saskatchewan, have shapes comparable to the Bluff, also. Other reefs in the outcrop belt do not have the configuration of the Bluff. In fact, at least one, the Highway 10 dome west of the Bluff, may have its climax community on the southeast side of the buildup. This dichotomy of reef morphology may indicate that current directions and nutrient supply may be influenced by local conditions, i.e. currents may be deflected by other reefs or obstructions on the sea floor. The Highway 10 dome appears to be part of a cluster of reefs, and the proximity of other reefs may have resulted in deflection of the prevailing currents causing them to approach other reefs in the cluster from slightly different directions, and thus altering the direction of prevailing nutrient supply. It is not uncommon for reefs and mud-mounds to develop in clusters. An excellent example of an ancient mud-mound complex can be seen in Swimming Woman Canyon in the Big Snowy Mountains, Montana, where three Waulsortian-type mounds form a cluster some 1500 m across (Smith, 1982). Winnipegosis reef clusters are documented at several localities in the subsurface including the Swan River area of western Manitoba (McCabe, 1987) and the Tableland-Macoun-Hitchcock area of southeastern Saskatchewan (Martindale *et al.*, 1991). Whether or not isolated reefs or complexes develop is undoubtedly related to the number of positive features that existed on the seafloor at any specific location.

Factors controlling initiation of Reef growth

To date, the only recognizable, yet somewhat ambiguous control is structural. A comparison of the Precambrian structure map and the upper Winnipegosis paleostructure map indicate that there is a suggestion of a structural trend that may control reef growth along the eastern edge of the study area. This trend may be related to the Birdtail-Waskada Axis and the Nelson River gravity anomaly, both of which mark the western limit of the Precambrian Superior Province. A second trend lies immediately to the west of the first one and a third to the west of that. Each is occupied by several Winnipegosis reefs. The latter appears to follow the regional northwesterly lineations as recognized by Penner *et al.* (1987) and Kent (1974). However, it would be more in keeping with the basement geology if the structural trends were northerly, mimicking the fabric of the Trans-Hudson Orogen, which underlies most of the study area. The Ashern Formation structure map subtly verifies the amount of vertical sequence affected by the Precambrian features, and adds impetus to the proposal that the initial development of, at least, some Winnipegosis reefs is structurally controlled.

Future Considerations

Further drilling at the Bluff would be fruitful, but coreholes in other reefs proximal to the Bluff would enhance the understanding of reef geometry and growth trends. A likely location for drilling is the Highway 10 dome which was carried out in late summer 1992 (see Bezys, GS-33, this volume).

A detailed seismic survey of the reef cluster west of the Bluff may be a faster way of determining the size and configuration of each reef in the complex. If the technique is successful in delineating the reefs, the results could verify whether or not individual reefs in clusters have different shapes than those of isolated reef, the configuration of which was established by prevailing winds.

A number of lines of investigation need to be looked at in the subsurface project.

1. Second or third derivative structure mapping is required to evaluate some of the subtle stacking of structures that appears to be occurring.
2. Isopach maps of the lower Winnipegosis and Ashern formations are needed to identify paleobathymetrically positive features. Trends of these might be readily recognizable and help to identify regional structural features. Since lower Winnipegosis is not a recognized interval in the Saskatchewan provincial database, it will have to be picked in all wells being used in the mapping program.
3. The isopach mapping must be followed up with core examinations where possible in anticipation that the lithologic information may reflect, types of controls other than structural, *i.e.,* paleokarst or carbonate sand bodies.

REFERENCES

Dunham, R.J.
1970: Stratigraphic reefs versus ecologic reefs; American Association of Petroleum Geologists Bulletin, v. 54, p. 1931-1932.

Eherts, J.R. and Kissling D.L.
1987: Winnipegosis platform margin and pinnacle reef reservoirs, northwest North Dakota; in Core Workshop Volume, Fifth International Williston Basin Symposium (D.W. Fischer, ed.); North Dakota Geological Survey Miscellaneous Series 69, p. 1-31.

Kent, D.M.
1974: The relationship between hydrocarbon accumulations and basement structural elements in the northern Williston Basin; in Fuels: a geological appraisal (G.R. Parslow, ed.); Saskatchewan Geological Society Special Publication No. 2, p. 63-79.

Kent, D.M. and Minto, J.W.
in prep.: Wind and current controlled geometry of some Middle Devonian reefs, Williston Basin area. (A version of this paper was presented at the 1992 AAPG national convention held in Calgary, AB., June, 1992. The abstract may be found in the convention program.)

Martindale, W. and McDonald, R.W.
1990: Sedimentology and diagenesis of the Winnipegosis Formation, Tableland area, S.E. Saskatchewan; **in** The development of porosity in carbonate reservoirs (G.R. Bloy and M.G. Hadley, eds.); Canadian Society of Petroleum Geologists, Continuing Education Short Course Notes, p. 6-1 to 6-24.

Martindale, W., Erkmen, U., Metcalfe, D. and Potts, E.
1991: Winnipegosis buildups of the Hitchcock area, southeastern Saskatchewan - a case study; **in** Sixth International Williston Basin Symposium (J.E. Christopher and F.M. Haidl, eds.); Saskatchewan Geological Society Special Publication No. 11, p. 47-63.

McCabe, H.R.
1987: The Middle and Upper Devonian carbonate and evaporite sequence of southern Manitoba; Canadian Society of Petroleum Geologists, Second International Symposium on the Devonian System, Field Excursion B2.

Neumann, A.C., Kofoed, J.W. and Keller, G.H.
1977: Lithoherms in the Straits of Florida; Geology, v. 5, p. 4-11.

Penner, L.A., Mollard, J.D. and Hodgson, R.A.
1987: Remote sensing for petroleum exploitation in Saskatchewan; Saskatchewan Energy and Mines Technical Report No. 5, 199p.

Sereda, R.D. and Kent, D.M.
1987: Waulsortian-type mounds in the Mississippian of the Williston Basin: new interpretations from old cores; **in** Fifth International Williston Basin Symposium Volume (C.G. Carlson and J.E. Christopher, eds.); Saskatchewan Geological Society Special Publication No. 9, p. 98-106.

Smith, D.L.
1982: Waulsortian bioherms in the Paine Member of the Lodgepole Limestone (Kinderhookian) of Montana, U.S.A.; **in** Symposium on the paleoenvironmental setting and distribution of the Waulsortian facies (K. Bolton, H.R. Lane, and D.V. LeMone, eds.); El Paso Geological Society and University of Texas at El Paso, El Paso, Texas, p. 51-64.

GS-35 STATUS OF THE MANITOBA OIL AND GAS WELL DATABASE (MOGWIS), GEOLOGICAL SERVICES' COMPONENT

by Glenn G. Conley

Conley, Glenn G., 1992: Status of the Manitoba oil and gas well database (MOGWIS), Geological Services' component; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 138-140.

BACKGROUND AND OBJECTIVES

The Manitoba Oil and Gas Well Information System (MOGWIS) is a comprehensive relational well database system that is currently being developed as a joint project between Petroleum Branch and Geological Services Branch. Petroleum is responsible for the development and maintenance of the general well data, production, and engineering components. Geological Services is responsible for development and maintenance of the stratigraphic data and Phanerozoic core storage data. Stratigraphic data will also be maintained by Petroleum.

The Manitoba Oil and Gas Well Information System will incorporate all existing paper and computer databases into one centralized integrated system. MOGWIS will provide rapid access to all well records for internal users and external clients, and represents a major step in the automation of technical information services of Petroleum and Geological Services. The ultimate goal of MOGWIS is to assist clients in the exploration and development of the mineral resource and oil and natural gas potential of Manitoba.

Current Status of the Project

The schema (Public Petroleum Data Model - PPDM) that was adopted is a relational model developed by a consortium comprising Gulf Canada Resources, Applied Terravision Systems, Digitech Information Services, and Finder Graphic Systems. The model was published by Rhynes (1990) as PRISM and is available to the general public. The Public Petroleum Data Model Association has been established to oversee modifications and extensions to the model, as well as its distribution. The PPDM Association has recently released Version 3.0. Petroleum Branch has recently joined the PPDM Association as a voting member. Table GS-35-1 contains a listing of version 3.0 database tables.

Table GS-35-1

PPDM Version 3.0 database tables. The tables are grouped according to relationships. The asterisk (*) indicates tables containing data required by Geological Services. Data dictionary or look-up tables have not been included.

Table Name		Description
1	**General Well Data/Well Locations Section:**	
*	Nodes	Locational information about a node.
*	Well	General well data.
*	Well DLS NTS	NTS and DLS location data.
	Well Prior Identification	Record of UWI changes.
*	Well Directional Survey	Determines deviation in a drilled well bore.
*	Well Directional Survey Points	Specific point in a directional survey.
*	Well Metes and Bounds	Surveyor's offset from a specific township corner.
*	Well Offshore Location	Offshore (Hudson Bay) location data.
2	**Lithologic Interval Section:**	
*	Measured Sections	Record of stratigraphic thickness and lithologies.
*	Lithologic Logs	Strip Log.
*	Depositional Environment Interval	Interpreted depositional environment.
*	Lithologic Intervals	Descriptive record of lithology.
*	Lithologic Major Rock	Description of principal rock type.
*	Lithologic Porosities	Description of porosity.
*	Lithologic Diagenesis	Description of diagenesis.
*	Lithologic Structures	Description of structures.
*	Lithologic Components	Description of a major rock type components.
*	Lithologic Grain Sizes	Description of grain sizes.
*	Lithologic Rock Colors	Description of rock colors.
3	**Well Agreements Section:**	
	Business Associate	Party associated with a well (Client, Company).
	Well License	Licensing information.
	Well Interest	Interest percentage of partners in a well.
	Well Rights	Rights of ownership.
4	**Well Completions Section:**	
	Well Completions	Completion interval in a well bore.
	Well Plugbacks	Description of well plugbacks.
	Well Treatments	Description of well treatments.
5	**Well Core Analysis Section:**	
*	Well Cores	Core general information.
*	Well Core Storage	Core storage location.
*	Well Core Description	Descriptive well core data.
*	Well Core Formation	Cored formations.
*	Well Core Methods	Method(s) used during core analysis.
*	Well Core Samples	Details about core section used for analysis.

Table Name		Description
*	Well Core Analysis	Core analysis results.
*	Well Core Shows	Trace of oil or gas in core or cuttings.
6	**Well Drilling Events Section:**	
	Well Status	Status history of a well
	Well Drill Status	Current drilling status.
	Well Events	Information about significant well events.
	Well Tubulars	Information about type of casing run.
	Well Cements	Well cementation data.
	Well Tour Occurrence	Noteworthy event taking place during drilling.
7	**Well Fluid/Sieve Analyses Section:**	
	Well Oil Analyses	Information associated with oil analysis.
	Well Oil Viscosity	Information about well viscosity.
	Well Gas Analyses	Information associated with gas analysis.
	Well Gas Analysis Details	Detail gas analysis information.
	Well Water Analysis	Information associated with water analysis.
	Well Water Analysis Details	Detail water analysis information.
	Well Sieve Analysis	Well sieve analysis information.
	Well Sieve Screens	Sieve analysis screen information.
8	**Well Interpretations Section:**	
*	Well Formations	Formation information.
*	Well Faults	Fault information
	Well Payzones	Pay or producing zones in a well bore.
	Well Porous Interval	Porous interval information.
	Zone	Zone of specified characteristics.
9	**Well Pressures Section:**	
	Well Pressures	Summary information about well pressures
	Well AOF Pressures	Absolute open flow pressure.
	Well Press_4pt	Pressure reading for a four point AOF test.
	Well BH Pressures	Well bottom hole pressure.
10	**Well Production Section:**	
	Well Production Zones	Information about producing zones.
	Well Monthly Production	Well Monthly production information.
	Well Daily Production	Well daily production information.
	Unit	Combination of leases information.
11	**Well Tests Section:**	
*	Well Tests	Includes well formation and production tests.
*	Well Test Vo	Well test valve open information.
*	Well Test Vo Flows	Well test valve open flow information.
*	Well Test Vo Recovery	Well test valve open recovery.
*	Well Test Contaminant	Type of contaminants present in a well test.
*	Well Test Analyses	Result of the analysis of a well test.
*	Well Test Pressure	Pressure measurements fora well test.
*	Well Computed Analyses	Computed analysis information about a well test.
*	Well Computed Analysis Gauges	Computed analysis gauge information.
*	Well Test Muds	Well test mud information.
*	Well Test Narrative	Test information narratives.
*	Well Test Shutoffs	Well test shutoff information.
*	Well Shows	Hydrocarbon shows detected in the well.
12	**Well Velocity Section:**	
	Well Velocities	Well velocity information
	Well Checkshot Survey	Summary of checkshot survey information.
	Well Checkshots	Detail information for checkshot survey.
13	**Wireline Logs Section:**	
*	Wireline Jobs	Well logging job.
*	Wireline Trips	Sequential logging runs.
*	Curves	Well trace recorded by the sensing equipment.
*	Curve Intervals	Interval continuously recorded by logging tools.
*	Curve Scales	Original source chart information.
*	Digital Curve Intervals	Log curve that has been digitally captured.
*	Mud Samples	Sample of fluid during drilling.
*	Mud Resistivities	Resistivity measurement of the mud.
*	Logging Tools	Logging tool information

Petroleum Branch has begun the verification of general well data records. In 1991, a summer student was hired to verify approximately 1000 wells (license number 3300 to 4400). In 1992, three summer students were hired to verify an additional 1000 wells (license number 1 to 1000). Because the 1992 wells are the oldest wells, the data is more difficult to verify. Petroleum anticipates that data verification will be complete by late 1993. Once the verification process is complete, Petroleum will re-enter the corrected data.

Geological Services has undertaken the verification of the stratigraphic data (formation tops) on a project basis. R. Bezys, currently working on the Red River Project, has completed verification of all Lower Paleozoic formation tops. Wireline logs and cores were used in the verification process. This involved the relogging of 10 oil and gas cores, 61 stratigraphic and mineral exploration cores, and establishing stratigraphic picks for 150 oil and gas wells from wire line logs. More than 5100 tops have been verified. Calculation of isopachs and subsea elevations for the tops is in progress. In addition, old logs and new relogs of oil and gas wells are being entered in MS Word and will be merged into the database as they are completed. About 500 mineral exploration, stratigraphic and water resources wells will be also be merged into the database.

To accurately position the wells on a digital map, Geological Services undertook the following process: a) Linnet Graphics was contracted to produce an accurate township corner digital map for the entire province of Manitoba; and b) Geological Services employed a summer student for a month to verify the metes and bounds and KB elevations for each of 4400 wells. The metes and bounds are the surveyor's offsets from a specified township corner and, when used with an accurate township corner map, will allow accurate positioning of the well. KB, or Kelly Bushing, elevations are required for the calculation of subsea elevations of each formation. Once the necessary data is updated, Energy and Mines' PAMAP GIS system will be used to generate digital maps. We hope to show that the database, in combination with the GIS, will permit shortening the cycle of Phanerozoic map production by allowing the computer to do the data retrieval and the majority of the contouring.

A Phanerozoic nomenclature chart for Manitoba was developed by R. Bezys, C. Martinuk and G. Conley.

The Geological Services component of MOGWIS is being developed in a single user version of Oracle database software by G. Conley. This involves the development (programming) of screen forms for data entry and querying the database and, report forms for hard copy output. When funding permits, the database will be migrated into a centralized multi-user Oracle database. However, because the database is being developed in a single user environment, G. Conley must also enter all data updated by Geological Services.

Phanerozoic core storage data is being maintained by D. Berk (Geological Services) in dBase IV files. This system has already proven to be valuable in considerably reducing the amount of time required to retrieve Phanerozoic core. In addition, dBase IV programs have been written for recording storage locations of stratigraphic and exploration core. Core storage will be moved into the centralized Oracle database when it becomes available.

Future Developments

Once adequate funding is available, the data will be moved into full daily operation in a centralized Oracle multi-user, networked database. It is hoped that this can be accomplished in the near future.

Full daily operation means that Petroleum and Geological services will enter and update well data directly into the tables of the centralized information system, rather than into the current series of stand-alone databases. Each user would enter data directly into the group of tables under their responsibility. Users would have access to all levels of data, limited only by their security level.

The long term goal in developing the MOGWIS database component is to use it as the host database for a Stratigraphic/Petroleum Geographic Information System (GIS). This type of system would allow selective extraction of data from the database and provide visual display of the data as a 2 or 3 dimensional map.

In order to facilitate distribution of verified stratigraphic data, the data will be made available to clients in the form of; a) paper listings, b) ASCII (text data) listings on a floppy disk; or c) as dBase IV or Foxpro database files. For further information, contact Ruth Bezys.

REFERENCES

Rhynes, P. J.
1990: PRISM: Petroleum and Resource Industry Information Storage and Management; Geobyte, v. 5, no. 5, p. 31-35.

GS-36 GEOPHYSICAL SURVEYS FOR KAOLIN - SYLVAN AREA

by I.T. Hosain

Hosain, I.T., 1992: Geophysical surveys for kaolin - Sylvan area; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 141-144.

INTRODUCTION

During the latter part of July, seven days were spent in the Sylvan area (Fig. GS-36-1) to test various geophysical methods for locating and tracing clay channels within the limestone and dolomite bedrock. Pits and drillholes in the area intersected good quality kaolin that could be profitable to extract if found in sufficient quantity.

The survey comprised 19 km of VLF-EM using two Geonics EM-16 units, 700 m of EM-34, and 1 km of gravity in the area of the pits and along section roads. For the EM-16 survey the transmitting station NAA at Cuttler, Maine was used throughout. This operates at a frequency of 24.0 khz. The EM-34 was run with both coils horizontal in a vertical dipole mode and coil spacing of 20 and 40 m, both coils vertical in a horizontal dipole configuration, and also with the transmitter vertical receiver horizontal and transmitter horizontal receiver vertical with a coil separation of 40 m. A 2.6 g/cm^3 specific gravity was used for the bouguer correction in the gravity calculations. Latitude, free-air and drift corrections were applied, but topographic corrections were not included as the surrounding area was fairly flat.

GEOLOGY (Assessment file 92981)

The Arborg claim blocks are located in the flat Interlake region of Manitoba where exposure is poor, though the glacial drift is only 3 to 5 m thick. The bedrock geology consists of Ordovician limestone and dolomite that probably belong to the Stony Mountain Formation. The stratigraphy established elsewhere shows that the Stony Mountain Formation is underlain by dolomitic limestone of the Fort Garry, Selkirk, Cat Head and Doghead formations, and Winnipeg Formation sandstone, which rests unconformably on the Precambrian basement. The regional dip is gently to the southwest and the total thickness of Paleozoic rock, at the property, is probably in the order of 200 m. Structurally

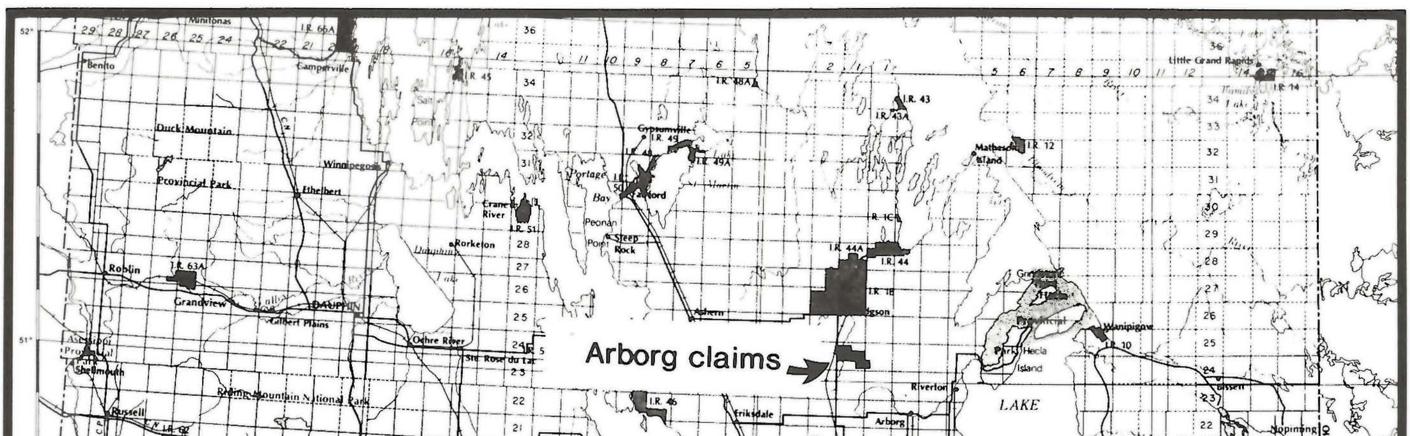


Figure GS-36-1: *Location map, Arborg Project-Sylvan area.*

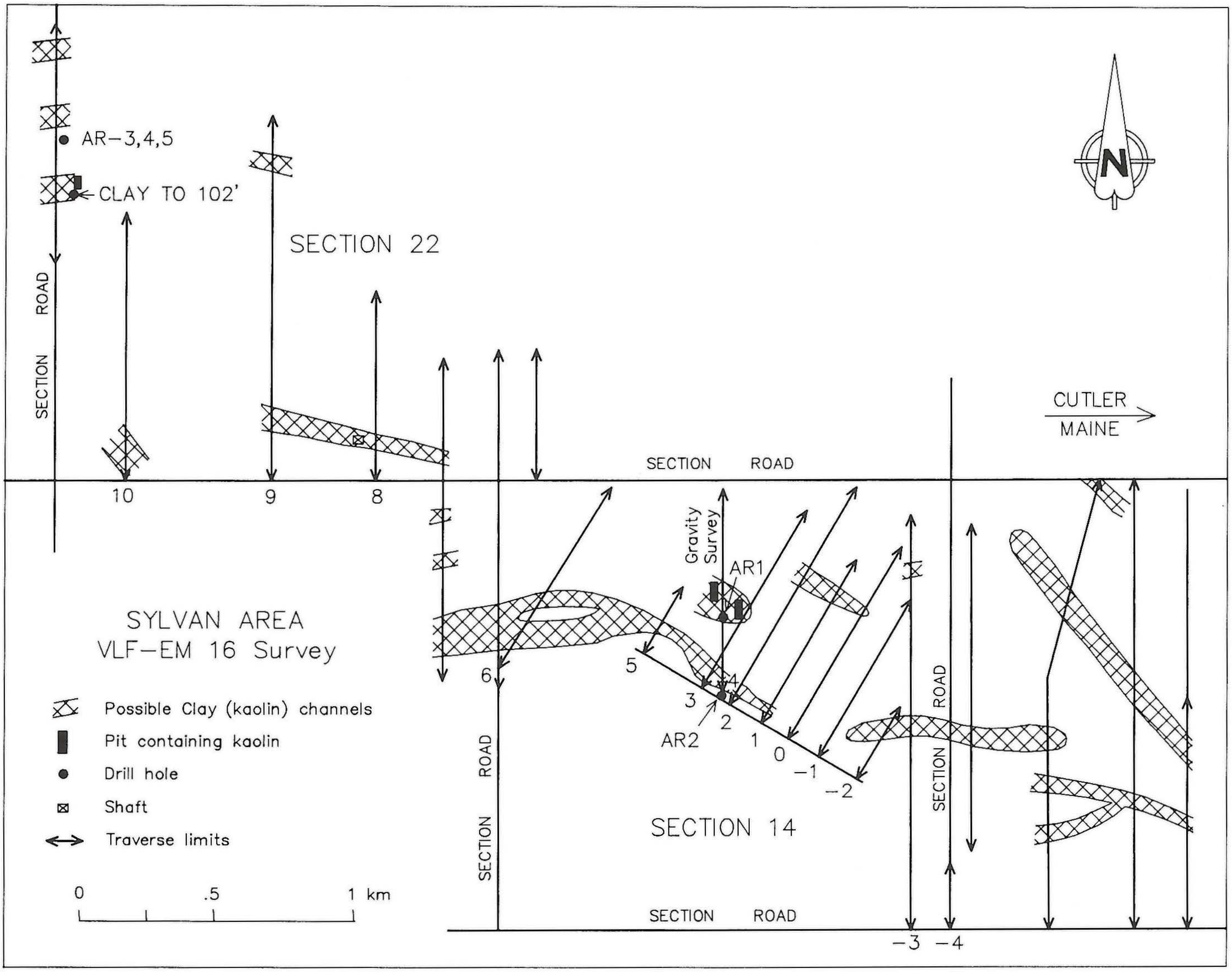


Figure GS-36-2: Sylvan area, VLF-EM 16 survey.

anomalous inliers of Precambrian rocks occur 50 km and 110 km to the northwest. It is thought that the claim group is situated on a northwest-trending structural high, in which case the depth to Precambrian basement might be significantly less than 200 m.

The feature of interest at the property is an occurrence of clays and sands in a fossil gorge in the Paleozoic carbonate rocks. The gorge is at least 54.8 m (180 feet) deep; fossil plants indicate it is Cretaceous age. The occurrence was discovered in pits, by local farmers, and was investigated in 1957 by Kaolin and Minerals Exploration Ltd. as a possible source of commercial china clay. EM geophysical surveys outlined a sinuous course to the gorge, which could be traced over a distance of some 8 km. The width has been estimated between 60 to 100 m. The exploratory work undertaken in the 1950's did not indicate a viable kaolin deposit.

DRILLING (assessment files 92981 and 93089)

Drillhole AR-1 drilled in 1980 on an HLEM anomaly, intersected 42.7 m of kaolin under 12.2 m of till. Although the hole did not encounter radioactivity above a background count rate of 60 to 70 c.p.s., it was decided that the work had been inconclusive as the hole had not penetrated to the bottom of the gorge. Accordingly, Midwest Drilling was engaged to undertake further drilling and commenced work on April 13 , 1981. A site 1600 m "upstream" from AR-1 was chosen on an HLEM anomaly in the vicinity of test drilling undertaken in the 1950's. The first hole AR-3 encountered limestone bedrock at a depth of 10 m and, after coring 3 m of pale grey micritic limestone, the hole was stopped and the drill moved 25 m south. The second hole, AR-4, encountered limestone bedrock and was stopped at a depth of 9.1 m. The drill was then moved 40 m north to a site very slightly north

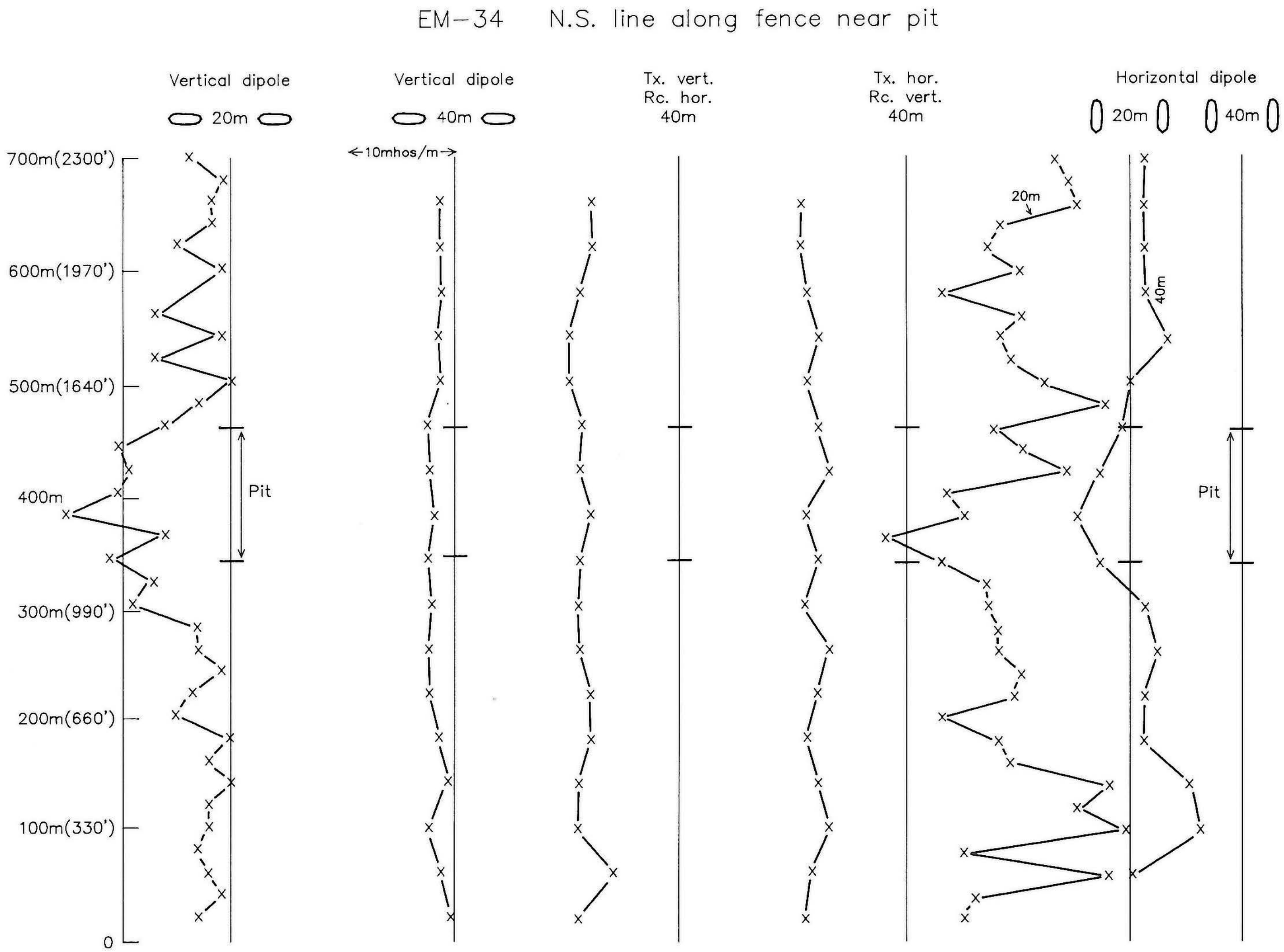


Figure GS-36-3: EM-34 north-south line along fence near pit.

of the centre of the HLEM anomaly. The third hole, AR-5, intersected 53.0 m of limestone boulders and clay overlying limestone. The hole was allowed to continue because of the possibility of encountering the Precambrian basement below the gorge at a fairly shallow depth due to a structural high. However, the hole was still in limestone at a depth of 84.0 m and was stopped. The hole was probed for natural gamma radiation using an Exploranium unit. Only fairly steady background radiation of about 40 c.p.s. was detected.

Hole AR-2 was sited 370 m south of AR-1 on an HLEM conductor, which was thought to represent a possible tributary channel to the main one intersected in the first hole. The drill penetrated only 6 to 10 m of till resting on dolomite bedrock. The hole was stopped at 15.2 m and the drill was moved off the property. It was decided to curtail the drilling program in view of the fact that the depth capabilities of the rig were unsatisfactory.

RESULTS OF CURRENT WORK

The results of the VLF-EM survey are shown in Figure GS-36-2. Many conductors were delineated; some coincide with the known channel. Clay edges produce predominantly in-phase anomalies. A filter developed by D.C. Fraser (Fraser, 1969) was applied to the field data. This filter suppresses the geological noise and accurately outlines the limits of the conductors. The filter amplifies anomalies produced by near surface conductors (Fraser, 1969). From Figure GS-36-2 the delineation of various conductors after application of the filter is evident. The positive in-phase readings above 10% appear to reflect the clay horizons.

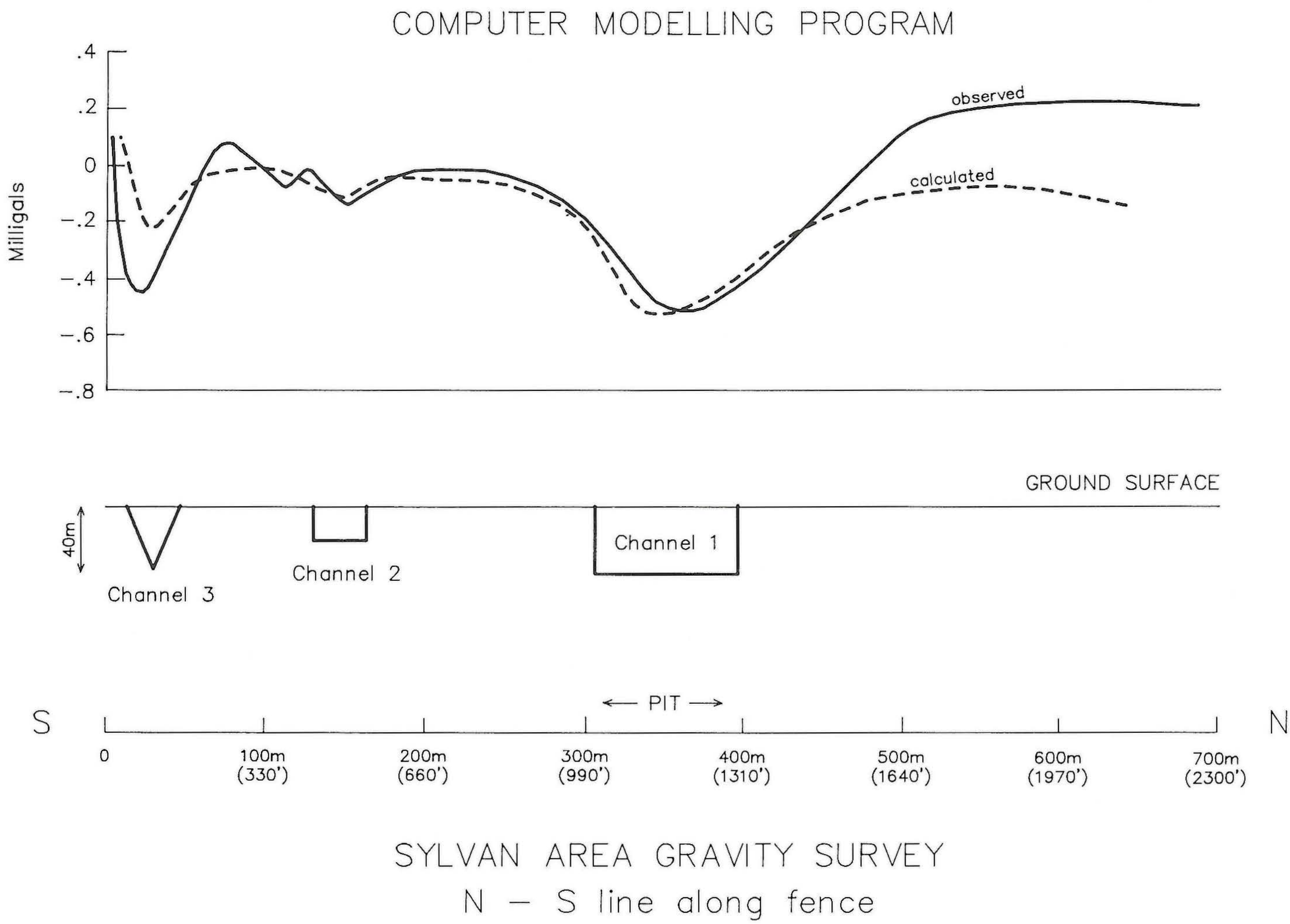


Figure GS-36-4: *Sylvan area gravity survey; north-south line along fence.*

REFERENCES

Assessment Files 5004, 92981, 93088
Manitoba Energy and Mines

Fraser, D.C.
1969: Contouring of VLF-EM data; Geophysics, Volume 34, No. 6, p. 958-967.

GS-37 INDUSTRIAL MINERALS INVESTIGATIONS IN THE SELKIRK MAP AREA (NTS 62I)

by J.D. Bamburak

Bamburak, J.D., 1992: Industrial minerals investigations in the Selkirk map area (NTS 62I); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p 145-148.

INTRODUCTION

The objective of this project was to evaluate the industrial mineral potential of bedrock within the Selkirk map area (Fig. GS-37-1). In order to achieve this objective, it was necessary to document all industrial mineral occurrences in the study area and to relate them to the regional geology.

The Selkirk map area consists mostly of bedrock that ranges in age from Precambrian to Devonian (Fig. GS-37-2). Small pockets of Jurassic and Cretaceous strata have also been reported from drill holes, but these beds are not dealt with in this report because of lack of surface exposure and limited areal extent.

Numerous reports have been written on the bedrock geology of the Selkirk map area, the most important are noted below. The Precambrian geology was described in several papers edited by McRitchie and Weber (1971). The stratigraphy of Ordovician and Silurian formations was described by Baillie (1951, 1952) and by Cowan (1971, 1978). Industrial mineral investigations of high-calcium limestone, peat and dolomite resources were carried out by Bannatyne (1975, 1980, 1988). Water well records and other drill hole data were used by Betcher (1986) to prepare a set of maps that depict the bedrock geology, overburden thickness and bedrock topography.

During a three month field season, over 30 "new" Paleozoic outcrop exposures were examined and sampled. Quarry sections were measured and rock units that are potential sources of industrial minerals were sampled. Four quarries, not previously described, were added to the data base. A detailed site map was prepared for one Precambrian outcrop that is a potential source of dimension stone. Holes M-38-92 and M-39-92 were drilled at localities where data for stratigraphic correlation was deficient and to provide samples of limestone and dolomite for analyses; three holes (M-35-92, M-36-92 and M-40-92) were drilled in support of the high-magnesium dolomite investigations (see Bezys, GS-33, this volume).

OBSERVATIONS

Dimension Stone

At the Cold Spring Granite Limited's quarry, located 14 km south of Lac du Bonnet and situated in the Lac du Bonnet batholith, 5 "colours" of granite stone are produced in either finished pieces or as large blocks, which are shipped to the U.S.A. for cutting and polishing. The quarry has reached its present maximum depth and effort is now directed at removing stone laterally across the outcrop. A large monzogranite outcrop, also situated within the Lac du Bonnet batholith, is

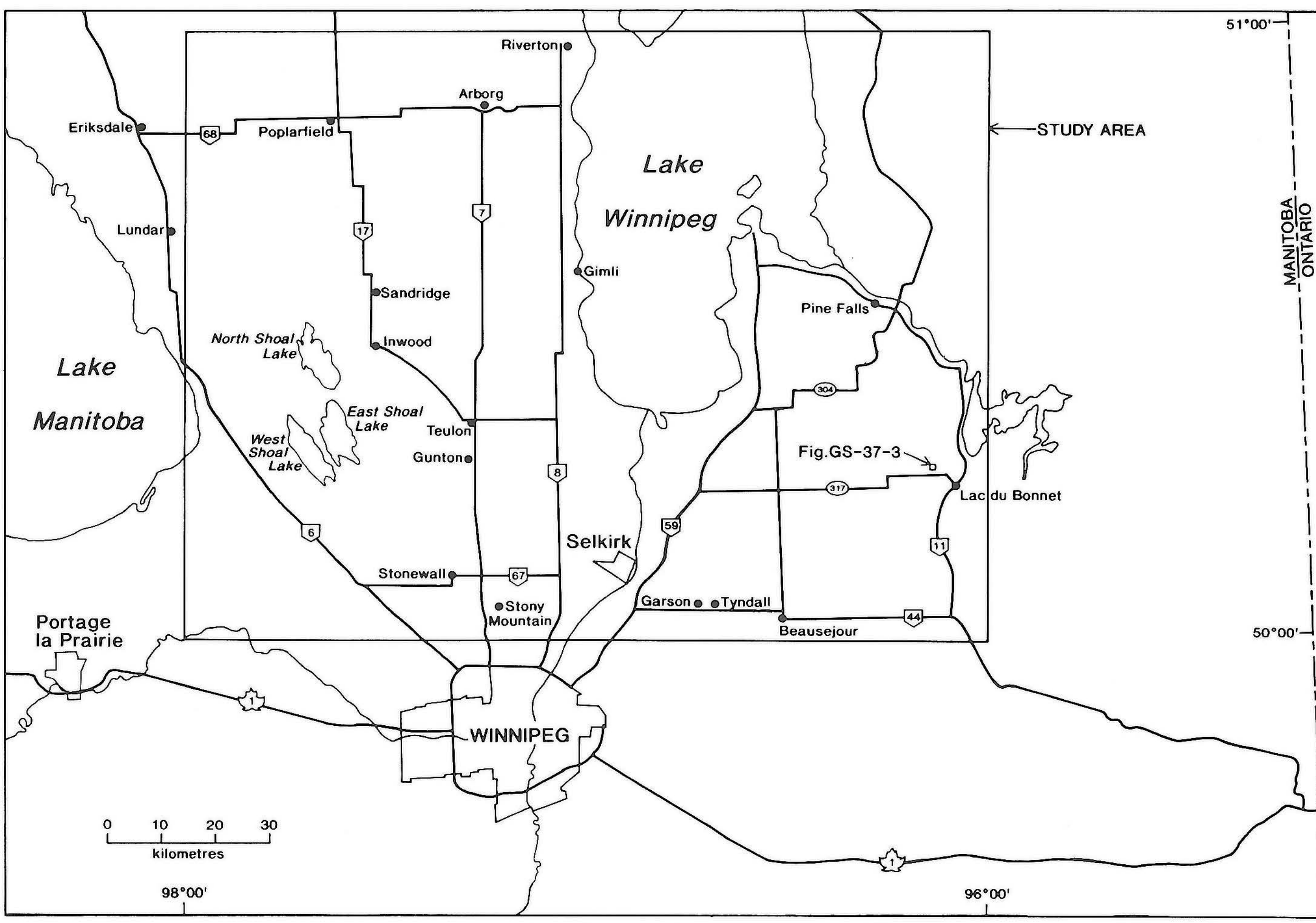


Figure GS-37-1: Location map for the study area (NTS 62I).

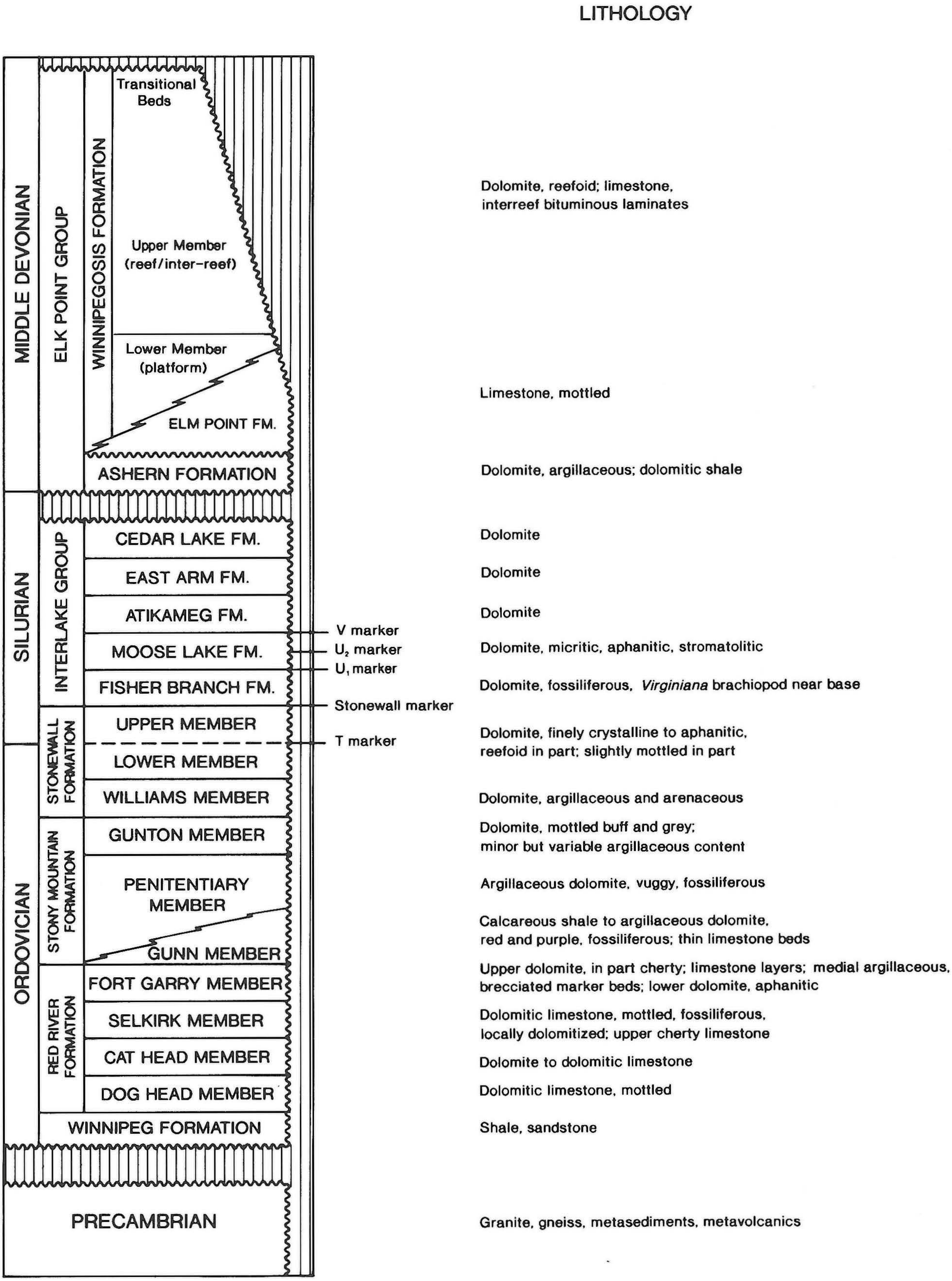


Figure GS-37-2: *Formational nomenclature in the study area.*

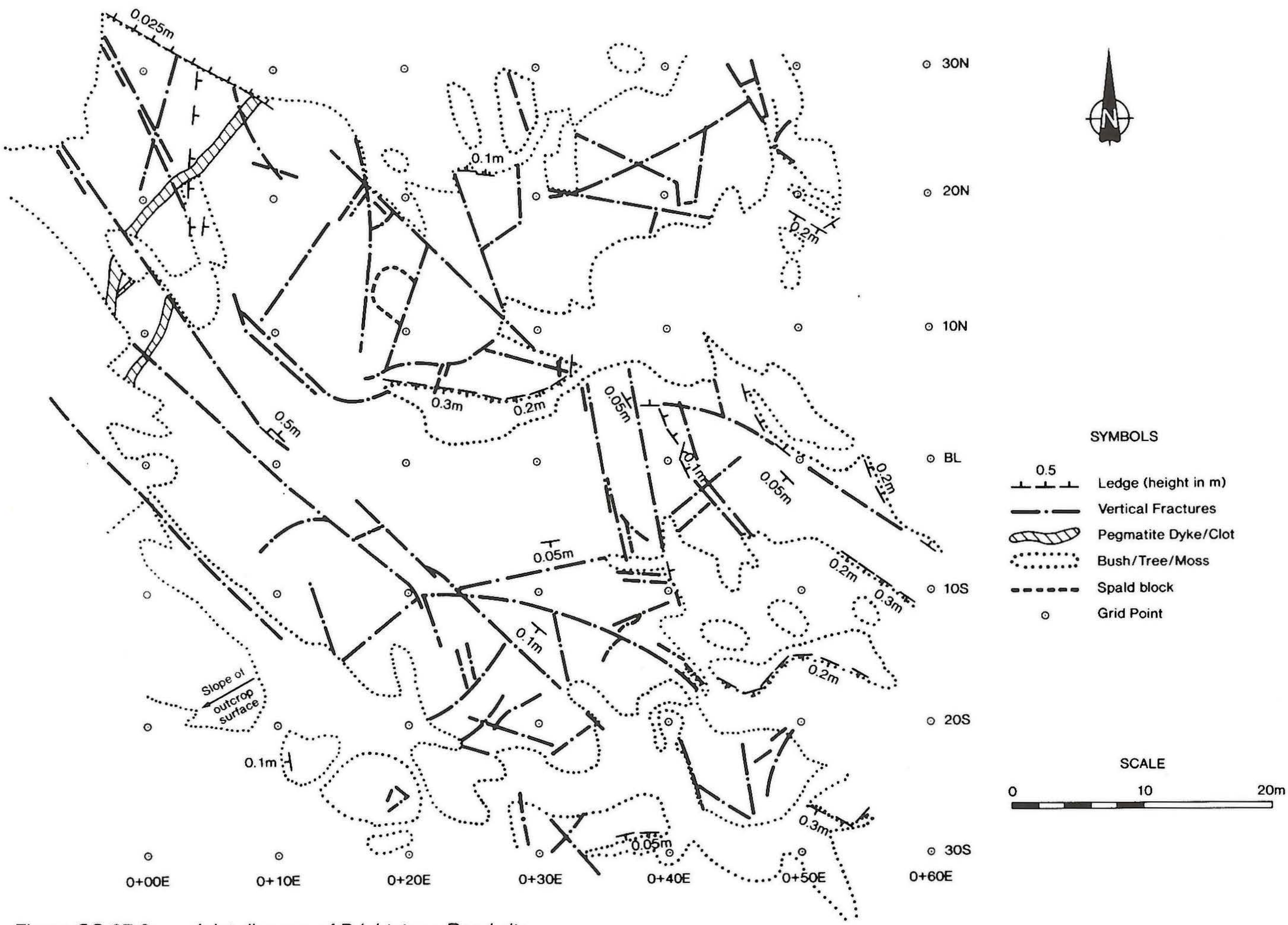


Figure GS-37-3: Joint diagram of Brightstone Road site.

located 2.5 km north of PR 317 along Brightstone Road. A detailed site map (Fig. GS-37- 3) was made at the southwest corner of the outcrop, which rises several metres above the surrounding prairie. The rock is similar to that quarried at Cold Spring, but the partly weathered upper surface appears to have a greyish, rather than a pinkish, colour.

Outcrops situated at the western margin of the Great Falls pluton were examined last year (Bamburak and Schmidtke, 1991). These were found to be unsuitable for dimension stone due to the highly fractured nature of the outcrops and the presence of epidote. Similar rock, also unsuitable for dimension stone, occurs north of Pine Falls along PR 304. At least 10 quarries were developed for aggregate in the immediate vicinity of PR 304. One of these quarries located in Sec. 26, Tp. 19, Rge. 10 EPM, is being rehabilitated as a portion of a Sustainable Development Project. A circular interpretative trail with the quarry as the centre is planned.

The Gillis Limited quarry at Garson produces Tyndall stone from the middle beds of the Selkirk Member and it was in full operation during the year. Three "colours" of Tyndall stone are produced in a variety of finished shapes and sizes; they are buff, grey and gold. No new deposits of Tyndall stone were located during this summer's investigations, although potential sources of this stone are probably present beneath thin overburden in the area around the quarry.

A four year old quarry 8 km southwest of Libau, produces aggregate from the Selkirk Member. The stone is mottled similar to the Tyndall stone produced at Garson; however, there are abundant chert nodules, numerous "chimneys" filled with younger sediments, and beds locally altered to a powder-like consistency. Some large blocks indicate that there may be limited potential for dimension stone in the vicinity of the quarry, but the above characteristics probably would make extraction of blocks of consistent appearance difficult. At the north end of the quarry, the mottles are reddish brown. This colour is not present at the Garson Quarry and thus it may be a potential new product.

Facing stone from the Gunton Member of the Stony Mountain Formation and the Stonewall Formation have been used in the past to construct buildings and lime kilns in Gunton and Stonewall. Several buildings in Winnipeg, including the Hudson Bay Company, were constructed from stone obtained from the Stonewall Formation. Several localities of such stone were noted within the map area and these could be utilized if there was sufficient demand.

Dolomitic Lime

The production of lime in the map area was very important to developing communities in the past. Lime was used for such purposes as tanning of leather, paper production, cement and purification of sugar. Evidence of old lime kilns that utilized local bedrock was found at Garson (Selkirk Member), at Stonewall (Stonewall Formation from 1882-1967), northeast of Stonewall (Gunton Member) and north of Inwood and at Poplarfield (Moose Lake Formation).

Dolomitic lime could be produced at an unlimited number of localities in the map area.

High-magnesium Dolomite

In 1991 a drilling program conducted by Manitoba Energy and Mines outlined a geological reserve of 67 million tonnes of dolomite within a small area of the Fisher Branch Formation, located 3 km northwest of Sandridge. This material averages 21.6% MgO and 0.23% Residue (Bamburak and Gale, in prep.). On the basis of additional analyses, potential sources of high-magnesium dolomite are also present within the underlying Stonewall Formation and the overlying Moose Lake Formation.

High-calcium Limestone

Limestone zones within the Red River Formation are situated at the base of the Dog Head Member and near the top of the Selkirk and Fort Garry members (Bannatyne, 1975).

Thin limestone layers, interbedded with red calcareous shale in the upper 1.6 m of the Gunn Member of the Stony Mountain Formation, occurs at Stony Mountain within the former City of Winnipeg Quarry (Bannatyne, 1988, p. 18, 19). A sample of limestone and shale was analyzed and returned 42.5% CaO and 4.90% MgO. If the shale can be successfully removed by washing, then a higher CaO product can be obtained. A thickness of 20.6 m of Gunn Member was penetrated in Hole M-2-69 drilled at the quarry; however, the relative percentage of high-calcium limestone is unknown.

Silica Sand

A glass container factory, the first in Western Canada, was built in 1906 at Beausejour. Silica-rich sand was quarried at the plant site from the Pleistocene Belair moraine, which was probably derived in large part from the Ordovician Winnipeg Formation. The Manitoba Glass Works produced jars and beer, soft drink, medicine and ink bottles until 1914, and employed 350 workers at its peak. The lure of free land and natural gas prompted the move by the company to Redcliff, Alberta.

A preliminary study of the Mars Hill locality, located 15 km north-northwest of Beausejour, in 1984 (Watson, 1985), indicated that a large deposit of silica-rich sand may be present.

At Selkirk, a pilot plant designed to produce silicon metal was recently completed. The source of the feedstock, silica sand or lump quartz, for the plant has apparently not been decided.

Peat Moss

Despite a very wet and cold summer, production continued at the sphagnum peat moss operations of Fisons Horticulture, at two sites along PTH 44 about 13 km east of Beausejour. The processing plant is located at the North Julius bog. Locations of peat bogs in the map area were described in detail by Bannatyne (1980).

CONCLUSIONS

The Selkirk map area, which historically has produced a wide variety of industrial mineral products, is presently producing many of these products and contains potential sources of new products.

Dimension stone sources are located within the Lac du Bonnet batholith and in the vicinity of Garson, Gunton and Stonewall. Dolomitic lime sources are situated throughout the Ordovician and Silurian outcrop belt. High-magnesium dolomite deposits with over 21% MgO and very low impurities have been proven within the 15 m thick Fisher Branch Formation, and are known to occur within immediately adjacent overlying and underlying Silurian formations. High-calcium limestone may exist in economic quantities within the Red River and Stony Mountain formations; further work must be done to develop the potential of this commodity. A possible source of silica sand is present at Mars Hill, near Beausejour, but follow-up work is required before tonnage and grade estimates can be made. Sphagnum peat moss deposits have been outlined in the map area.

ACKNOWLEDGEMENTS

The Department of Natural Resources deserves special recognition for providing complementary field accommodation at its bunkhouse in Riverton and a camp site at Grand Beach. Hooman Shirazi was a willing and capable assistant. Contributions by the drill crew were greatly appreciated.

REFERENCES

Baillie, A.D.

1951: Silurian geology of the Interlake area; Department of Mines and Natural Resources, Mines Branch, Publication 50-1, 82p.

1952: Ordovician geology of Lake Winnipeg and adjacent areas, Manitoba; Manitoba Mines Branch, Publication 51-6, 61p.

Bamburak, J.D. and Gale, G.H.

in prep.: Evaluation of magnesium resources in Phanerozoic dolomites of the Interlake area, Manitoba: Part 2 - Sandridge area; Manitoba Energy and Mines.

Bamburak, J.D. and Schmidtke, B.E.

1991: Dimension stone investigations in southeastern Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 77-83.

Bannatyne, B.B.

1975: High-calcium limestone deposits of Manitoba; Manitoba Mineral Resources Division, Publication 75-1, 103p.

1980: Sphagnum bogs in southern Manitoba and their identification by remote sensing; Manitoba Energy and Mines, Economic Geology Report ER79-7, 103p.

1988: Dolomite resources of southern Manitoba; Manitoba Energy and Mines, Economic Geology Report ER 85-1, 39p.

Betcher, R.N.

1986: Groundwater availability Selkirk area (62I); Manitoba Natural Resources, Groundwater Availability Map Series Selkirk Area (62I), 1:250 000.

Cowan, J.

1971: Ordovician and Silurian stratigraphy of the Interlake area, Manitoba; **in** Geoscience Studies in Manitoba, A.C. Turnock (ed.); Geological Association of Canada, Special Paper 9, p. 235-241.

1978: Ordovician and Silurian stratigraphy of the Interlake area, Manitoba; University of Manitoba, M.Sc. thesis (unpublished), 73p.

Gale, G.H.

1991: Evaluation of magnesium resources in Phanerozoic dolomites of the Interlake area, Manitoba: Part 1 - Reconnaissance; Manitoba Energy and Mines, Open File OF91-3, 19p.

McRitchie, W.D. and Weber, W.

1971: Geology and geophysics of the Rice Lake region, southeastern Manitoba; Manitoba Department of Mines and Natural Resources, Mines Branch, Publication 71-1, 430p.

Watson, D.M.

1985: Silica potential of the Libau-Beausejour area; Manitoba Energy and Mines, Open File Report OF 85-2, 12p.

GS-38 DEVELOPMENT OF A LEVELLED AEROMAGNETIC DIGITAL DATA BASE FOR CANADA

by R. Dumont[1], K. Anderson[1]

Dumont, R. and Anderson, K., 1992: Development of a levelled aeromagnetic digital data base for Canada; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 149.

The Geological Survey of Canada's airborne magnetic data acquired over a period of 45 years represent over 10 000 000 line km of survey. Most of this data was originally published in contour map form. In the last decade the data have been published as colour maps at 1:1 000 000 after being gridded at 812.8 m and levelled to adjacent surveys. The GSC has now undertaken to compile all of the total field aeromagnetic data into a contiguous grid, sampled at 200 m. Using the existing 812.8 m levelled grid as a reference datum profile data of adjacent surveys are levelled and gridded. High sensitivity detailed surveys are also levelled to the same datum. To date, the processing for the Maritime Provinces, Ontario, Manitoba and Saskatchewan is complete.

Digital data are now available in formats compatible with commercial interpretation packages and can be obtained on a variety of media: 9-track, Exabyte, cartridge, CD, floppy, or via Internet.

Licensing arrangements are being made with a number of companies who will broaden the distribution of aeromagnetic data to the private sector.

1 Geological Survey of Canada, Geophysics Division, Aeromagnetic Section

GS-39 INVENTORY OF KARST LANDFORMS AND FEATURES, MANITOBA'S INTERLAKE

by W.D. McRitchie

McRitchie, W.D., 1992: Inventory of Karst landforms and features, Manitoba's interlake; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 150-152.

GENERAL

The continuing reconnaissance and exploration of karst landforms in the Interlake included groundwork in the Grand Rapids, Devil's Lake, Pine Lake, Gypsum Lake, Sylvandale, Poplarfield, and Steeprock areas, as well as a visit to Brabant Point on Lake Winnipegosis.

Only a few new caves were located; however, the inventory of major drainpoints in the floors of clump-willow fens was enlarged, with new discoveries north of Devil's Lake, north of Jackpine Lake, west of Mile 12 (north of St. Martin Junction), and northeast of Gypsum Lake on the Warpath Trail. All appear to be part of an extensive subcutaneous drainage system that persists throughout the Interlake; previous occurrences have been reported from Mill Ridge and throughout the Grand Rapids uplands (McRitchie, 1991). Drainage in all instances cited is to the south (down dip).

West of Buffalo Lake, a chain of major drainpoints was identified at the base of an east-trending escarpment (Cedar Lake Formation?) (Fig. GS-39-1), with numerous embayments that resulted from collapse of older subterranean chambers (Fig. GS-39-2). Teardrop Basin, which occupies one of the embayments, contains a centrally uplifted and dissected peat mound, that resembles a palsa, as well as numerous mats of peat stranded along the east, west and south shorelines (Fig. GS-39-3).

The easterly trend of the escarpment persists for over 10 km, with two mesa-like outliers of Cedar Lake Formation to the north. This trend is perpendicular to what was shown on earlier maps and may indicate that the axis of the Moose River syncline (and eastern boundary of the Churchill/Superior Boundary Zone) lies further to the east than was previously thought. However, in this context, stratigraphic drillhole M-29-92, on the Sturgeon Gill Road, penetrated to basement comprising a fine grained ultramafic Molson dyke and peridotite that appear to be part of the Superior Province, unaffected by the Hudsonian metamorphic overprint.

Further south, numerous beaded chains of sinkholes were found on the Sylvandale Community Pasture, where purple-mottled dolomite of the Penitentiary Member is widely exposed in well jointed pavement lying above, and to the west and south, of a 3 to 5 m high northeast-facing escarpment of Upper Fort Garry Formation cherty and vuggy dolomite. Numerous wind-driven pumps on the plateau are used to raise water into troughs for livestock, the depth of the water table is estimated at around 5 m.

Measurements taken here, and at numerous other sites in the southern Interlake confirmed the predominance of joints with orientations concentrated in three sets at 0° to 10°, 45° to 60° and 100° to 120°.

MESOZOIC AND OTHER INFILL

Other stratigraphic drillholes in Paleozoic carbonates at the REPAP site near The Pas, at The Bluff on Dawson Bay, and in the southern Interlake, continue to intersect numerous cavities filled with Mesozoic sediments (Bezys, GS-33, this volume). Fossil caves (up to 3 m and 4 m in diameter), totally plugged with green stratified clay (containing marcasite nodules, crinoid ossicles and rhomboid barite crystals), were identified in otherwise well bedded Elm Point Formation limestone exposed in the Canada Cement and Continental Lime quarries at Steeprock. A 15 to 20 cm thick vertical dyke of coarse grained (Cretaceous ?) sandstone with calcitic cement was also observed in the north wall of the Canada Cement quarry. An open, near vertical solution pipe (Fig. GS-39-4), in the north wall, and counterparts in the floor of the quarry, testify to the ongoing karsting of the carbonates in the area.

A similar cave, plugged with green clay (containing white kaolin pellets and sparse crinoid ossicles), was found in Selkirk Formation dolomite exposed in the new Haniken and Selkirk Supply quarry on Highway 59, south of Libau. This quarry also contains a brown sandstone-filled dyke in the south wall, and at the top of the quarry face, a 40 to 60 cm wide, 2 m deep grike filled with delicately laminated grey and cream Pleistocene clay, with gently concave bedding traces.

Figure GS-39-1: Cedar Lake Formation escarpment at northeast end of Teardrop Basin, west of Buffalo Lake, Grand Rapids Uplands.

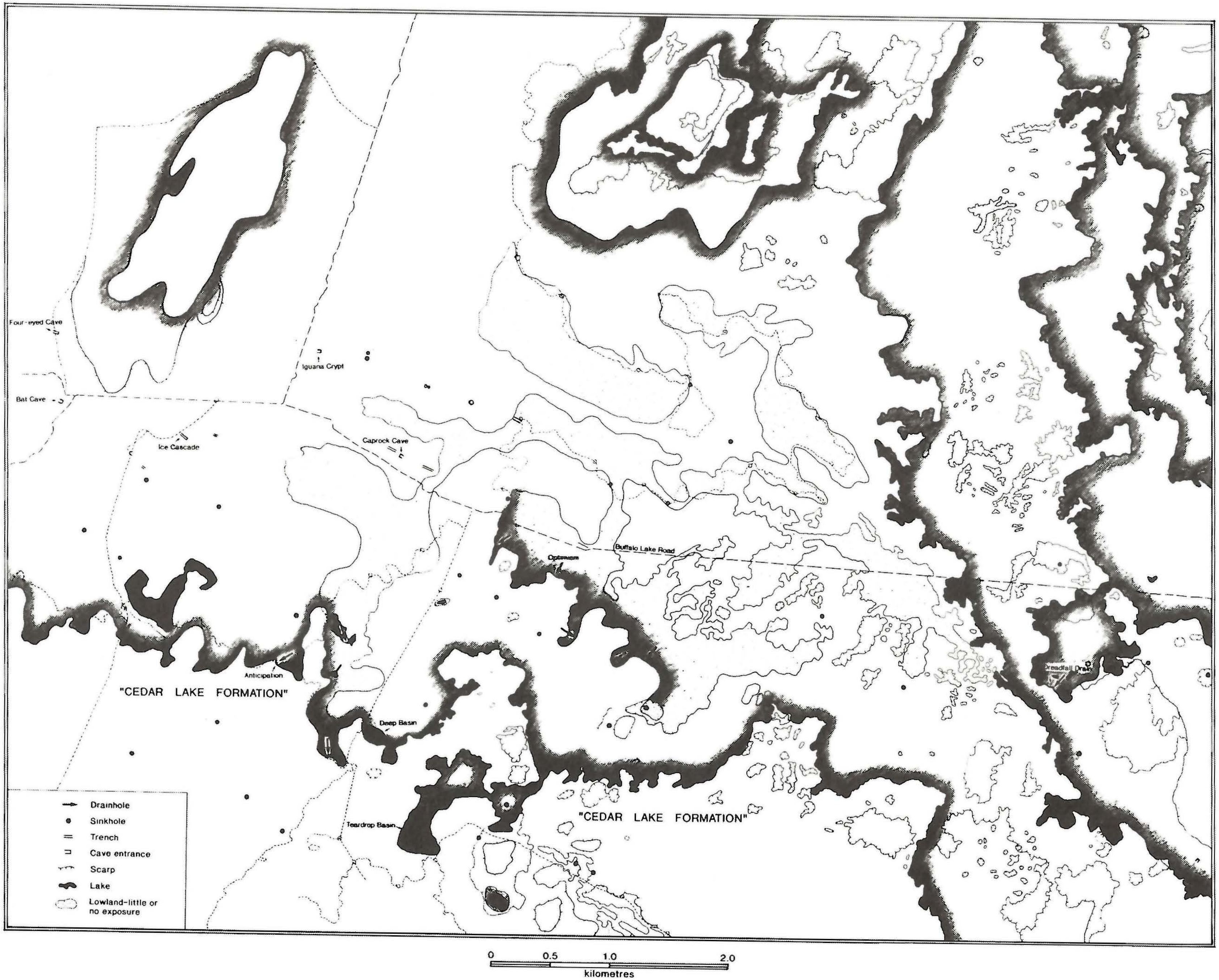


Figure GS-39-2: *East-trending scarp and outliers, near the contact of the Cedar Lake and East Arm formations, Grand Rapids, west Buffalo Lake.*

Figure GS-39-3: *Rafted mats of peat strewn along the shoreline of Teardrop Lake, east of Deep Basin. West of Buffalo Lake and Grand Rapids Uplands.*

Figure GS-39-4: *Near vertical solution pipe in Elm Point Formation limestones, north wall of Canada Cement quarry, Steeprock, Manitoba.*

SYLVAN KAOLIN

Several different geophysical instruments were used in an attempt to trace fossil gorges at Sylvan, infilled with Cretaceous sand, kaolinitic clay and lignite (Hosain, GS-36, this volume). The ground traverses were augmented, and given regional dimension, by an airborne VLF and magnetic survey using the GSC Skyvan. Analysis of the ground and airborne surveys will be undertaken to determine if a combination of the two techniques can be used routinely to trace similar buried channels elsewhere in the Interlake.

A more comprehensive review of karst features and processes in the Interlake Region is contained in the atlas of Caves in Manitoba's Interlake, published in early 1992, by the Speleological Society of Manitoba.

REFERENCES

McRitchie, W.D.

1991: Karst in Manitoba's Interlake: sinkholes and subcutaceous drainage; **in** Manitoba Energy and Mines, Report of Field Activities, 1991, p. 98-103

Speleological Society of Manitoba

1992: Caves in Manitoba's Interlake region, from surveys conducted by the Speleological Society of Manitoba, 150 p.

GS-40 REED LAKE GABBRO PROJECT

by Brian L. Williamson[1]

Williamson, B.L., 1991: Reed Lake gabbro project; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1992, p. 153.

During the Canada-Manitoba Mineral Development Agreement 1984-89, the results of studies by Young and Ayres of several mafic-ultramafic intrusions in the Snow Lake-Flin Flon area suggested that the Reed Lake Gabbro intrusion ranked high in mineral potential. As a result, the current studies were initiated under the 1990-95 MDA to focus on this intrusion. The intent of the current study is to conduct field mapping and sampling of the intrusion in order to document layering and petrochemical trends within the intrusion, extend and supplement the preliminary igneous stratigraphy proposed by Young and Ayres (1985), and investigate aeromagnetic trends and mineral potential of the intrusion.

Previous detailed aeromagnetic data that have been collected (total field and calculated vertical gradiometer; Konings, 1988) are filed in the Recording Office (Mines), Winnipeg, Manitoba. They indicate the presence of three principal aeromagnetic trends that strike north-south within the bounds of the intrusion. The strongest anomaly is at the center of the body, with weaker trends at the upper (western) and lower (eastern) contacts. The basal anomaly consists of a series of elongate, narrow zones that individually strike slightly oblique to the other magnetic highs, but collectively are strike parallel. Sampling completed by E.I. Tanczyk during July, 1992 for remanent magnetism studies will aid interpretation of these aeromagnetic data.

Two recently completed gravity profiles (Thomas *et al.*, in press) have indicated the presence of a 14 mgal Bouguer anomaly centered on the intrusion and continuous along its strike length, which terminates abruptly at the intrusion's south end coincident with the start of Paleozoic cover. This suggests the presence of denser rocks (pyroxenite/periodite or oxide enriched rocks) within the intrusion. Further study by gravity modelling will refine this hypothesis.

A six week field program during June-July, 1992 included sampling of a cross section through the intrusion along the Grass River at its south end, and some detailed study and sampling of the basal portion of the intrusion in the Grass River-Radar Point area. Samples are currently being processed for chemical and petrographic analysis. Although abundant outcrop is present in the area, severe overgrowth of moss and lichen will preclude the detailed mapping which would form the basis for detailed petrological studies during this project.

The rock types consists of a mixed variety of gabbroic rocks, from anorthosite to pyroxenite. The lower part of the section is a mixture of anorthositic, leuco-, normal and melagabbros and pyroxenites, sometimes exposed as discrete outcrops and sometimes showing the layer contacts. In the middle and upper parts of the section is a mixture of leucogabbro to melagabbro, with quartz-bearing rocks mixed in throughout. Numerous layering contacts were found, striking approximately north-south and dipping steeply west to vertical. A variety of intrusive breccias and dykes (which may turn out to be intrusive contacts and feeder dykes for various rock units) were found at a number of locations throughout the section.

The aeromagnetic anomalies can be correlated on the ground with more mafic rocks (melagabbro to pyroxenite) which attract a swing magnet. These rocks may carry minor disseminated sulphide. Unequivocal peridotites were not found, although possible candidates were sampled from the two lower anomalies. No massive oxide or sulphide layers were found.

A traverse across one of the zones of the basal magnetic anomaly (approximately 100 m across) was able to locate magnetic rocks on the ground. The rock types within the anomalous zone are highly variable (leucogabbro to pyroxenite), are interlayered at the metre to 10 m scale, and are not petrographically distinct in the field from similar rocks observed between magnetic anomalies.

The uppermost magnetic anomaly correlates with a mafic melagabbro, containing sporadic minor disseminated sulphide, which was traced along strike for 120 m. It is enclosed by overlying quartz-bearing normal to anorthositic gabbro, and underlying leucogabbro that contains melagabbro dykes (which could turn out to be feeder dykes). The presence of a highly mafic unit near the roof of the intrusion is problematic, and not consistent with a simple model of a homoclinal igneous stratigraphy resulting from differentiation of a single pulse of magma. This raises the possibility that the Reed Lake Gabbro formed from multiple intrusive events.

Future work will proceed on gravity modelling, remanent magnetism, petrographic and petrochemical analysis, and continued field mapping.

1 Geological Survey of Canada

REFERENCES

Konings, M.

1988: Report on a combined helicopter-borne magnetic, electromagnetic and VLF Survey, Reed Lake area, Manitoba for International Platinum; Assessment Report on file at Recording Office, Mines, Winnipeg, Manitoba.

Thomas, M.D., Williamson, B.L., Williams, R.P. and Miles, W.

in press: Gravity surveys in the Cormorant Lake map-sheet, Manitoba-Saskatchewan: A Progress report; Geological Survey of Canada Paper 93-1 Current Research.

Young, J. and Ayres, L.D.

1985: Characterization of mafic-ultramafic rocks in the Flin Flon-Snow Lake area, Manitoba; unpublished report to the Geological Survey of Canada re: contract OST84-00087, 59 p.

PUBLICATIONS AND GEOLOGICAL STAFF

Publications Released
November 1991 - November 1992

MANITOBA ENERGY AND MINES

Geological Services Branch

Ames, D.E., 1991:
The Ruttan Cu-Zn deposit and depositional environment: an update; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 106-107.

Athayde, P., 1991:
Manitoba mineral inventory; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 96.

Bailes, A.H. and Galley, A.G., 1991:
Geological setting of base metal mineralization in the Anderson Lake area (NTS 63K/16SE and 63J/13SW); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 8-13.

Anderson Lake (South) (parts of NTS 63K/16SE and 63J/13SW); Manitoba Energy and Mines, Preliminary Geological Map 1991S-2, 1:5 000.

Anderson Lake (North) (parts of NTS 63K/16SE and 63J/13SW); Manitoba Energy and Mines, Preliminary Geological Map 1991S-3, 1:5 000.

Stall Lake (South) (part of NTS 63J/13SW); Manitoba Energy and Mines, Preliminary Geological Map 1991S-4, 1:5 000.

Stall Lake (North) (part of NTS 63J/13SW); Manitoba Energy and Mines, Preliminary Geological Map 1991S-5, 1:5 000.

Bailes, A.H., Galley, A.G. and Hicks. R., 1991:
Wekusko Lake (Northeast) (part of NTS 63J/13SW); Manitoba Energy and Mines, Preliminary Geological Map 1991S-6, 1:20 000.

Bamburak, J.D., 1991:
High-calcium limestone investigations east side of Lake Manitoba, south of the Narrows (NTS 62I and 62O); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 84-88.

Bamburak, J.D. and Schmidtke, B.E., 1991:
Dimension stone investigations in southeastern Manitoba; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 77-83.

Bezys, R.K., 1991:
Stratigraphic mapping (NTS 63F, 63K) and core hole program 1991; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 61-73.

Conley, G.G., 1991:
Manitoba oil and gas well information system (MOGWIS); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 74-76.

Corkery, M.T., 1991:
Cross Lake supracrustal investigations (part of NTS area 63J/9); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 56-57.

Corkery, M.T. and Cameron, H.D.M., 1991:
West Cross Lake (parts of 63J/9SE and 63J/9NE); Manitoba Energy and Mines, Preliminary Geological Map 1991K-1, 1:20 000.

Fedikow, M.A.F., 1991:
Metallogeny of the Herblet Lake gneiss dome complex, Snow Lake area; Manitoba Energy and Mines, Abstract.

Sediment-hosted Zn-Cu (Bur Zone) and Zn-Pb-Ag (Kobar/Ruby) massive sulphide type deposits, Snow Lake area (NTS 63J/13); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 43-46.

Geology and alteration at the Wim Deposit (part of NTS 63N/1); Manitoba Energy and Mines, Preliminary Geological Map 1991S-1, 1:5 000.

Fedikow, M.A.F. and Dunn, C.E., 1991:
A vegetation geochemical survey in the vicinity of the Tanco pegmatite, Bernic Lake area, southeastern Manitoba (NTS 52L/6); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 105.

Fedikow, M.A.F. and Trembath, G.D., 1992:
Mineral deposits and occurrences in the Wimapedi Lake area, NTS 63O/4 ; Manitoba Energy and Mines, Mineral Deposit Series Report No. 25, 137p.

Fedikow, M.A.F. and Ziprick, D., 1991:
The geological setting of the Wim massive sulphide type Cu deposit, Snow Lake area (NTS 63N/1); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 41-42.

Fedikow, M.A.F., Ferreira, K.J. and Baldwin, D.A., 1991:
Johnson shear zone - a regional metallogenic feature in the Lynn Lake area; Manitoba Energy and Mines, Mineral Deposit Thematic Map Series Map 91-1.

Fedikow, M.A.F., Ferreira, K.J. and Chackowsky, L., 19991
A vegetation geochemical survey in the Dot Lake area, Agassiz metallotect, Lynn Lake: implications for mineral exploration and environmental monitoring; Manitoba Energy and Mines, Abstract.

Fedikow, M.A.F., Parbery, D. and Ferreira, K.J., 1991:
Geochemical target selection along the Agassiz Metallotect using stepwise discriminant function analysis; Economic Geology, v. 86, p. 588-599.

Ferreira, K.J., 1991:
Geology of the Leo Lake area, Flin Flon, Manitoba; Manitoba Energy and Mines, Open File OF91-2, 51p.

Geological Survey of Canada, 1992:
Federal/ Provincial aeromagnetic surveys in the Dawson Bay region (parts of NTS 63C and 62N at 1:250 000, and 63C/SE, 63C/SW, 63C/NW, 62N/NE and 62N/NW at 1:100 000; Geological Survey of Canada, Open File 2494 (available for viewing at Manitoba Energy and Mines).

Gobert, G. and Nielsen, E., 1991:
Till geochemistry of the Snow Lake-File Lake area (NTS 63K/16, 63J/13); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 47-48.

Gunter, R., 1991:
High-calcium limestone (NTS 62O west half); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 89-94.

Lenton, P. and Chackowsky, L., 1991:
GIS and computer projects within Manitoba Energy and Mines; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 97.

Manitoba Energy and Mines, 1991:
Manitoba Geological Services Branch - Staff and Functions; Brochure.

Mining and exploration companies active in Manitoba; Brochure.

Provisional project and output listing; Miscellaneous Publication 91-1.

Report of Activities, 1991.

Selected Manitoba-based contractors and consultants serving the exploration industry; Brochure.

Manitoba Energy and Mines, 1992:
Kettle Rapids Area NTS 54D; Manitoba Energy and Mines, Bedrock Geology Compilation Map Series NTS 54D, 1:250 000.

Marten, B.E., 1992:
Geology of the God's Lake, Munroe Lake, Webber Lake area, Manitoba; Manitoba Energy and Mines, Geological Report GR83-1D, 28p.

McGregor, C. R. and Macek, J.J., 1992:
Interpretation of exploration drill core from the southwestern extension of the Thompson Nickel Belt; Manitoba Energy and Mines, Preliminary Geological Report PR92-1 (available for viewing at Manitoba Energy and Mines).

McRitchie, W.D., 1991:
Karst in Manitoba's interlake: sinkholes and subcutaneous drainage; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 98-103.

McRitchie, W.D. and Duke, J.M., 1991:
Introductory Review; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 1-3.

Norquay, L.I., Prouse, D.E., Bieri, M. and Gale, G.H., 1991:
Geology of a part of the North Star Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 31-40.

Norquay, L.I., Prouse, D.E., Bieri, M. and Gale, G.H., 1992:
North Star Lake area (part of NTS 63K/15NE); Manitoba Energy and Mines, Preliminary Geological Map 1991F-1, 1:10 000.

North Star Lake area (part of NTS 63K/15SE); Manitoba Energy and Mines, Preliminary Geological Map 1991F-2, 1:10 000.

Ostry, G. and Trembath, G.D., 1992:
Mineral deposits and occurrences in the Batty Lake area, NTS 63N/2; Manitoba Energy and Mines, Mineral Deposit Series Report No. 19, 274p.

Parbery, D., 1991:
Agassiz Metallotect project; Manitoba Energy and Mines, Economic Geology Report ER91-2, 8 maps, 1:5 000 and marginal notes.

Prouse, D.E., 1992:
Manitoba's Precambrian drill core collection program: an update and review; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 95.

Schledewitz, D.C.P., 1991:
Geology of the Webb Lake area (NTS 63K/15); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 5-7.

Webb Lake (NTS 63K/15); Manitoba Energy and Mines, Preliminary Geological Map 1991K-2, 1:20 000.

Syme, E.C., 1991:
Elbow Lake project - Part A: supracrustal rocks and structural setting; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 14-27.

Syme, E.C. and Whalen, J.B., 1991:
Elbow Lake (part of NTS 63K/15W); Manitoba Energy and Mines, Preliminary Geological Map 1991F-3, 1:20 000.

Theyer, P., 1991:
Mineral deposit investigations in the Gods Lake area (NTS 53L/9, 53L/10, 53L/16); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 58-60.

Elk Island and Jowsey Island (part of NTS 52L/9); Manitoba Energy and Mines, Preliminary Geological Map 1991G-1, 1:10 000.

Turek, A. and Weber, W., 1991:
New U-Pb Zircon ages from the Rice Lake area: Evidence for 3 Ga crust; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 53-55.

Weber, W., 1991:
Geology of the English Brook area, southeastern Manitoba (NTS 62P/1); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 49-52.

Lithoprobe activities in Manitoba, 1991; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 104.

Weber, W. and Young, J., 1991:
English Brook (NTS 62P/1); Manitoba Energy and Mines, Preliminary Geological Map 1991R-1, 1:20 000.

Whalen, J.B., 1991:
Elbow Lake project - Part B: Granitoid rocks; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 28-30.

Zwanzig, H.V., 1991:
Geological investigations in the Kisseynew - Batty Lakes area (Parts of 63N/13, 14, 63N/1-4); **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1991, p. 4.

LIST OF GEOLOGICAL STAFF AND AREAS OF CURRENT INVOLVEMENT

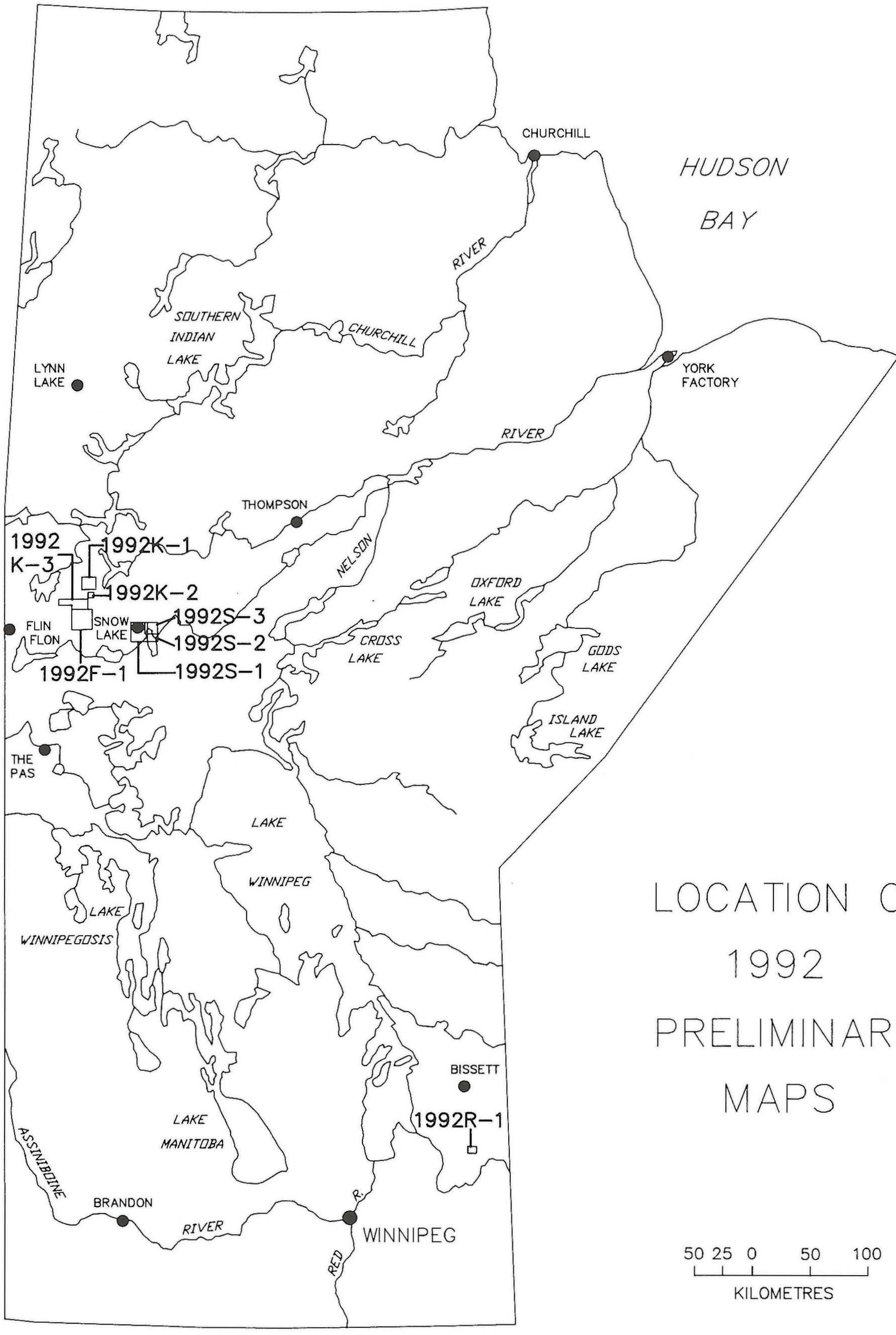
GEOLOGICAL SERVICES

POSITION	PERSONNEL	AREA OF CURRENT INVOLVEMENT
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. Cameron	Pipestone Lake
	M.T. Corkery	Cross Lake-Northern Superior Province, Nelson and Churchill Rivers
	H.P. Gilbert	Tartan Lake, Wekusko Lake-South
	P.G. Lenton	Cross Lake, Data Management and Analysis
	Dr. J.J. Macek	Thompson belt
	D.C.P. Schledewitz	Kississing Lake
	E.C. Syme	Flin Flon, Athapapuskow Lake, Elbow Lake
	Dr. H.V. Zwanzig	Churchill Province, Kisseynew belt
Mineralogist	C.R. McGregor	Mineralogy; Sub-Phanerozoic Precambrian
Geological Compiler (Atlas)	D. Lindal	1:250 000 Precambrian compilation maps
Phanerozoic Geologist	R.K. Bezys	Southwest Manitoba, Hudson Bay Lowlands, and Interlake
Mineral Investigations:		
Senior Mineral Deposit Geologist	Dr. G.H. Gale	Manitoba, specifically Flin Flon and Snow Lake
Mineral Deposit Geologists	Dr. P. Theyer	Island Lake/Southeast Manitoba: PGE investigations
	G. Ostry	File Lake-Sherridon area
	K. Ferreira	Mineral Deposit Geological Assistant
Resident Geologist (The Pas)	D.E. Prouse	Exploration activity, drill core program
Resident Geologist (Flin Flon)	T. Heine	Flin Flon - Snow Lake region; North Star, Elbow Lake
	L. Norquay	North Star Lake
Industrial Minerals Geologists	W.R. Gunter	High-calcium limestone
	B.E. Schmidtke	Silica; industrial mineral inventory
	J.D. Bamburak	High-magnesium dolomite; building stone
Computerization:	G.G. Conley	Stratigraphic data files
	L.E. Chackowsky	Geographic Information Systems
Geophysics, Geochemistry and Terrain Sciences:		
Section Head	I.T. Hosain	Rice Lake/Interlake
	Dr. M.A.F. Fedikow	Snow Lake/Southeast Manitoba
	Dr. E. Nielsen	Elbow Lake
	G. Matile	Southern Manitoba

PRELIMINARY MAPS 1992

GEOLOGICAL SERVICES BRANCH **Scale**

1992K-1	Meat Lake (part of NTS 63N/2) by H.V. Zwanzig	1:20 000
1992K-2	Evans Lake (part of NTS 63N/2) by H.V. Zwanzig	1:20 000
1992K-3	Webb Lake - Fay Lake (NTS 63K/14NE and 63K/15NW) by D.C.P. Schledewitz	1:20 000
1992F-1	Elbow Lake (part of NTS 63K/15) by E.C. Syme and J.B. Whalen	1:20 000
1992S-1	Chisel-Anderson-Morgan Lakes (NTS 63K/16E) by A.H. Bailes and A.G. Galley (supersedes 1990S-1)	1:20 000
1992S-2	Wekusko Lake (North) NTS 63J/13SW by A.H. Bailes and A.G. Galley (supersedes 1991S-6)	1:20 000
1992S-3	Anderson-Kormans and Stall Lakes (parts of NTS 63K/16SE and 63J/13SW) by A.H. Bailes and A.G. Galley (supersedes 1991S-2, -3, -4, -5)	1:10 000
1992R-1	Page Property, Bird River Sill (NTS 52L/5NE) by J. Young (University of Manitoba)	1:2 000



LOCATION OF
1992
PRELIMINARY
MAPS